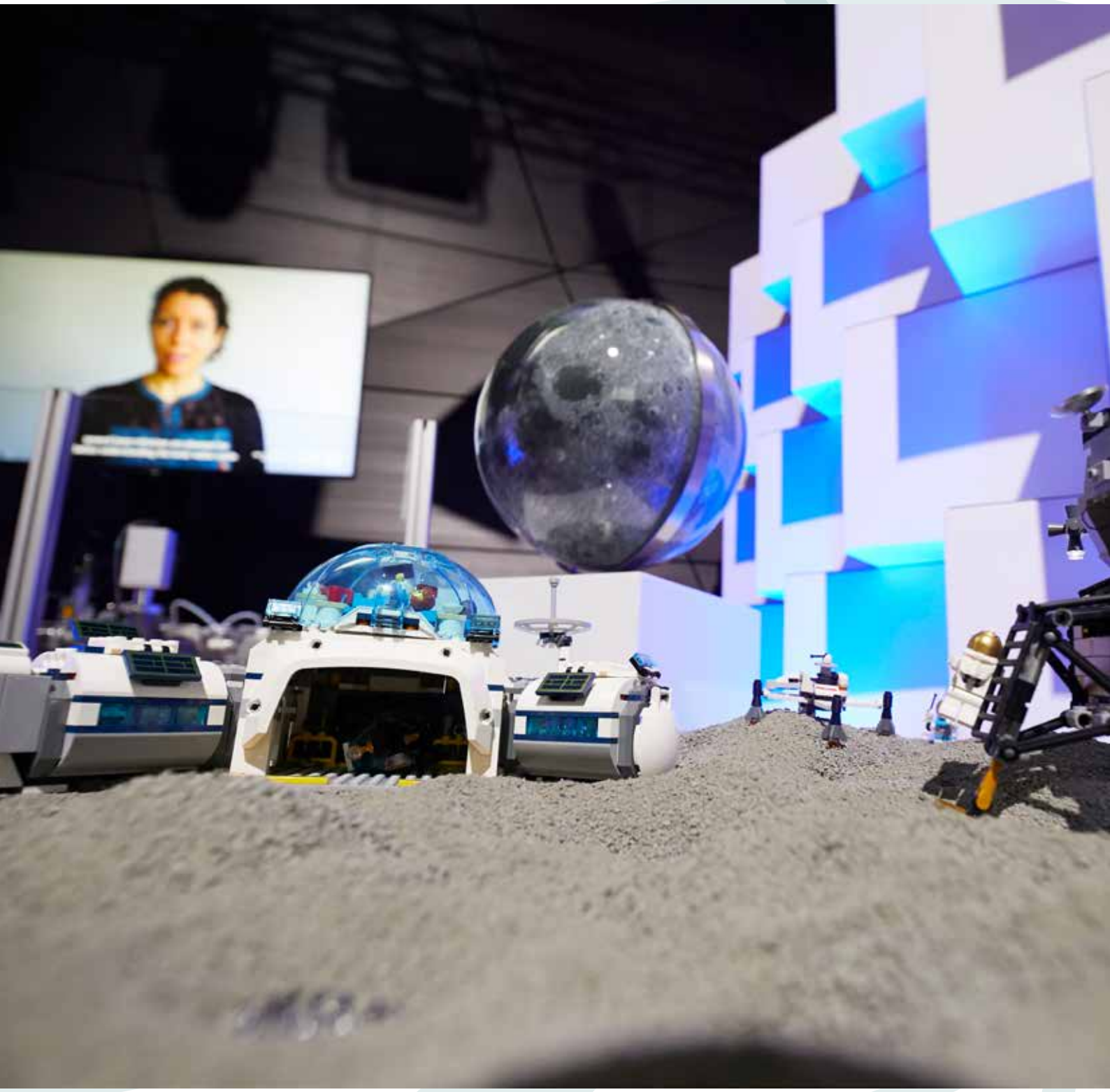
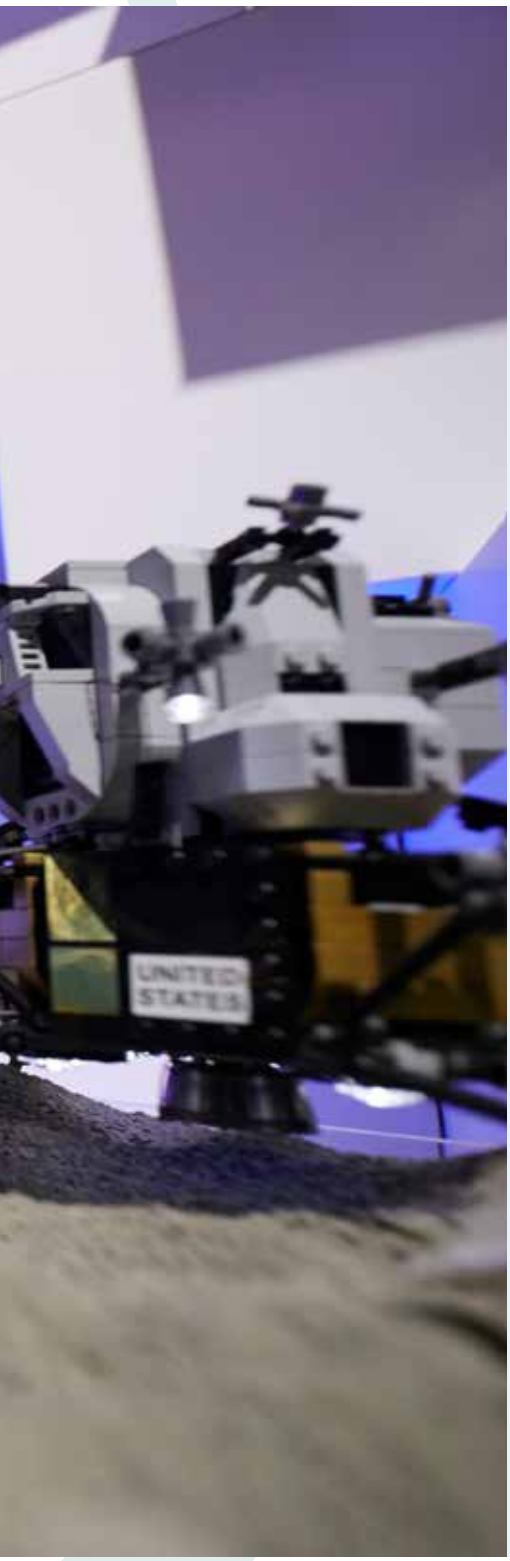
TOGETHER FOR AN EFFECTIVE TRANSITION

ANNUAL REPORT 2022

LUXEMBOURG
INSTITUTE OF SCIENCE
AND TECHNOLOGY

LIST





CONTENTS

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

TOGETHER FOR AN EFFECTIVE TRANSITION

The climate emergency combined with the spike in energy prices that Europe experienced in 2022 gave new impetus to the search for low-carbon alternatives and to the transition to a more sustainable and safer energy system throughout Europe. Many European Member States, including Luxembourg, are now taking active measures to increase green energy production while seeking to diversify oil and gas supplies and reduce overall demand.

The Luxembourg government is actively involved in this move towards transformation. At the beginning of the year, it announced its desire to intensify its commitment to climate action by proposing an update to the national energy and climate plan (*Energie- a Klimaplang fir Lëtzebuerg*). The new plan envisages a significant increase in the share of renewable energies in overall energy consumption from 25% to 37%, the strengthening of current measures and the launch of new initiatives to ensure a fair transition.

However, there are considerable challenges to be overcome when it comes to a successful energy transition, particularly in the technology sector. Examples include difficulties in accessing raw materials in the supply chain – which are essential for vital decarbonisation technologies – and the development of a secure digital network capable of supporting the deployment of variable renewable energy production, decentralised energy resources and emerging threats such as cyber attacks. In the face of these challenges, the research and innovation (R&I) expertise developed by LIST in recent years, particularly in the field of digital twins and energy systems, materials for the production and use of hydrogen and biomethanisation processes, is taking on a new importance. Together with our private and public partners, we are helping to accelerate innovation in Luxembourg and to create new solutions that can promote energy transition and, more broadly, sustainable transition.

In 2022, our 676 employees continued our mission: to push the boundaries of research for high-impact innovations, while maintaining a sustainable-by-design approach, i.e. to intelligently design products, services and technologies that have as little impact as possible on the environment.

Creating a joint laboratory with industrial partners

During this last period, LIST signed 18 new collaboration agreements, most of which relate to the energy transition or contribute to reducing our partners' environmental impact. In particular, it concerns the agreement with Encevo/Creos on the transformation of the energy network based on the increased use of energy-related data, agreements with CLE as well as Schroeder and Associates in the field of sustainable construction, the agreement with Gradel on environmentally friendly lightweight composites and the agreement with FM Global on climate resilience. The memorandum of understanding with Meluxina, Luxembourg's supercomputer with high energy efficiency, is also an essential step in LIST's high-performance computing strategy.

With the inauguration of the Sustainable Composite Materials and Manufacturing Innovation Center (SCMM) by our Materials Research and Technology (MRT) department, LIST is sending a strong signal that it intends to meet the future needs of the transport market, which is facing the greatest transformation in its history. This programme is supported by four major players in European transport, namely Toyota, Airbus, Thales Alenia Space and Alstom, and is partly funded by the Ministry of Higher Education and Research and the Ministry of the Economy. In April 2023, Euro-Composites and Gradel became the first two members of the innovation centre.

At Tech Day 2022, LIST and Goodyear welcomed the impressive results achieved in the field of materials and data sciences during the six years of the largest public-private partnership to be established in Luxembourg. The two parties signed a memorandum of understanding to establish a second strategic partnership.

Accelerating innovation through scientific excellence

In line with its mission to transfer innovation and accelerate the economic impact for industry, LIST has created the Invitrolize spin-off, which aims to detect chemical respiratory irritants at an early stage in the development of new products.

Scientific excellence remains the cornerstone of LIST's ambitions, as attested to by 123 national competitive projects, 57 international competitive projects and 162 collaborative projects in progress in 2022, as well as 180 scientific publications included in the most important 10% in their category.

In terms of excellence, Dr Kathryn Hadler, an internationally renowned scientist in the field of mineral processing and recovery, supported by a PEARL Chair of the Luxembourg National Research Fund (FNR) with a budget of 3.7 million euros over five years, was appointed Director of ESRIC (European Space Resources Innovation Centre) from 1 April 2022.

Uniting our strengths to benefit society

As part of research projects, LIST and the National Health Laboratory (LNS) have joined forces to work on innovative solutions in the fields of microbial pathogens, food safety, toxicology, environmental health and human biomonitoring.

LIST continued its analyses of SARS-CoV-2 in wastewater and published its 110th report at the end of December. These studies continue in 2023.

Finally, LIST has signed a multi-year agreement for 2022–2025 with the Luxembourg government and has seen its grant increase by 18% for this period. Signing it has also confirmed LIST's strategy as defined in the 2022–2025 multi-year programme of work. The latter sets out eight objectives aimed at increasing LIST's economic, political, environmental, social, regional and academic impact.

LIST also produced its self-assessment report as part of an external assessment for the Ministry of Higher Education and Research and was evaluated by a panel of scientific and innovation experts selected by the Interface consultancy.

Developing the skills of tomorrow

In addition to the 25 theses that were successfully defended in 2022, LIST took the lead on the creation of two new doctoral training units (DTU) funded by the FNR's PRIDE programme in the fields of functional materials (DTU HYMAT) and sustainable polymer composites (DTU SusPoCo), the latter being launched in collaboration with the Department of Engineering (DoE) of the University of Luxembourg. At the same time, LIST also worked with the Centre for Contemporary and Digital History (C^2DH) of the University of Luxembourg to launch a third doctoral training unit in the deep data science of digital history. Thanks to these units, a total of 17 PhD students will be trained at LIST over a period of four to six years.

In this report, we are particularly pleased to present the successes of our committed and talented co-workers, without whom we would not be able to help address global challenges and ensure an effective and sustainable transition. With LIST's new CEO ad interim, Dirk Fransaer, appointed at the start of June following the departure of Thomas Kallstenius, the Board of Directors and all of our staff intend to continue on this path in the coming years, building on the results achieved so far.

Eva KREMER
Chair of the Board of Directors

Dr Thomas KALLSTENIUS
CEO

KEY FIGURES

HUMAN RESOURCES

As of 31.12.2022

676 employees

66 % men

34 % women

54 nationalities

77 % researchers or innovation experts

For the whole of 2022

114 new recruits

100 PhD students based at LIST

SCIENCE AND TRANSFER

27 PATENTS FILED

7 spin-offs (existing for 3 years or more)

19 paid licences

178 scientific articles in 1st quartile journals

25 doctoral theses successfully defended

R&D PROJECTS IN PROGRESS IN 2022

123 national competitive projects

57 European competitive projects

7.24 %

of income from services

162

collaborative projects and similar

∑ 428 RDI projects and contracts in total

RESEARCH CONTRACT TYPES

- 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.

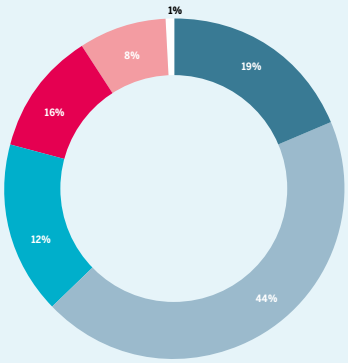
INTERNATIONAL COLLABORATIONS

NUMBER OF CONTRACTS IN PROGRESS PER COUNTRY

EUROPEAN UNION (EU)	679
Austria	27
Belgium	66
Bulgaria	12
Croatia	8
Cyprus	8
Czech Republic	10
Denmark	16
Estonia	3
Finland	16
France	111
Germany	77
Greece	37
Hungary	8
Ireland	12
Italy	63
Latvia	5
Lithuania	7
Malta	2
Netherlands	40
Poland	14
Portugal	28
Romania	4
Slovakia	3
Slovenia	11
Spain	81
Sweden	1

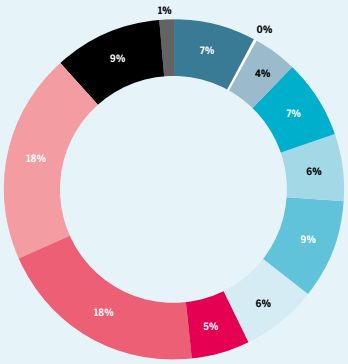
REST OF THE WORLD	71
Albania	1
Czech Republic	4
Estonia	3
Iceland	2
Israel	4
Japan	1
Korea	2
Norway	5
Serbia	3
Switzerland	6
Turkey	6
United Kingdom	33
Uruguay	1

BREAKDOWN OF PARTNERSHIPS IN PROGRESS IN 2022 BY TYPE OF PARTNER



- Universities (142)
- Companies (333)
- Research centres (122)
- Public institutions (89)
- Foundations and associations (62)
- Other (6)

BREAKDOWN OF PARTNERSHIPS IN PROGRESS IN 2022 BY SECTOR



- Agro and natural resources (64)
- Automotive/aeronautical (2)
- Biotech / Cleantech (36)
- Construction (60)
- Education technology (52)
- Energy (79)
- Health and medical technology (57)
- Domestic security (47)
- ICT (164)
- Industry (163)
- Mobility (84)
- Space (11)

OUR COMMITMENTS

OUR COMMITMENTS

A GOOD PLACE TO BE AND WORK

At LIST, our most valuable asset is our staff. That is why they are our top priority. We are implementing numerous initiatives to ensure our colleagues' well-being and good mental health at the Institute. This particularly translates into significant efforts being made to improve staff comfort in our buildings, and more specifically in open spaces: partitioning, creating micro-meeting rooms, supplying noise-cancelling headphones, drawing up a code of conduct, etc.

LIST invests heavily in the continuous training of all its staff. It provides a wide range of courses in technical subjects, soft skills and wellbeing. These courses are presented either online, in person or in a hybrid format. They are tailored to the different profiles in our organisation, whether they are direct or indirect players in the field of research and innovation.

In June, 60% of our staff completed the first survey to provide LIST with a social barometer of its employees' experience. The purpose of this survey is to measure how likely our employees are to recommend LIST as a pleasant place to work and to better understand the drivers that influence their satisfaction and commitment. In response to the question: "On a scale of 0 to 10, am I willing to recommend LIST as a place to work?", 68% of respondents gave a score from 7 to 10; the average score being 7.1 out of 10.

A PLACE WHERE EVERYONE IS WELCOME

At LIST, we make our diversity a strength. We are committed to fairness in the recruitment, career development and work-life balance of our employees. In order to further develop these areas, we are participating in the Positive Actions programme of the Ministry of Equality between Women and Men (MEGA). A working group has been set up and an action plan has been developed to work on the areas for improvement. The plan will be reviewed and validated by the Ministry.

In addition, as part of implementing our diversity and inclusion strategy, we have launched a training programme for our managers, recruitment committee members and new recruits: introduction to the area, managing a diverse and inclusive team and unconscious bias. A general training programme covering the various areas of diversity, equality and inclusion has also been completed by all of our colleagues.

In terms of external visibility, LIST, Luxinnovation and Widong launched a poster campaign as part of national diversity day. For two weeks, 47 portraits of colleagues of 37 different nationalities were displayed in the windows of the Maison de l'Innovation in Belval. This exhibition was accompanied by a website and social media campaign presenting the project, its concept and its context to the general public. Finally, for the second consecutive year, LIST was an official sponsor of Pride Week, which celebrated the LGBTIQ+ movement in Luxembourg.

We also regularly participate in the various IMS working groups, which have made it possible, in particular, to develop an online training programme on the LGBTIQ+ community.

Finally, we have continued our joint work with other Luxembourg research institutes, the FNR and the University of Luxembourg to improve the professional situation of female researchers in Luxembourg and to increase the country's appeal as a place for scientists to work.

Michaël Janes, Jean-Paul Schmit, Hugo-Pierre Corrado & Maxime Chopin

A PLACE WHERE QUALITY AND SAFETY ARE TOP PRIORITY

For several years, we have made security one of our priorities. In 2022, while 41 incidents were reported, the target of zero was achieved in the laboratories where no accidents were reported.

We now have a brand new portal at our disposal to ensure all activities concerning health, safety and the environment at work, as well as risk and compliance, are monitored to the best of our ability. This provides colleagues with a means of creating workflows and paperless forms and processes, such as the procurement of scientific equipment or the transfer of equipment between laboratories, the risk assessment process for health, safety and the environment, incident management and management of accidents at work, health inspection or regulatory controls and changes in authorisation. This new platform supports the entire management of internal documentation, from the creation of a document to its publication.

In addition to staff safety, we have continued our efforts in information system security, in particular by implementing new antivirus software and network adaptations. We have strengthened our clean desktop policy, including security features.

A PLACE COMMITTED TO SUSTAINABLE DESIGN

At LIST, we are committed to setting an example for sustainability in our research activities and in our day-to-day operations. The 'Sustainability' working group has published its report on our carbon footprint in 2021 and how the Institute's environmental impact has developed in terms of greenhouse gas emissions since 2019. Document's main conclusion: LIST saw its carbon footprint reduced by 8% in 2021 compared to 2019, the Institute's reference year for measuring emission reductions. Our target involves a 24% reduction by 2025 compared to 2019.

In view of the international geopolitical context in 2022, a new short-term objective has been added. The aim was to reduce LIST's energy consumption by 15% in order to respond to a request from the Ministry of Higher Education and Research following the European Union's natural gas reduction agreement. We have therefore taken technical measures to increase energy sobriety at LIST and to raise awareness among our employees of the individual behaviour that each of them can easily adopt.

The year's other sustainability highlights include the appointment of Elorri Igos as Sustainability Officer, raising awareness of soft mobility through the MUV application and participation in the Tour du Duerf, as well as the donation of 50 used laptops to the Luxembourg Digital Inclusion Association, which is working to help the most disadvantaged to have access to information technology and computing.

Sivashankar Krishnamoorthy, Estelle Fischer & Benoît Otjacques (absent: Anne Trigaux, Sébastien Cambier)

A PLACE WHERE ETHICS ARE A MUST

At LIST, we make a point of respecting fundamental rights and applying the most appropriate ethical standards. Our Ethics Committee dealt with 47 applications, 42 of which related to the process of submitting research projects. We have reviewed LIST's activities in the field of security and defence, for which several research projects have been proposed.

LIST's Ethics Committee consists of six employees from different departments who are trained for this very important mission.

Elorri Igos

OUR RESEARCH & OUR INNOVATION

1. SUPPORTING THE TRANSITION TO AN ENVIRONMENT FREE FROM TOXIC SUBSTANCES

> So far, the only reliable way to identify respiratory sensitisation has been once the occurrence of people becoming sensitised on their workplace or in their homes has been observed by doctors. Our solution aims at overcoming the current limitation by further improving and optimising the only available in vitro alveolar model able to identify respiratory sensitizers. For natural or man-made chemicals, we can predict whether there is a hazard that they are respiratory sensitisers.
>
> Arno GUTLEB,
> Leader of the Environmental Health Group

Chemicals are ubiquitous in our everyday lives. They are found in the composition of almost all devices we use. Chemicals provide a basis for low-carbon, pollution-free, energy-efficient and resource-efficient technologies, materials and products which we need to make our society and our economy more sustainable. At the same time, these chemicals contain properties that are harmful to human health and the environment.

At LIST, our aim is to assess the unintended toxic effects of low-carbon solutions and to predict the harmful effects of chemicals without resorting to animal testing, and to improve the reuse of waste to ensure an efficient and smooth transition.

Success Story No. 1

ANTICIPATING THE HARMFUL EFFECTS OF CHEMICALS WITHOUT RESORTING TO ANIMAL TESTING

Predicting the impact of chemicals on our health without resorting to animal testing; this is the ambition of Invitrolize, a LIST spin-off founded in June 2022 and registered with the Luxembourg Chamber of Commerce. The company markets innovative 3D in vitro alveolar models to predict the risks of respiratory sensitisation and irritation. For the first time, these models can be used to predict respiratory sensitisation in realistic exposure conditions.

The spin-off is based in a laboratory in the Belvaux building and is developing its activities in the form of a start-up with the aim of sustainably improving assessments of the toxicity of chemicals and their impact on health.

On the 2nd national 3R day, the National League for the Protection of Animals (Lëtzebuerger Déiereschutzliga) also received an award for the contribution made by LIST and its Environmental Health team to reduce, replace or significantly perfect the use of animals in research, thanks to the development of these in vitro tests on human respiratory tracts.

Sabrina Burla & Arno Gutleb


Oona Freudenthal

Success Story No. 2

WORKING TOWARDS A BETTER ASSESSMENT OF CHEMICALS FOR THE BENEFIT OF HUMAN HEALTH AND THE ENVIRONMENT

Since 2022, LIST has held the Luxembourg seat on the Socio-economic Analysis Committee (SEAC) of the European Chemicals Agency (ECHA). Appointed by the Ministry of the Economy, Oona Freudenthal contributes to the work of SEAC, whose role is to assess the socio-economic impact of potential legislative measures with regard to chemicals, whether concerning proposals to restrict manufacturing, marketing or use of a substance, or the availability, appropriateness and technical feasibility of alternatives to using such hazardous substances.

In collaboration with the IT for Innovative Services department and with a view to an artificial intelligence (AI) app, Oona also began research in 2022 within the framework of a private-public partnership funded by the AXA Foundation. Her research project aims to help authorities and policy makers to establish an appropriate regulatory framework for these substances and to better manage the risks they pose to human health and the environment. The results of this research project will provide a better understanding of the risks chemicals pose to industrial clients, public health and citizens. This combination of an applied research project and a mission to implement a science-based policy strengthens LIST's activities and the offer of political support in the field of security and sustainability through design (safe and sustainable by design).

Success Story No. 3

TRANSZEROWASTE, IMPROVING THE REUSE OF WASTE AS A RAW MATERIAL

Europe's dependence on imported steel sources is increasing and is jeopardising goals for the decarbonisation of industry. In order to guarantee the independence of this sector as well as its compatibility with decarbonisation objectives, we are pursuing, together with our European partners, an ambitious objective to optimise the recycling of residues throughout the steel production chain, from both a techno-economic and environmental perspective.

The Horizon Europe TranszeroWaste Project, coordinated by LIST, aims to improve the reuse of waste as a raw material in two promising processes to decarbonise the sector, using hydrogen and electricity. LIST goes beyond assessing the technical and economic performance of these new recycling technologies and takes into account their eco-design and their environmental assessment in order to ensure more sustainable choices. In the long term, these innovative solutions will pave the way for a steel production chain that will not only depend less on imports, but will also be more circular and more environmentally friendly.


Elorri Igos

2. BIOTECHNOLOGY FOR SUSTAINABLE GROWTH AND DEVELOPMENT

> “At some point in the future where there are Martian outposts, the future colonists will have to grow plants in situ using resources that can actually be found on Mars, such as regoliths. So it’s necessary to understand how plants react from a physiological point of view when grown on this type of substrate. We went up to a maximum of four weeks to see how the plants would behave on regolith simulants and they do grow, but as expected they show signs of nutrient deficiencies.”

Gea GUERRIERO,
Senior Research and Technology Associate

Industrial and environmental biotechnology is at the convergence of numerous scientific and engineering disciplines with the aim of providing technical solutions that will have an impact on several sectors of the economy. Research in life sciences and biotechnology is already making specific improvements in the agri-food sector, water and soil quality, chemicals, renewable energies and public health.

At LIST, our research projects aim to: organically produce valuable chemicals and enzymes from plant cells and microbes through fermentation and recovery operations; utilise biomass at the end of use and other waste streams from agri-food supply chains as a source of bioenergy, biopolymers and chemical components for innovative and commercially interesting applications; develop new technologies for environmental monitoring; develop and test performance and economically evaluate biomanufacturing schemes and scalable technologies.

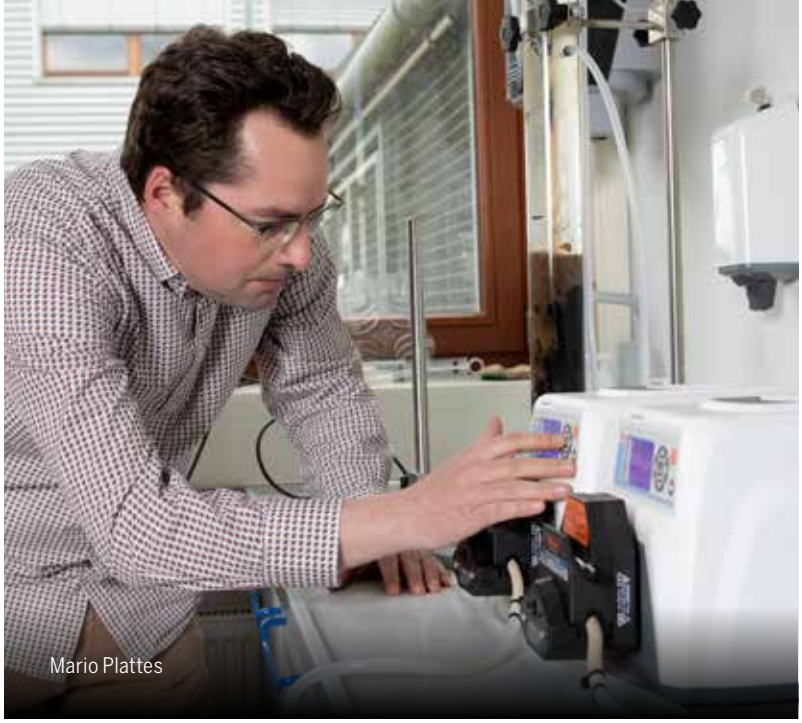
Success Story No. 1

TAKING A GREEN STEP ON THE RED PLANET

According to the international roadmap for space exploration, the first human installations on the planet Mars are planned by 2040. The cultivation of edible plants in situ on Martian or lunar surfaces will generate oxygen while at the same time producing food for visitors and future colonies. Water emitted and purified by plants will be able to be condensed and recycled. In line with the national research and innovation strategy and its objectives focusing on space resources to support life, LIST has begun to study plant growth on the simulated Martian regolith using a combination of imaging and omics. Italian ray-grass was used as a model of a rapidly growing herbaceous species.

The research teams showed that plants can grow on simulated regolith, despite the scarcity of the fundamental element nitrogen. They can even regrow after being cut. The ray-grass can therefore be used in a hypothetical scenario where it is harvested to obtain the organic matter to be used as feed. The molecular data obtained for the first time showed changes in the plant mechanism, whereby the leaves and roots adapted to grow in the substrate. The results published in the Science of the Total Environment attracted the interest of NASA’s Open Science Data Repository (GeneLab) and were highlighted in the Mascot newsletter.

Roberto Berni


Mario Plattes

Success Story No. 2

WASTEWATER TREATMENT WITH A BIOLOGICAL GRANULAR TREATMENT PROCESS

Aerobic granular sludge is now an alternative to the conventional process of activated sludge in biological wastewater treatment. Wastewater treatment plants equipped with aerobic granular sludge achieve high processing efficiency and have lower investment and operating costs than plants equipped with conventional activated sludge, which are in the majority in Luxembourg.

LIST has developed a model for aerobic granular sludge intended for engineering applications based on mathematical process models. This model can predict the concentrations of pollutants during the different operational phases of treatment.

In line with the digitisation objectives of the national research and innovation strategy, LIST studied the mechanical modelling of biological wastewater treatment processes and its application to a pilot unit at a local operator's premises. The scientific and technical aspects of this work were published in the Journal of Chemical Technology and Biotechnology (Society for Chemical Industry, London, UK), where the authors also presented a perspective article on the general use of the Monod kinetic model.

Success Story No. 3

IMPROVING THE MONITORING OF RISKS RELATED TO CYANOBACTERIA IN LUXEMBOURG'S BATHING WATERS

For more than 10 years, LIST has been commissioned by the Water Management Authority to carry out the operational monitoring of the proliferation of cyanobacteria – blue algae – in official bathing waters in accordance with a European directive. These algae can release toxins and pose a threat to public health.

Throughout the world, cyanobacteria are causing problems in freshwater ecosystems. According to current climate change projections, the problem is expected to get worse. In order to protect public health, it is essential to gain a better understanding of these cyanobacteria and, in particular, their life cycle in order to propose management strategies. In this regard, LIST provides data that can trigger alerts or the closure of Luxembourg's beaches for a period of time.

In 2022, LIST carried out three projects involving the deployment and testing of a unique combination of cutting-edge technologies. In particular, this combination brings together remote detection and in situ detection, automated image acquisition and the rapid dosage of cyanotoxins in order to stimulate the collection of data in the field and to provide information on the risks associated with effective spatial and temporal resolution. An early warning system has been developed for the effective protection of public health, while at the same time improving our understanding of cyanobacteria in order to better forecast algal blooms.

A participatory monitoring project has recently been launched, involving citizens in the reporting and documentation of algal blooms in waters used for recreational purposes.


Jean-Baptiste Burnet

3. DETECTING THE EFFECTS OF CLIMATE CHANGE FOR BETTER RISK MANAGEMENT

> The European ECOSTRESS Hub integrates a team of researchers to work on a common goal to understand water stress variability from space. One part is dedicated to advancing science algorithm and global validation of water stress, and another part focus on high-end engineering architecture to build the hub for algorithm integration in a cloud environment. This project is a perfect example of LIST's interdisciplinarity between science and technology and a precursor for ESA's future water-cycle mission.

Kaniska MALLICK,
Lead Research and Technology Associate

Today, changes on a global scale are primarily due to mankind's growing demand for natural resources. The Earth's system (i.e. the climate and the environment) is now operating in an unprecedented state, where unpredictable and harmful changes are becoming increasingly likely. Most of the technologies available to monitor, predict and provide for the future trajectories of the Earth's system are limited and hamper the progress made so far, particularly when it comes to studying the acceleration of the water cycle and its implications for the various components of environmental systems. Whilst new generations of instruments have recently been developed, offering unprecedented temporal and spatial resolutions and transmission rates for environmental monitoring protocols, there is an urgent need for new tools tailored to collecting, transmitting, validating, sorting and using rapidly increasing data flows.

The new tools and new solutions we are implementing at LIST help to guide emergency response operations, balance immediate economic interests and to set long-term sustainable development objectives in an increasingly uncertain and rapidly changing context.

Success Story No. 1

REMOTE DETECTION OF THE EARTH'S EVAPOTRANSPIRATION FOR NASA AND ESA

The Ecosystem Spaceborne Thermal Radiometer Experiment on the Space Station (ECOSTRESS) monitors water loss due to evaporation and transpiration processes on the Earth's surface. LIST contributed to this mission by successfully implementing the European ECOSTRESS hub and supplying lots of ecosystem data on the thematic operating platform on food security.

This achievement led to the EURANUS follow-up project, funded by the European Space Agency (ESA), which, on a European and African scale, aims to develop products relating to the surface temperature of the land, evaporation, productivity of ecosystems and the efficiency of water use, using all ECOSTRESS archives.

Tian HU

Thanks to this effort, LIST's "Surface Temperature Initiated Closure" (STIC) evaporation model has become one of the NASA Jet Propulsion Laboratory's official algorithms for generating ECOSTRESS products on the water cycle on a continental scale. These evaporation products with high spatial resolution from the International Space Station's sensor greatly facilitate future studies attempting to quantify the impact of ecosystem restoration on water availability at a regional level, as already reported in Nature Geosciences by the former PhD student from DTU Hydro-CSI, Anne Hoek van Dijke, and her supervisors.

Success Story No. 2

DEVELOPING NEW KNOWLEDGE AND SUSTAINABLE SOLUTIONS TO COMBAT DISEASES AND AGRICULTURAL PESTS

At the end of 2022, a new Biosafety Level 3 laboratory was set up and officially opened at LIST's Belvaux site.

Vector-borne plant pathogens affect almost all crops and can lead to significant economic losses for farmers. A laboratory of this kind is therefore able to carry out experiments on plant pathogens and pests that are not yet present in our region but which could become established in the future due to climate change. These research topics are currently being studied at LIST as part of the Horizon 2020 Virtigation project.

Our new laboratory therefore represents a valuable asset for generating new knowledge and sustainable solutions concerning agricultural pests in a changing environment. The next stage will be to test new biopesticides in the laboratory. These biopesticides to combat parasites and quarantine diseases are being developed in collaboration with the Green Tech Innovation Centre.

Matteo Ripamonti

Stan Schymanski

Success Story No. 3

BETTER FOREST MANAGEMENT IN THE FACE OF GLOBAL CHANGE

As part of the FNR Mobility project "Tracing rainfall through forest canopies into catchments" (TRAFIC), Professor Richard Keim (Louisiana State University) joined forces with LIST in 2022 in view of their common research interests, namely the response of forests to global change.

The main TRAFIC objective was to understand the mechanisms involved in conveying water through forest canopies into catchments. An initial tracker-assisted attempt (with stable isotopes of oxygen and hydrogen) to measure water flow routes and residence times in a forest canopy-soil linked continuum was carried out, in a pioneering way, in forests around the city of Luxembourg.

TRAFIC has provided new data and a process-driven understanding that will ultimately improve our ability to predict changes in how forests respond to climate change and to adapt forest management strategies accordingly.

4. DEVELOPING SMART SYSTEMS FOR A CLEAN ENERGY TRANSITION

> In the long term, the FlexBeAn project aims to contribute to the active participation of households, SMEs, industries and e-mobility actors in the energy transition by the active provision of flexibility to grid operators or energy market participants. This would help with the integration of distributed energy resources, such as renewable generation, e-mobility or heat pumps, and supports the economic optimisation of grid assets, to the benefits of society and economy.

Daniel KOSTER,
Lead Engineer

The energy transition will only be possible through a paradigm shift to achieve the European Union's ambitious objectives for carbon neutrality by 2050. This involves the implementation of more decentralised and cleaner energy technologies, which exploit the full potential of distributed resources. They will rely on renewable sources and storage solutions, as well as on the widespread use of digital technologies to fundamentally transform our design of these future energy systems.

The work carried out by LIST is part of a clean energy transition for Luxembourg and Europe. Consequently, our projects focus, amongst other things, on the simulation and optimisation of energy assets and electricity networks, the design of new energy markets and related services, in addition to development of distributed control systems and the combination of digital technologies with the automation of energy processing.

Success Story No. 1

MAKING E-MOBILITY IN THE ELECTRICITY NETWORK A REALITY

Luxembourg is increasingly dependent on renewable energy sources, which fluctuate more than traditional sources. The country is also facing other forms of consumption due to the decarbonisation of the heating and transport sectors. In fact, it is essential for its electricity network to adapt.

Encevo, a leading player in the field of sustainable energy in Luxembourg and the Greater Region, has signed a framework partnership agreement with LIST and the Interdisciplinary Centre for Security, Reliability and Trust (SnT) of the University of Luxembourg with the aim of uniting their innovative forces in order to speed up the transition to a sustainable energy landscape. The first project resulting from this partnership, entitled "Flexibility possibilities and user behaviour analysis" (FlexBeAn), focuses on smart networks.

In this partnership, LIST focuses on the areas of society and network flexibility. The objective is to implement an integrated model capable of assessing the flexibility of different sectors (households, industries, SMEs and in the field of e-mobility) in order to enable users to adapt their consumption in line with the overall demand for electricity on the network in the long term.

Daniel Koster

Pedro Rodriguez & Gregory Baltas

Success Story No. 2

USING ENERGY DIGITISATION AND ARTIFICIAL INTELLIGENCE TO ENSURE WE ADAPT TO RENEWABLE ENERGIES

The objective set by the European Union to be climate neutral by 2050 will have a profound effect on the energy sector, which will be increasingly reliant on distributed energy sources such as renewable energy sources, energy storage, electric vehicles and variable demands connected to distribution systems.

In the long term, operational planning decisions made by agents will no longer be sufficient to maintain the security and stability of distributed systems with increasingly variable operation. As a result, most decisions need to be made in situ and in real time based on the instantaneous data from the distributed networks.

In order to answer these questions, the new project "Learning Enabled Autonomous Real-Time Operation for Distribution Grids" (LEAP), funded by the National Research Fund (FNR), is providing innovative solutions based on cutting-edge technology such as machine learning, which is a key tool for carrying out the energy transition. The project will reveal new knowledge and methods in the fields of energy digitisation and artificial intelligence in order to ensure we adapt to the increasing use of renewable energies and the acceleration of the energy transition, with a view to long-term research.

Jun Cao

Success Story No. 3

COORDINATING THE LUXEMBOURG PILOT AGRIPHOTOVOLTAIC FARM WITH HYDROGEN STORAGE AND BATTERIES

Demonstrating innovative forms of storage and successfully operating them and integrating them into energy systems and innovative network architectures is essential to making the transition to clean energy.

The Horizon Europe project "Innovative Energy Storage Technologies towards Increased Renewables Integration and Efficient Operation" (I-STENTORE) obtained by LIST in 2022 examines the integration of various energy storage solutions and their combinations. Innovative storage systems will be presented and their cooperation with integrated assets will be co-optimised, with the final objective being to achieve reliability, energy quality, profitable exploitation and to maximise asset life.

LIST is the technical coordinator of the project. It is managing a demonstrator in Luxembourg to study the availability, robustness and security of several energy production and storage systems on an agriphotovoltaic farm (Agri-PV). The aim is to optimise the use of locally produced renewable resources in order to meet the needs of the farm, while at the same time supporting the operator's overall network. Within the framework of this demonstration, LIST is collaborating, in particular, with the Luxembourg companies European Dynamics and Green Power Storage Solutions.

5. DESIGNING STATE-OF-THE-ART TECHNOLOGY SOLUTIONS TO MEET DIGITAL NEEDS

> CON-NET will push back the frontiers of multilayer network visualisation to allow an end user to better understand the source and impact of online misbehaviour and misinformation.
>
> Fintan MC GEE,
> Senior Research and Technology Associate

Our world produces data at an unprecedented rate. Sensors are multiplying in number and collecting large amounts of data on the behaviour of individuals and groups, as well as on the functioning of machines and equipment and even environmental developments. LIST supports the digital transformation of our society and economy by focusing on the interaction between people, data, computers and the physical world.

LIST's research in the field of computer sciences combines the power of computers and human capabilities to make better, faster, fairer, more well-founded and reliable decisions. We study all systems, whether cyber, physical or social, in order to imagine, design, test and develop the next generation of technologies in a world where computers and humans work together harmoniously and on an equal basis to solve complex problems.

Fintan Mc Gee

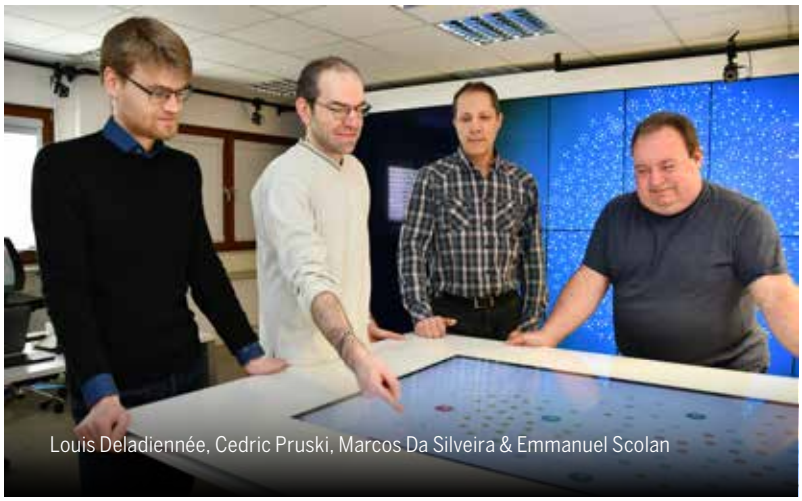
Success Story No. 1

UNDERSTANDING AND STOPPING THE SPREAD OF FAKE NEWS

The sharing of misleading information, whether out of context or completely false, and the banding together to coordinate action ("brigading") that accompanies it, alter the quality of the information we receive online, regardless of whether the bad behaviour was intentional.

Through the CON-NET project, LIST uses machine-learning techniques to process large quantities of data with the aim of identifying suspicious trends, signals and behaviour, as well as entities that are behaving badly. This approach is complemented by a visual analysis approach, including the human factor in the loop, in order to provide a context and understand the spread of misinformation online. In this way, we tackle the complexity of social media networks online.

The CON-NET project is funded within the framework of the CHIST-ERA programme and brings together a consortium of partners from all over Europe.



Louis Deladiennée, Cedric Pruski, Marcos Da Silveira & Emmanuel Scolan

Success Story No. 2

CREATING A KNOWLEDGE-SHARING PLATFORM FOR THE SPACE RESOURCES COMMUNITY

In May 2022, as part of Space Resources Week, LIST presented the knowledge-sharing platform of the space resources community. This data visualisation tool incorporates nearly 1,300 scientific publications. It will be supplemented over time with information, patents, books, press articles, legislative documents and even social media posts. The platform is accessible free of charge to the community involved in space resources upon registration.

This knowledge-sharing platform meets the community's needs and expectations and follows a survey conducted between April and July 2021. The survey revealed the great diversity of stakeholders in the space sector as well as its economic potential, linked to land-based activities such as mining, energy and even construction.

Benjamin Gateau

Success Story No. 3

DEVELOPING THE HUMAN DIGITAL TWIN

A digital twin is a virtual representation of physical systems (traffic, water, air, etc.) and physical assets (buildings, resources, etc.) that can perform simulations, tests and predictions of planned actions almost in real time. A twin is essentially used to obtain information about action in a simulated world before action is taken in the real world, which opens up enormous opportunities for companies, authorities and humans too.

In order to boost research on human digital twins, LIST is involved in two major projects. The first is the HORIZON Europe HealthyW8 project. Coordinated by the Luxembourg Institute of Health (LIH), it aims to promote a healthy lifestyle by using customised intervention portfolios with a view to preventing and controlling obesity during vulnerable stages of life.

The second is a project carried out in an association between the National Research Agency (ANR) in France and the National Research Fund (FNR) in Luxembourg. Named "AI for Cognitive Cyber-Physical Systems" (AI4C2PS) and coordinated by the Université de Lorraine (CRAM), it operates the digital twin concept in a decentralised way where each cyber-physical (CPS) and human system is twinned. The objective is to achieve an effective collaboration between man and machine by incorporating a cognitive level to promote an understanding and learning of one other's behaviour so as to adapt and respond accordingly.

6. DESIGNING THE NEXT GENERATION OF INTERCONNECTED DIGITAL SYSTEMS

> The results of the Secure5GeXP project have been welcomed by the Ministry of Economy, which supports the project. As a result, the Ministry has endorsed an extension of the current project and has encouraged a follow-up project between POST and LIST.
>
> Qiang TANG,
> Leader of the Trustworthy Data Systems Group

In Luxembourg, the high degree of network connectivity undoubtedly has a significant impact on the quality of the service provided, particularly in terms of communication speed. However, other factors must be taken into account in a value proposition associated with the services. These include, for example, data security, the user interface and the compliance of services with national and international regulations and standards. All these service qualities are based on both properties of the IT infrastructure used and aspects related to the quality of applications deployed on these infrastructures as well as on the organisational dimensions and the human skills needed to provide the services. At LIST, our teams combine information technology, networks and operational research to develop the next generation of interconnected digital systems based on reliable data and networks.

Success Story No. 1

DESIGNING A LEARNING SOLUTION TO DETECT ANOMALIES IN TELECOMMUNICATIONS NETWORKS

In close collaboration with POST within the framework of the Secure5GeXP project, LIST has developed a semi-supervised solution based on deep learning methods to enable the detection of anomalies in the central telecommunications network. The solution was validated with private data from POST as well as with simulated data created by LIST on the basis of an open-source simulator. POST continues to validate the solution before it is put into production.

The flagship field of research and innovation combining machine learning and cybersecurity was also boosted by the launch of the Horizon Europe LAZARUS project. It aims to solve many of the security problems faced by modern software during its development cycle.

Qiang Tang


Pascal Lhoas & Ion Turcanu

Success Story No. 2

BOOST TO CONNECTED AND AUTONOMOUS MOBILITY

LIST's activities in the field of connected and autonomous mobility produced successful results in 2022. Three projects were accepted for funding, the first by the European Commission (Horizon Europe) and the other two by the FNR (FNR BRIDGES and INTER ANR-FNR). These projects are at the interface between the world of network communications and mobility, facing very specific constraints and drawing on cross-disciplinary expertise from the IT for Innovative Services department, particularly concerning the digital twin.

During the year, other projects were carried out, in particular 5G-MOBIX (Horizon Europe) and PASCAL (Horizon Europe), both of which were designed to experiment with and test the limits of connected and autonomous mobility services in the future. The PASCAL project, coordinated by LIST and funded by the European Commission, aims, for example, to assess to what extent European citizens accept future connected and autonomous vehicles and does this by means of an interdisciplinary approach combining innovative tools in human and technological sciences.

Success Story No. 3

TRACKING THE TRANSPORT OF HAZARDOUS PRODUCTS THROUGH BLOCKCHAIN

LIST has developed several applications that allow the innovative use of blockchain, in particular the transport of hazardous goods in cross-border scenarios.

Within the framework of the DG-Sec project, funded by Erasmus+, LIST has worked on using blockchain and connected objects (IoT) to track the transport of hazardous products. We have a web-based simulation interface, which interacts with intelligent contracts on two different blockchain technologies, with the aim of storing the different stages of transport in transactions.


Thierry Grandjean, Damien Nicolas & Oussema Gharsallaoui

Success Story No. 4

SERVING RENEWABLE ENERGY COMMUNITIES, THANKS TO WESHAREENERGY SOFTWARE

LIST has developed "We Share Energy", a multi-platform simulation software designed to serve renewable energy communities as part of a collaborative project with the Luxembourg Regulatory Institute (ILR) called Smart Electricity.

Part of this project was to develop an energy community simulator. Under the impetus of the European Union, the Member States must allow citizens to form "energy communities", i.e. to meet as a group of electricity consumers and producers and exchange their electricity to reduce each member's consumption.

WeShareEnergy is therefore a tool enabling every Luxembourg citizen to simulate such an energy community and to see its benefits according to the members invited, the electricity-sharing rules and each member's behaviour. These energy communities will play a significant role in the great challenge posed by the energy transition in the future.


Jocelyn Aubert

5G: OPENING UP A RANGE OF NEW POSSIBILITIES

> While our teams are already working on the sixth generation of mobile networks (6G) and thinking about the applications of the next decade, it is crucial not to lose sight of the current generation, i.e. 5G, which is already perceived less clearly by the public and companies than it was in the past. 5G-PLANET is a great example of a project that has led to the creation of concrete, tangible demonstrators, showing the R&D challenges we face and proving the value of using these advanced communication technologies, particularly in the field of mobility.

Sébastien FAYE
6G Technology & Innovation Line Manager

5G opens up new possibilities but it also creates a sense of uncertainty among the population. The introduction of the new generation of 5G mobile telephony a few years ago raised a number of questions among the population and even caused some confusion.

What is 5G? How does it compare to other technologies? What is the impact of 5G on the performance of mobility compared to other communication technologies? What are its capabilities and limitations?

In this case, research has the means to answer these questions scientifically and to therefore provide reassurance.

Success story

EXPLAINING 5G AND DEMONSTRATING ITS POTENTIAL IN LUXEMBOURG

Thanks to the 5G-PLANET project, regular major communication exercises were carried out by LIST throughout the year. Funded by the Luxembourg government's media, connectivity and digital policy department (SMC), this project has led to major dissemination activities. In particular, it has led to the development of three demonstrators, which are all based on technologies used by LIST in its mobile network research and development activities. The 5G-PLANET project also made it possible to raise public awareness using the digital twin concept, in other words by recreating a digital copy of part of Luxembourg's 5G infrastructure, which was then used to demonstrate the potential of 5G in Luxembourg.

Important partnerships have also been formed, in particular with Telindus, which has signed a collaboration agreement to further stimulate the development of business. These initiatives are in line with the digital innovation hub's overall approach and help to convey a positive message: research and innovation as a means of testing and understanding before investing!

Sébastien Faye

DIGITAL UPSKILLING: PREPARING THE LABOUR MARKET FOR THE SKILLS OF TOMORROW

The digital and green transitions have led to an increased demand for certain skills, thereby exacerbating structural shortages.

It is expected that the transformations in the labour market due to automation, digitisation and the ecological transition will lead to a greater actual relocation of economic activity and demand for skills between industries and professions.

Success story

CREATING A DYNAMIC BETWEEN TECHNOLOGY AND SKILLS IN THE LABOUR MARKET

The FNR Initiate UPSKILL project, coordinated by the Luxembourg Institute of Socio-Economic Research, is at the intersection of a threefold challenge: the necessary green transition, the competitive and socially harmonious digital transformation of the economy and the adequate and proactive upskilling and retraining of the workforce. This project contributes to cutting-edge research and provides practical solutions to promote responsible and sustainable development for Luxembourg.

This project responds to an urgent need for knowledge about the dynamic between technological innovation and skills in the Luxembourg and European labour markets. In order to close this gap, decision-makers must have tools in place to enable them to meet the challenges regarding employment and skills. The future Skills Observatory platform will provide up-to-date information on skill requirements as well as tools and strategies to increase the benefits and adaptability of the labour market.

In addition, the Skills Observatory will provide guidance to political decision-makers and stakeholders in the development of programmes for vocational education, development and retraining for job applicants and the workforce in general, with the aim of pre-empting the skills deficit, supporting economic groups and preventing unemployment. By 2024, UPSKILL aims to launch a new National Centre of Excellence in Research (NCER) to meet the challenges identified with all the stakeholders involved in Luxembourg and in the Greater Region.

Marie Gallais

> “In collaboration with the Luxembourg Institute of Socio-Economic Research (LISER), the Upskill project paves the way to a future large-scale research project aiming to develop a platform for skills data and forecasting, and policy support, as part of digital and green transitions.”

Marie GALLAIS
Leader of the Human Modelling and Knowledge & Engineering Group

7. DESIGNING THE NEXT GENERATION OF COMPOSITE MATERIALS

> Our project focuses on implementing surface treatment techniques to enhance the compatibility between bamboo fibres and the matrix. By addressing concerns such as thermal degradation and facilitating self-healing capabilities, we aim to significantly improve the mechanical properties of bamboo fibre composites. This research endeavor not only expands the range of polymers suitable for bamboo fibres but also extends their applications, particularly in wet environments. Through these advancements, we anticipate bolstering the market position of bamboo fibres and creating opportunities for exploration in new market segments.

Levent KIRKAYAK,
Head of the Structural Composites Unit

Composite materials are difficult to reuse or recycle because the available technologies, such as high-temperature pyrolysis and grinding (to be used as a filling material), are not environmentally friendly or economically viable. Furthermore, environmental legislation on the recycling of end-of-life components and structures means that from 2025, for example, 80,000 tonnes of fibre-reinforced polymer composites will have to be recycled every year in Europe.

LIST aims to develop the next generation of composite materials, with a focus on their sustainability and recycling, while maintaining unparalleled performance in terms of weight/mechanical properties. We study all the constituent parts of a composite material, ranging from structure and synthesis to the engineering of raw materials through to the complete manufacture of composite structures, including design optimisation and functional tests. The combined use of advanced modelling and experimentation makes it possible to speed up the definition and implementation of a sustainable-by-design approach for these composite materials that are better and more sustainable.

Success Story No. 1

DECARBONISATION OF THE AUTOMOTIVE INDUSTRY THANKS TO BAMBOO SUPER FIBRES

Due to their exceptional mechanical qualities, the main materials used today to strengthen polymer composites are glass fibre and carbon fibre. However, these fibres are hard to recycle, non-biodegradable and have a large carbon footprint.

Natural fibres such as bamboo, flax or hemp are alternative resources that can be used as strengthening materials. Several studies come to the conclusion that these natural fibres, particularly bamboo, are environmentally superior to synthetic fibres at each stage of the composite material life cycle.

Carlos Fuentes Rojas

Signing of the partnership with Daher

Success Story No. 2

OPTIMISING THERMOPLASTIC COMPOSITE WELDING TECHNOLOGY

Daher, a company specialising in the aeronautical industry, and LIST have entered into a major partnership aimed at optimising welding technology for the assembly of primary aircraft substructures based on thermoplastic composites. The three-year bilateral agreement focuses on infrared welding technology suitable for large, thick parts and intended to revolutionise the industrial manufacture of high-quality structural parts.

Thermoplastic composites are increasingly used in the aerospace industry because of their lightness, mechanical strength and ability to be welded. Another advantage is that they require less energy than rival composite materials and have the enormous advantage of being recyclable.

The application of this technology will expand the welding solutions for thermoplastic composites offered by Daher and KVE Composites, a Dutch company specialising in the design, manufacture and assembly of high-performance thermoplastic composites. The partnership benefits from Daher's expertise as a designer and manufacturer of aerostructures as well as LIST's expertise in materials science and process development.

Success Story No. 3

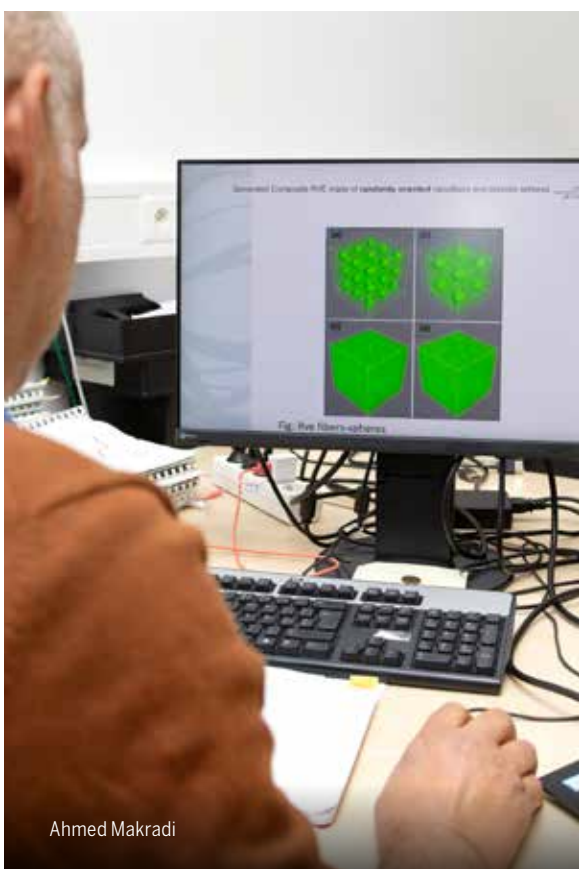
ADVANCES IN MONITORING THE STRUCTURAL HEALTH OF CERAMICS

Within the framework of a European project (M-era.Net CENTAUR), LIST's work has focused on creating ceramic matrix materials reinforced with short or continuous fibres, which are suitable for the 3D printing extrusion process.

The micromechanical models that have been developed aim to accurately predict the effective elastic properties and electrical conductivity of ceramic matrix composites in 3D printing as well as the damage produced in these composites.

LIST researchers have developed a unique mechanical extraction technology to obtain long bamboo fibres without damaging them as well as a process to obtain high-performance cellulose microfibres from bamboo fibres.

Transformed in this way, the bamboo super fibres have excellent tensile strength exceeding the mechanical properties of glass fibre and all other natural fibres. These results offer an alternative way to speed up the sustainable generation of long-fibre-reinforced polymer composites needed for key sectors such as the automotive and aviation industries.


Ahmed Makradi

AN INNOVATION CENTRE FOR COMPOSITE MATERIALS AND PROCESSES

In Luxembourg, the transport sector is the largest emitter of greenhouse gases, accounting for more than 60% of total emissions. As part of the European effort to reach the net zero emissions target by 2050, each country must present its own road map to substantially reduce its emissions. In this context, the Luxembourg government can rely on LIST, one of LIST's proposals being to develop composite materials with a very low carbon footprint and to demonstrate their benefits for the transport sector by means of demonstrators of specific applications for the automotive, rail, space, aeronautical and future urban air mobility sectors.

> "Airbus is very honoured and pleased to support the SCMM Innovation Centre. Highly skilled staff and state-of-the-art equipment are providing a perfect platform for shared research efforts which have already been launched in an ambitious timeframe. We are fully convinced that LIST will provide innovative and sustainable solutions for our future challenges, e.g. in the technology fields of Aircraft Interior Structures or Advanced Composites Processing for Zero Emission applications."
>
> Christian RÜCKERT
> Head of R&T Materials & Processes, Airbus

Success story

A NEW INNOVATION CENTRE FOR ZERO EMISSION MOBILITY

In December 2022, LIST opened the Sustainable Composite Materials & Manufacturing Innovation Centre (SCMM IC). The initiative focuses its research and innovative development priorities on the challenges faced by the transport sector in the search for zero emission mobility solutions. The aim of the innovation centre is to speed up the use of materials and processes with a low carbon footprint for functional composite parts that will meet the needs of the vehicles of the future.

To this end, innovative technological bricks of materials, for example biosourced and/or recyclable materials as well as efficient manufacturing and recycling processes, will be integrated into highly relevant demonstrators aligned with the vision of major industrial leaders, their equipment manufacturers and major suppliers in the automotive, rail, space and aeronautical sectors, not forgetting the emergence of urban air mobility.

The centre proposes an effective approach allowing for a rapid transition of research results to the real economy by bringing together, in an ambitious innovation programme, end users (OEM), national and international operators along the entire composite value chain and LIST researchers.

The initiative involves four major players in European transport, namely Toyota, Airbus, Thales Alenia Space and Alstom, who share their critical needs to enable the medium-term marketing of ultralight, recyclable and low-carbon vehicles.

This innovation programme will initially last four years with a budget of more than 16 million euros, co-funded by LIST, the Ministry of Research and Higher Education, the Ministry of the Economy and active members from industry. In particular, it will include an investment of 3 million euros from LIST for new industrial technologies to complement the composite platform provided by the Materials Department.

Inauguration of the Sustainable Composite Materials & Manufacturing innovation centre

Henri Perrin & Masoud Bodaghi

8. USING FUNCTIONAL POLYMERS AS A FORCE FOR INNOVATION

> The new high-performance polymers we have created offer numerous possibilities for application in the development of composite materials used in the automotive, aerospace, and space industries.

Pierre VERGE
Lead Research and Technology Associate

Functional polymers are derived from macromolecules that have unique properties. They are generally inexpensive and easy to synthesise. Polymer manufacturing technology facilitates the free transformation of molecular structures of organic compounds, opening up a field of possibilities.

At LIST, we are working on the synthesis, formulation and processing of polymers in order to obtain improved specific properties and multi-functionality through experimental and digital approaches based on polymer chemistry and physics, including molecular modelling. Our research is based on two priorities: the production of sustainable polymer materials, mainly from industrial or agricultural residues, and the physics and chemistry of smart/reactive polymers.

Success Story No. 1

CREATING A NEW FAMILY OF POLYMER MATERIALS

A new family of polymer electrolytes has been created thanks to the support of an INTER grant from the National Research Fund (FNR) within the framework of the DISAFECAP project (Safe Solid-State Supercapacitors using Dynamic Ion Gels from Poly(ionic Liquids)), in cooperation with two French partner universities (CY Cergy Paris University and Lyon University 1).

This new family of polymer materials called dynamic ion gels is obtained by combining polymers and oppositely charged silica nanoparticles. This process leads to the creation of robust polymers with self-healing properties and high ionic conductivity.

Dhahabia Abdallah Boina

Samet Ozyigit, Célia Ziane, Charles Jehl, Killian Bourdon, Daniel Schmidt & Vincent Boulic (absents : Channya Hesse, Carlos Ivan Cardona Garcia)

Success Story No. 2

NINE PHD STUDENTS TO DEVELOP A NEW GENERATION OF SUSTAINABLE POLYMER COMPOSITES

Our aim is to develop a new generation of sustainable polymer composites based on recyclable resins and renewable and/or recycled fibres. The envisaged materials should not only be recyclable but also processable and repairable, while retaining the attractive characteristics of existing high-performance composites. With this in mind, we are coordinating a doctoral study research programme co-funded by the National Research Fund's (FNR) PRIDE programme.

The thesis topics range from the computerised and experimental design of new resins to the implementation of recycling processes, as well as the use of organic raw materials and the implementation of design strategies facilitating the repair and reuse of end products. This effort will generate the new fundamental knowledge needed to put these results into practice as well as creating a new generation of researchers in the critical field of sustainable plastic and composite technologies.

Success Story No. 3

THE MOVE TOWARDS SAFE, CONVENIENT AND POWERFUL LITHIUM-ION BATTERIES

LIST has developed two families of new high-performance ionic conductive polymer materials (polymer electrolytes). The first family consists of single block copolymers containing chemically related anions and mobile cations. In these materials, the uncharged blocks ensure rigidity up to high temperatures and make the material mechanically strong, while the charged blocks ensure the transport of low-strength ions. The resulting conductive block copolymers provide an attractive combination of mechanical/thermal stability and high ionic conductivity, making them a particularly appealing option for electrical energy storage applications.

In cooperation with Politecnico di Torino University (Italy), these copolymers have been used as a solid electrolyte base for safer lithium batteries.

Daniil Nosov & Alexander Shaplov

9. DEVELOPING NEW MULTI-FUNCTIONAL NANOPARTICLES

> Our study builds upon the knowledge acquired and published in our previous articles, and presents for the first time the synthesis of a regio-selectively modified dendritic silica particle and its impact on tire tread rubber silica nanocomposite. Within this work, We have outperformed the classical rubber / silica model composites and have paved the way for decreasing rolling resistance and improving grip of the next generation of tire.
>
> Jean-Sébastien THOMANN,
> Leader of the Powder and Colloids Engineering Group

Nanomaterials have special properties related to their size and nanometric structure. This makes them of great interest because of their strong potential to create new innovative products in many areas.

At LIST, we are developing new multifunctional nanoparticles for our partners. We are working on the technological development of materials controlled at the nanometric level, which, combined with an innovative chemistry of these same materials, makes it possible to demonstrate properties that are all the more remarkable as they are integrated into functional devices.

Success Story No. 1

A NANOPARTICLE PAVES THE WAY FOR THE NEXT GENERATION OF TYRES

In collaboration with Goodyear, LIST has revisited the tyre tread skeleton called the silica percolation network. Using a new modified dendritic silica nanoparticle, LIST achieved better results than conventional rubber/silica nanocomposites and paved the way for the next generation of tyres with better traction and lower rolling resistance.

The application of such a charging system for the reinforcement of tyre rubber opens up new prospects for the design of tyres with low rolling resistance and competitive traction together with sustainable performance. This study was published in the Chemical Engineering Journal and the particles are patented.

Jean-Sébastien Thomann

Resmi Anand & Lise Innocent

Success Story No. 2

LIGNIN IN ANTIBACTERIAL ADDITIVES

Lignin, which is present in most vascular plants and in a few algae, is of interest to researchers mainly because of concerns about the environment and limited oil resources. It has so far been considered as waste in the production of paper pulp and burned to produce energy. The structure, properties and types of lignin depend on their source and extraction process.

LIST's research has led to a description of how the fundamental understanding of nanoprecipitation of polymer nanoparticles makes it possible to modulate the mechanical, optical and thermal stability of biosourced nanoplastics made from renewable and unused resources, including lignin. These particles are currently being developed to reinforce elastomers, as an antibacterial additive for composites and as anti-ageing capsules in cosmetics. This study has been published in Journal of Colloids and Interfaces Science and the particles are patented.

Success Story No. 3

DEVELOPING CONTRAST AGENT NANOPARTICLES USED IN ULTRASOUND

While developing "green" chemical processes, one of our studies demonstrated the synthesis and stabilisation of amorphous calcium carbonate nanoparticles thanks to green processes and stabilisers. These particles may be used in medical technology as contrast agents in ultrasound. The study was published in Royal Society of Chemistry Green Chemistry and the particles are patented.

SIX YEARS OF A WINNING PARTNERSHIP WITH GOODYEAR

> The partnership with LIST has really been vital to Goodyear enabling mobility and I look forward to seeing how we continue to grow together and innovate responsibly and sustainably.
>
> Chris HELSEL,
> Senior Vice President Global Operations and Chief Technology Officer chez Goodyear

Over the past six years, LIST and Goodyear have collaborated to achieve significant results in the fields of materials research, in the understanding of structure-property relationships and in data science.

TOP RESULTS

Launched in 2017, the largest public-private partnership to have been formed in Luxembourg with a budget of around 50 million euros has led to impressive results in science and technology in the fields of materials and data science for tyres: 13 achievements in the field of data science, 15 developments in new materials, 94 scientific publications and conference contributions as well as 17 trade secrets and 14 patents.

These achievements have been implemented in the day-to-day operations of Goodyear and LIST in various fields. For example, Goodyear has deployed a decision-making solution for virtual tyre design including the software and licence, a data-based tyre development process, wear prediction and leak detection algorithm solutions for tyre intelligence, many new analytical capabilities of materials and a new approach to optimising the type and quantity of resins, helping to secure the supply of raw materials. Our partner is also considering using biosourced charges (lignin and cellulose) resulting from tests carried out within the partnership and integrating them into high-value-added products.

Xavier Fraipont, Vice President, Product Development EMEA, Goodyear

Signing of a new agreement on TechDay 2022

MAKING LUXEMBOURG A GROUND-BREAKING CENTRE OF INNOVATION IN THE FIELD OF MOBILITY

Supported by the Ministry of the Economy, this research collaboration has further shaped LIST's profile as a high-level research and technology organisation and has helped Goodyear to secure its position as a market leader in the development and manufacture of tyres.

The National Research Fund (FNR) has supported this collaboration in the field of materials technologies through the Industrial Partnership Block Grant (IPBG). During the final review, the FNR group of experts carefully assessed the results and stated that this partnership "has helped make Luxembourg a ground-breaking centre of innovation in the field of mobility, with a focus on tyres and tyre-related technologies". After completing their work under the aegis of the Goodyear-LIST partnership, we are proud to be able to write that more than 80% of PhD and post-doctoral students found a job within a few weeks of their contract ending, half of them in Luxembourg.

A NEW AND EVEN BROADER STRATEGIC AGREEMENT

Based on the success of the first partnership, a second strategic partnership is being prepared, taking into account socio-economic priorities and extending the scope of collaboration to additional areas of research. The development of virtual products, process digitisation and tyre intelligence will be additional areas of research in the data science category. The new generation of "green" tyres, "airless" tyres and the re-using of tyres at the end of their life will be additional areas for the development of materials and specific characterisation. LIST and Goodyear signed a memorandum of understanding at LIST Tech Day on 15 June in the presence of the Minister of the Economy Franz Fayot.

Marc Angotti, Daniel Schmidt, Jean-Sébastien Thomann, Jean Di Martino, David Ruch & Benoît Otjacques

10. INCREASING OUR INTERNATIONAL INFLUENCE IN THE FIELD OF NANOTECHNOLOGY

> The technology we investigate has the potential to make use of silicon carbide semiconductor foundries to produce quantum chips at large scales and cheap costs.
>
> Florian KAISER,
> Leader of the Quantum Materials Group

Nanotechnology can have a significant impact on society. It is already being used, for example, in the information and communications sectors. Detection of gas or (bio)molecules, mechanical or vibratory deformation, ambient energy recovery, storage and use; these are just some examples of the extraordinary properties made possible by nanotechnology.

LIST is working on the technological development of materials controlled at the nanometric scale and demonstrates their remarkable features by integrating these advanced materials into innovative devices. During the year, we boosted our initiatives by welcoming an internationally renowned researcher and increased our influence in the field of nanotechnology.

Success Story No. 1

A STEP TOWARDS LUXEMBOURG'S FIRST QUANTUM COMPUTER

In 2022, LIST welcomed Florian Kaiser, whose mission is to create a new materials research group for quantum computing. Florian previously held the post of assistant professor at the University of Stuttgart.

Over the next five years, the overall objective is to demonstrate the generation, manipulation and use of the qubits needed to demonstrate the first quantum computing originating from Luxembourg technology. The technology studied has the potential to generate more than ten qubits interlinked by a basic device drawing on the atomically controlled silicon vacancy on ultra-high-purity substrates.

This technology will be developed under the responsibility of Florian Kaiser, one of the world's experts in this technology.

Florian Kaiser

Success Story No. 2

SEVEN PHD STUDENTS SUCCESSFULLY DEFENDED THEIR PHD THESIS

From the largest doctoral training unit in the FNR PRIDE programme, seven PhD students successfully defended their thesis in 2022. Nikhar Khanna, Rutuja Bhusari, Tairan Francisco da Cunha, Sangitta Dutta, Alvar Torello, Naveen Aruchamy and Youri Nouchokgwe have been awarded the degree of "Doctor of the University of Luxembourg".

These researchers have demonstrated scientific and technological excellence with articles published in the best journals (Nature, Science, Nature Materials, Nature Communications) and three patents filed. After Tai Nguyen in 2021, Alvar Torello from the PRIDE MASSENA programme won the prestigious Laval Prize from the University of Luxembourg, which rewards an exceptional achievement in the field of electrical engineering.

Success Story No. 3

A LIST PHYSICIST ELECTED FELLOW OF THE AMERICAN PHYSICAL SOCIETY

Dr Jorge Iñiguez, a scientific expert from LIST's Materials Research and Technology (MRT) department, has been elected to the prestigious rank of Fellow of the American Physical Society (APS). This distinction rewards his "revolutionary contributions to the computational theory of ferroelectric and multiferroic materials".


Jorge Iñiguez

11. PUSHING THE BOUNDARIES OF SCIENTIFIC INSTRUMENTATION

> We have successfully demonstrated a methodology to link the nanoscale chemical evolution of reactive interfaces with the electrochemical properties of batteries.
>
> Santhana ESWARA MOORTHY,
> Lead Research and Technology Associate

At the intersection of action and knowledge, scientific instrumentation appears to be the embodiment of ongoing research. It keeps track of practices, know-how and knowledge that bear true witness to the scientific process.

We are passionate about speed, spatial resolution, atomic sensitivity and complex and dynamic data analysis. At LIST, our objective is to develop new instruments, processes and methodologies in the fields of plasma science and technology, thin-layer processing and nanoanalysis.

Success Story No. 1

CREATING UNIQUE NANO-ANALYTICAL TECHNIQUES IN BATTERIES

The development of efficient and safe energy storage technologies is essential in order to speed up the transition to sustainable and clean energy. Although lithium-ion batteries are now ubiquitous in everyday life, many nanoscale mechanisms underpinning how these batteries work are not yet fully understood. Knowledge of nanometric mechanisms such as transport and transfer of charges occurring at the internal battery interfaces will be useful in mitigating degradation processes and significantly improving the efficiency, safety and sustainability of these storage devices.

Investigating local electrochemistry on a nanometric scale in batteries during operation is a challenge that the battery research community is currently facing. To further develop tools and methods of analysis, including machine learning approaches for battery characterisation, an international research team led by LIST has received funding of EUR 5 million from the European Union and an additional EUR 700,000 from Switzerland.

Luca Cressa & Santhana Eswara Moorthy

Nicolas Boscher

Success Story No. 2

TURNING INDUSTRIAL DYES INTO ADVANCED MATERIALS

Within the framework of a European Commission Horizon 2020 project via the Marie Skłodowska-Curie Actions work programme, LIST has successfully developed thin functional polymer films from affordable industrial dyes. The synthesis of thin polymer films was carried out directly from the gas phase, allowing their molecular engineering and direct integration for practical applications. In particular, our researchers' discoveries in this project have made it possible to improve the photoactivity of thin films of polymer catalyst.

Success Story No. 3

EXPLORING NEW AREAS IN TERMS OF FUNCTIONALITY, SYNTHESIS AND CHARACTERISATION OF MATERIALS

LIST aims to create materials platforms integrating synthesis and characterisation, to develop pilot systems, collect engineering data sets, develop machine-learning algorithms and discover new materials to meet critical challenges.

The resulting data-driven discovery platforms will take advantage of LIST's capabilities to explore new areas in terms of functionality, synthesis and characterisation of materials. Examples of applications include the prediction of material properties, such as thermal conductivity, in order to design better insulators, the analysis of experimental data, for example mass spectrometry for structure elucidation and the optimisation of process parameters, in particular for the chemical/physical deposition process in the vapour or electrochemical phase.

Matthias Rupp

USING GREEN HYDROGEN TO COMPLETE THE FINAL STAGES OF DECARBONISATION

The production of green hydrogen from renewable energy is essential in order to facilitate a gradual transition towards a clean hydrogen economy and a more sustainable and intelligent energy mix.

At LIST, our aim is to use and coordinate our expertise to develop alternatives to variable renewable energy that consumes scarce land resources and to train future research engineers in the most advanced energy transition technologies.

> "The principle of electricity production by a chaotic trajectory pendulum system was validated and proved in the environment of the wave pool of the Thermes in Strassen. These results made it possible to validate a first level of performance of a 1/6th scale technological demonstrator incorporating an electrolyser for the in situ production of hydrogen. The system at scale 1 will aim for autonomous operation in a marine environment."

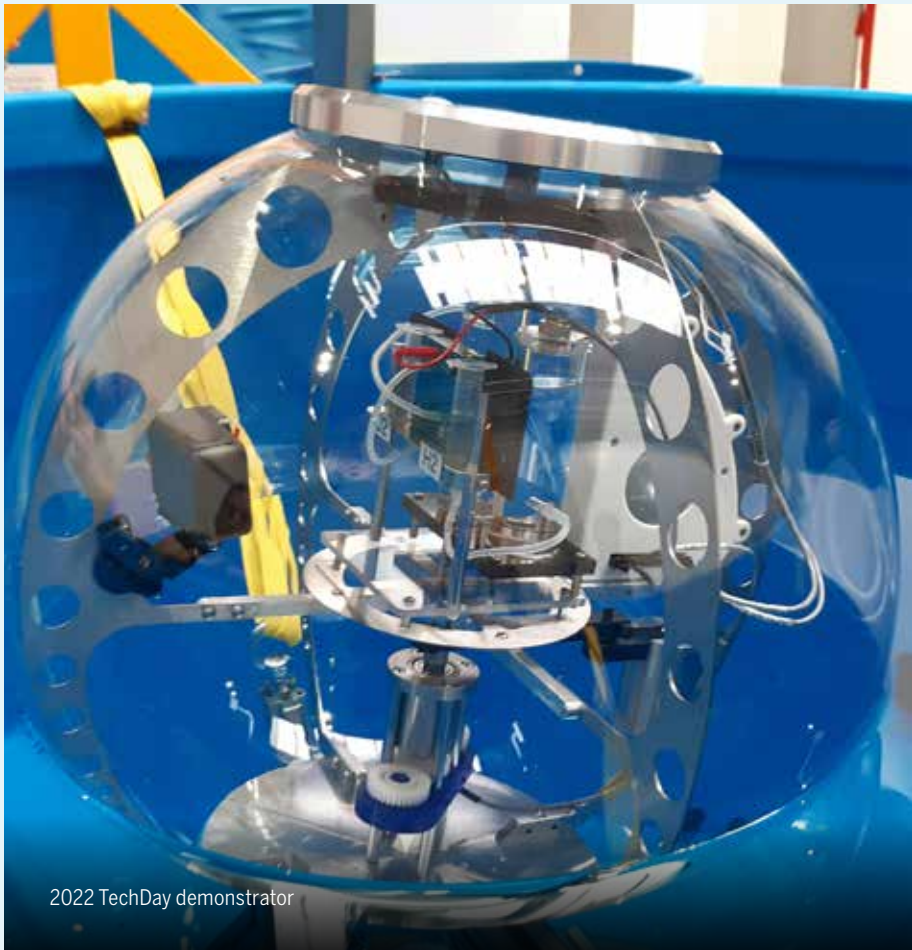
Jérôme POLESEL,
Technology & Innovation Manager

Success Story No. 1

PRODUCING GREEN HYDROGEN THANKS TO WAVE MOVEMENT

LIST has developed a proprietary technology providing freedom from the intermittent nature of variable renewable energy, such as solar and wind power, but from ocean's waves as a source of electricity in the water electrolysis process. This proof of concept has strong economic potential with regard to hydrogen production costs, while minimising the strategic dependence on critical metals and scarce land resources used in variable renewable energy.

This device was exhibited to local industrial stakeholders at the TechDay at the Maison des Arts et des Etudiants in Belval on 15 June 2022. It aims to convince local players of the robustness of the technology in order to move towards the next stage of a full-scale demonstrator in the marine environment. A recent visit by politic players has already enabled us to discuss the potential of this technology "made in LIST".



2022 TechDay demonstrator

Drialys Cardenas Morcoso

Success Story No. 2

TRAINING THE NEXT GENERATION OF RESEARCHERS IN FUNCTIONAL MATERIALS

As a doctoral training unit (DTU) funded by the National Research Fund via the PRIDE programme, HYMAT is training the next generation of PhD students in the functional materials used in hydrogen-related technologies. The cohort of eight PhD students, supervised by eight experienced LIST scientists, has access to the Institute's state-of-the-art infrastructure. In its current form, HYMAT provides the framework and resources to coordinate an interdisciplinary training programme to train future research engineers in the most advanced energy transition technologies.

The HYMAT programme draws on existing expertise and synergies within LIST to address the challenges associated with clean hydrogen production and use. LIST researchers are studying the main challenges of the strategic materials required for the specific technologies to underpin a sustainable and competitive hydrogen economy..

12. ACCELERATING THE USE OF SPACE RESOURCES

> We are convinced that innovation and great results come from diverse thinking and that different points of view are essential in our journey to becoming an international point of reference in the field of space resources.
>
> Kathryn HADLER
> Director, European Space Resources Innovation Centre (ESRIC)

Interest in space resources is constantly increasing and activity in this sector is growing. The field of space resources is vast but mainly focuses on using resources found on the moon, Mars and beyond to support space exploration and a new space economy. The objective is now to actively contribute to developing a sustainable ecosystem of space resources and to identify opportunities for transferring new concepts, technologies and services to Earth.

LIST now occupies a prominent place at the heart of this new European ecosystem. We have the benefit of high visibility and play a key role in the community with the ambition of becoming a centre of excellence.

We support this sector by conducting R&D activities relevant to industry, training the next generation of innovative players in the field of space resources and developing sustainable methods and solutions.

Success Story No. 1

ACCELERATING RESEARCH ACTIVITIES IN THE FIELD OF SPACE

Research work in the field of space grew considerably at LIST in 2022. Several projects have been launched, notably in the form of a partnership with well-known companies such as Airbus and AirLiquide and the Luxembourg start-up MaanaElectric. Backed by a PEARL Chair from the National Research Fund (FNR), with a budget of EUR 3.7 million over five years, Kathryn Hadler took charge of the European Space Resources Innovation Centre (ESRIC), the world's first innovation centre dedicated entirely to space resources. This internationally renowned scientist in the field of mineral processing and beneficiation is now in charge of the centre's development, supported by a research group focusing on the sustainable and responsible use of space resources.

LIST received a demonstration device from the European Space Agency (ESA), called Alchemist. This enables researchers to understand and improve the process of producing oxygen from lunar soil. It will be joined by other demonstrators and research infrastructures in 2023.

Kathryn Hadler & Ainur Yerzhankyzy

First ESRIC Start-up Support Programme

Success Story No. 2

INCUBATING COMPANIES SPECIALISING IN SPACE RESOURCES THROUGH THE ESRIC PROGRAMME

Within LIST, one of the main activities of the European Space Resources Innovation Centre (ESRIC) is to support the emerging commercial sector in the field of space resources. In 2022, the world's first business incubation programme completely dedicated to space resources was launched. The start-up support programme, resulting from a collaboration between ESRIC, Technoport and the European Space Agency (ESA), incubated the first five start-ups selected in the first half of 2022 following an open call for applications. After three months of preparation, one start-up was selected for two additional years of incubation. This is the Polish company Four Point. The company will establish a branch in Luxembourg at the start of 2023 and is currently based at Technoport. It will benefit from additional technical and commercial support and funding of up to EUR 200,000 for its activities.

In addition to this first selection, the programme has greatly benefited the ecosystem itself, leading to the creation of partnerships between the five start-ups.

Success Story No. 3

GETTING TO THE MOON WITH THE FIRST ESA-ESRIC SPACE RESOURCES CHALLENGE

Space resources are a key element in further space exploration. Identifying resources of interest, such as water, is also an essential part of the journey. In collaboration with our colleagues from the European Space Agency (ESA), we developed the first ESA-ESRIC Space Resources Challenge. This competition, which aims to drive innovation, was open to teams from all ESA Member States with the prize of a contract to develop the presented technology.

A first round of the competition was held in the Netherlands in 2021 and was used to select five teams for the final held at Rockhal in September 2022. For this occasion, Rockhal was transformed into a temporary lunar surface, with "lunar" dust, craters and a landing craft. The five teams competed throughout the week to map an area of the "Moon". On the last day, the site was opened to industry, guests and schoolchildren who had participated in a prize draw. At the end of the challenge, the winning team signed a partnership agreement with ESA and is now continuing to develop its technology related to the moon.


The ESRIC team


Space Resources Challenge 2022

Success Story No. 4

A GROWING TEAM - DIVERSITY AND GENDER BALANCE

Established in 2020, the team at the European Space Resources Innovation Centre (ESRIC) continued to grow in 2022. In April, the new Director, Kathryn Hadler, took up her post and was soon joined by several other colleagues. Currently made up of 16 people, ESRIC is proud to include experts from all over the world, bringing together knowledge and skills from the United Kingdom, Germany, Spain, France, Croatia, Italy, Romania, Mexico, Canada, Kazakhstan, India and Luxembourg. In addition to this cultural diversity, ESRIC has achieved a gender balance between men and women of 44%.

OUR NEW RESEARCH INFRASTRUCTURES

FOCUS ON KEY INFRASTRUCTURES

Our state-of-the-art infrastructure is one of LIST's main assets: the diversity and quality of equipment is a real added value for our researchers as well as for our partners who can pool their equipment in order to reduce costs and speed up their innovation agendas.

In 2022, LIST continued its work to expand and reorganise research and technology infrastructures:

Physical vapour deposition laboratory

IN HAUTCHARAGE

- The first extension work began in February in an industrial building with an area of approximately 3,400 m² close to our first laboratories. The installation of an 18-metre long piece of equipment used to perform physical vapour deposition (or PVD) has begun. It will be operational in mid-2023.
- Right next to it, the fitting-out of 1350 m2 of laboratories for the Environment Department must be arranged to accommodate bioreactors with volumes of up to 300 litres, which are closer to our partners' needs. Not far from this, new offices and two new meeting rooms have been set up by LIST in a building located on the site. Two research teams were able to invest in the premises.


ESRIC laboratory

IN BELVAUX

- The Advanced characterisation platform is now equipped with transmission electron microscopy (TEM), which uses an electron beam "transmitted" through a very thin sample to generate a highly magnified image. At the same time, CEBI and LIST have joined forces and combined their skills to create the first national characterisation and testing platform in order to provide a unique framework offering comprehensive services for Luxembourg and beyond.
- The building now accommodates a new laboratory for the innovative FRAGOLA (FRequency AGile Optical LAttices) project on the development of laser diagnostics and photonic applications.
- ESRIC laboratories have taken shape a bit more with the arrival of a few machines and some technical work, the new LIST department which is interested in using space resources should soon be able to take full possession of the area covering 150 m².
- Finally, a real-time simulation laboratory with hardware-in-loop (RT-HIL) capability and a laboratory to continue fungicide tests have been set up.


Transmission electron microscopy

IN BELVAL

- A laboratory dedicated to 6G has been set up. It is linked to future wireless network technologies and applications. Its main objective is to build an open 6G network digital twin in the coming years, serving as an interface between research and industry in the EU and Luxembourg. In the same building, the new mixed reality laboratory enables researchers to develop new augmented and virtual reality technologies. The laboratory includes an 3D positioning system that also allows interaction between real-world objects and digital worlds..


New 5G and 6G laboratory


New mixed reality laboratory

OUR COLLABORATIONS

TESTIMONIALS

"The advantage of working with a partner like LIST is that the approach is different because a research partner, unlike a supplier, is interested in long term results and their main motivation is not making commercial benefit. This relieves a little bit of a pressure on our side. And due to the fact that there's a large variety of specialists at LIST, we have access to people with different views within our domain, this makes for a very interesting collaboration."

Fréderic-Michael FOETELER
Engineer, Institut Luxembourgeois de Régulation (ILR)

"LIST plays a major role for Circuit Foil. Firstly, LIST's technical expertise and state-of-the-art research equipment provide an important advantage. The second aspect is the fundamental research carried out there, which Circuit Foil could not undertake due to a lack of time, staff and skills."

Julie MOUZON,
R&D Director, Circuit Foil

"We set up a collaboration with LIST to deploy an innovative idea, to make it operational so that it works, to turn it into a real experiment. We also needed to understand in advance the data that would need to be collected so that our trial, our experiment, would ultimately serve as a good prototype. LIST provided us with all this: this operational structure with a scientific and research mindset. LIST paved the way for us in the end."

Omar MAATAR,
Innovation director, Compagnie Luxembourgeoise d'Entreprises (CLE)

OUR COLLABORATION MODELS

BILATERAL RESEARCH

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

SERVICE AGREEMENT

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

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

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

COLLABORATIVE PROJECT

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

STRATEGIC PARTNERSHIP

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

"SPIN-OFF" OR "LICENSING"

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

RESEARCH WITH MULTIPLE PARTNERS: LIST'S PARTNER PROGRAMMES

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

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

SHARING OUR KNOWLEDGE WITH SOCIETY AND BUSINESSES

"The first objective of Tech Day is to raise public awareness of LIST. This is also an opportunity for our researchers to present the results of their research work in recent years and the extraordinary projects they are working on. Finally, it is also about establishing links with our partners and demonstrating how we can make a relevant contribution to their very diverse activities."

Eva KREMER,
Chair of the Board of Directors

LIST is an indispensable player in its field, not only because of its research and technology missions, but also because of the economic and social added value we generate. We play an important role in the dynamics of our institutional, industrial and socio-economic partners, by facilitating their access to scientific and technological expertise.

In order to promote the spread of scientific knowledge and culture, LIST has always been committed to promoting dialogue between science, technology and society: it is on the basis of this sharing that we can jointly ensure an effective transition.

To achieve our ambition, we have organised and contributed to numerous events aimed at as many people as possible.

TECH DAY 2022: A SHARING PLATFORM

"Think outside the box and bring your ambitions to life!" This was the motto of the fourth Tech Day organised by LIST on 15 June 2022, which brought together just over 300 participants at the Maison des Arts et des Étudiants in Belval. A total of around 200 companies were identified during the day.

Our researchers presented seven key technologies developed at LIST as part of the "Tech Village", including a "mega" stand entitled "Hydrogen: a key element in the energy transition".

Our institutional and industrial partners and the general public also discovered our new cooperation agreements with Goodyear, Schroeder & Associés SA in the field of water, construction and mobility, and with Telindus, a Proximus brand, in order to boost 5G expansion in the business sector in Luxembourg.

Georges Thielen receives the LIST Lifetime Award 2022

Signing of a collaboration agreement with Telindus

Opening of LIST Tech Day 2022

LIST Tech Day 2022: Tech Village

Address by the Minister for Economic Affairs, Franz Fayot

Partnership agreement signed with Schroeder et Associés

SHARING OUR KNOWLEDGE WITH SOCIETY AND BUSINESSES


Researchers' Days


Researchers' Days

SHOWCASING OUR WORK TO THE GREATEST NUMBER

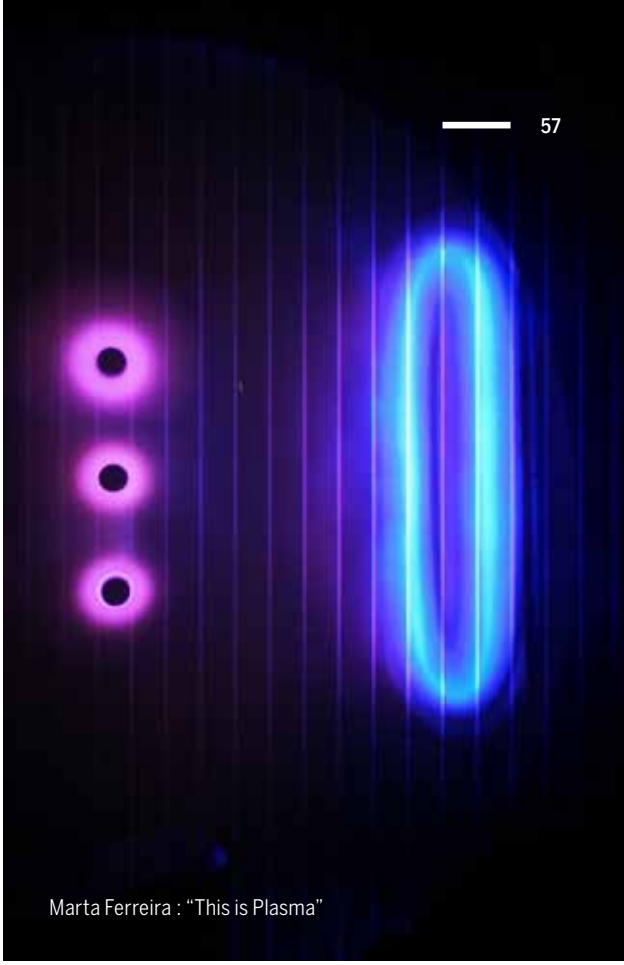
Researchers' Days have become a key event for research in Luxembourg, offering scientists a unique platform to present their work to a wide audience. During these two days dedicated to popularising science, including one for Luxembourg schoolchildren, our researchers presented the diversity of their projects through five thematic workshops dedicated to plants, 5G, the interaction between waves and fields and matter, energy recovery and water as an essential resource for the development of a sustainable robotic and human presence in space.

The 2022 FNR Science Image Competition aimed at showing the beauty of research and promoting scientific culture in Luxembourg rewarded the efforts of several LIST researchers. The photographs "This is Plasma" by Marta Ferreira, "Microcarriers" by Charlotte Stoffels, "Telescope" by Olivier Parisot, "Lost lake" by Jean-Baptiste Burnet and "The Hummingbird Hawk Moth" by Alain Dohet received awards.

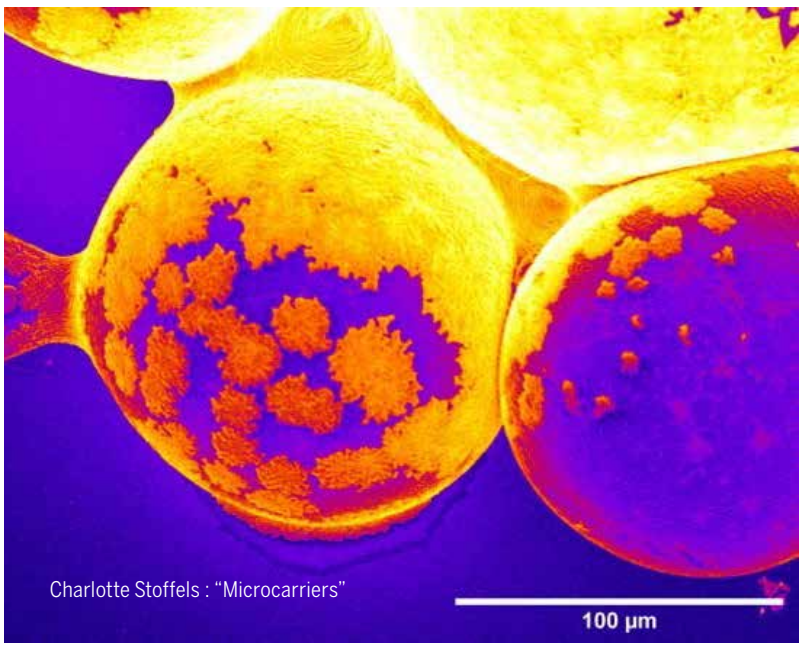
Our researchers presented Luxembourg solutions approved by the Solar Impulse Foundation by LIST/SOLAR IMPULSE at KlimaExpo 2022, the national exhibition dedicated to key players tackling climate change and solutions to it. Some have also contributed to the communication activities by Research Luxembourg, a joint initiative of all the key players involved in research in Luxembourg.


Visit from the Grand Duke, the Minister for the Environment, Climate and Sustainable Development Joëlle Welfring, the Minister for Energy and Spatial Planning Claude Turmes and the Vice-President of the European Parliament Marc Angel to our stand at Klima Expo

Alain Dohet : “The Hummingbird Hawk Moth”



Marta Ferreira : “This is Plasma”



Charlotte Stoffels : “Microcarriers”

Olivier Parisot : “Telescope”

Jean-Baptiste Burnet : “Lost lake”

RDI PARTNERS IN LUXEMBOURG AND EUROPE

A
- Administration des Ponts et Chaussées
- AdwäisEO
- Agora
- Airbus
- Airbus Defence and Space
- Air Liquide
- Alstom
- Anisoprint
- Arcelor Mittal
- Armacell
- AXA Assurance Luxembourg

B
- Bakertilly
- BGL BNP Paribas
- BrighterBins

C
- CCB
- CEA
- CEBI
- Centre National d'Etudes Spatiales (CNES)
- Centre National de Formation Professionnelle Continue (CNFPC)
- Ceratizit
- Chambre d'Agriculture Luxembourg
- Cimalux
- Circuit Foil Luxembourg
- CLE
- Commission nationale pour la protection des données (CNPD)
- Convis
- Creos

D
- Daher
- Direction de la Défense
- Direction de la Santé
- Domaines Vinsmoselle
- Dupont
- Dynaccurate

E
- Electris
- Encevo
- Energipark Réiden
- Equans
- European Space Agency (ESA)
- Everis

F
- Firis
- FM Global
- Fonds National de la Recherche Luxembourg (FNR)
- Forest Climate Change Fund (FCCF)
- Frewitt
- Frontier Connect

G
- GomSpace
- Goodyear
- Gradel
- Green Power Storage Systems
- Guala Closures

H
- Hap2u
- Hitec
- House of Entrepreneurship
- House of Training
- Hydrosat

I
- Institut fir biologësch Landwirtschaft an Agrarkultur Luxemburg (IBLA)
- Institut belge des services postaux et des télécommunications (IBPT)
- IEE
- IKO
- Institute for Training in the Construction Sector (IFSB)
- Incert
- Infrachain
- Institut luxembourgeois de régulation (ILR)
- Intrasoft international
- Institut Supérieur de l'Économie (ISEC)
- ispace

K
- Kronospan

L
- Laboratoire National de Santé (LNS)
- Luxembourg Institute of Health (LIH)
- Luxembourg Institute of Socio-Economic Research (LISER)
- Luxembourg Media and Digital Design Centre GIE
- Luxembourg Science Center
- Luxembourg Space Agency (LSA)
- Luxembourg Centre for Logistics and Supply Chain Management (LCL)
- Luxinnovation
- Luxmobility
- Luxplan
- Luxprovide
- Luxsense

M
- Met-Lux
- Ministère de l'Agriculture, de la Viticulture et du Développement rural
- Ministère de l'Enseignement supérieur et de la Recherche (MESR)
- Ministère de l'Economie
- Ministère de l'Environnement, du Climat et du Développement durable (MECDD)
- Ministère de la Digitalisation
- Ministère de la Santé
- Mondorf-les-Bains
- Motion-S
- MPG
- Musée National d'Histoire Naturelle

N
- nhbs
- No-Nail Boxes

O
- OHB Luxspace

P
- Pierre Fabre
- PM-International
- Polygone
- POST Luxembourg
- Probiotic Group
- Prosud
- Proximus

R
- Research Luxembourg
- RoamsysNext
- Rotarex
- RSS Hydro

S
- Sabeu
- Schroeder et Associés
- Sciex
- SecurityMadeIn.lu
- Service des média, de la connectivité et de la politique numérique
- Siden
- Sidero
- Sisaf
- Service Moyens Accessoires (SMA)
- SmartEnds
- Spuerkeess
- ST Life augmented
- Succy
- Syndicat des eaux du barrage d'Esch-sur-Sûre (SEBES)
- Syndicat intercommunal pour l'assainissement du bassin de la Chiers (SIACH)

T
- Telindus
- Thales Alenia
- Toyota

U
- Université du Luxembourg
- Université de Lorraine

V
- Vaonis
- Ville de Differdange
- Ville de Luxembourg
- Vitrocell

W
- Wagner-Schaffner
- Wasdi
- Westpole
- Wide andCo
- World Alliance

X
- Xnergi

Z
- Zeiss
- ZeroK Nanotech

3
- 3D-Oxides

LIST IN A NUTSHELL

DOCTORAL THESES DEFENDED

ACHARYA Kishor

"Site-selective atmospheric pressure plasma-enhanced chemical vapor deposition process for micrometric deposition - Simulation and experimental study", University of Luxembourg, 08/11/2022

ARUCHAMY Naveen

"Fatigue and breakdown studies of solution deposited oxide ferroelectric thin films", University of Luxembourg, 16/09/2022

AVRAMIDIS Iason

"Smart, sustainable, and grid-friendly buildings: Optimal integration in LV grids", KU Leuven (B), 01/07/2022

AYOUB Vita

"Assimilation de données d'observation satellitaire d'inondation pour une meilleure paramétrisation des modèles hydrauliques à large échelle", University of Montpellier (F), 02/12/2022

BHUSARI Rutuja

"Metal-oxide nanostructures for low power gas sensing", University of Luxembourg, 22/04/2022

CHUZEVILLE Lauriane

"Synthesis of supported Liquid crystal on echogenic capsules as targeted ultrasound contrast agent", University of Luxembourg, 25/05/2022

DA CUNHA Tairan

"Study of the (nano)fillers smart functionality and effect on tire performance", University of Luxembourg, 15/07/2022

DI MAURO Concetta

"Data Assimilation of SAR-derived flood extent maps into flood forecasting models via Particle Filters", Vienna University of Technology (AT), 29/11/2022

DUTTA Sangita

"Theoretical investigation of ferroelectricity in HfO2 and related materials", University of Luxembourg, 03/06/2022

FABIANI Ginevra

"Tree water use across landscapes and time", University of Florence (I) et University of Luxembourg, 01/12/2022

FEUCHEROLLES Maureen

"Maldi-Tof-enabled subtyping and antimicrobial resistance screening of the food and waterbone pathogen Campylobacter jejuni", University of Luxembourg, 17/06/2022

GUNAYDIN Abdullah

"Synthesis of poly(isobornyl methacrylate) and related block copolymers and their application for the reinforcement of styrene butadiene rubber", University of Luxembourg, 28/04/2022

HOEK VAN DIJKE Anne

"The link between vegetation functional traits and evapotranspiration at multiple spatial scales", University of Luxembourg, 10/06/2022

KHANNA Nikhar

"Metamaterial design and elaborative approach for efficient selective solar absorber", University of Luxembourg, 09/09/2022

LAI Ngoc Bao

"Integration of Grid Supporting Functionalities into Renewable Generation Systems Considering Communication Delays", Polytechnic University of Catalonia (E), 23/03/2022

LIU Bowen

"Post-quantum Remote Device Authentication and Data Analysis Protocol for IoT", University of Luxembourg, 17/10/2022

MALEKZAD Hediyeh

"Applying gradients to get optimal surface chemistry and topography for high performance biosensing", University of Luxembourg, 15/06/2022

MANISEKARAN Ahilan

"Renewable Lignin Nanoparticles as an Alternative Reinforcing Filler for Elastomers", University of Luxembourg, 21/11/2022

MILENOVIC, Milan

"Effect of climate change on interactions between whiteflies, parasitoids, endosymbionts, and the host plant", University of Catania (I), 24/11/2022

MORETTO Enzo

Titre confidentiel, University of Luxembourg, 12/10/2022

NOUCHOKGE Youri

"Scale law on energy efficiency of electrocaloric materials", University of Luxembourg, 09/09/2022

OST Alexander

"Investigation of Surface Sputtering and Ionization Processes under Non-Reactive Light Ion Irradiation: towards 4D SIMS Imaging", University of Luxembourg, 07/12/2022

PADMANATHAN Hiron Raja

"Crack Initiation and early crack growth in silica-filled solution styrene butadiene rubber", University of Luxembourg, 20/05/2022

TORELLÓ MASSANA Àlvar

"Electrocaloric coolers based on ceramic multilayer capacitor", University of Luxembourg, 07/07/2022

ZHAO Jie

"Large-scale flood mapping using SAR remote sensing data", Vienna University of Technology (AT), 25/10/2022

GOVERNANCE

BOARD OF DIRECTORS 2022

Photo from left to right: Stéphane Jacquemart, Candi Carrera, Letizia Lukas, Etienne Jacqué, Eva Kremer, Marie-Christine Mariani, Thomas Kallstenius, Diane Wolter, Isabelle Kolber, Robert Kerger, Steve Kremer & Benoît Otjacques (absent: Tom Battin)

OBSERVERS

Thomas Kallstenius
CEO

Stéphane Jacquemart
Chair of the Staff Delegation

GOVERNMENT COMMISSIONER

Robert Kerger
Advisor to the Ministry of Higher Education and Research

SECRETARY

Benoît Otjacques

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Deputy Director of Société Nationale de Crédit et d'Investissement (Luxembourg), Chair

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Corporate R&D Manager at CEBI International SA (Luxembourg), Vice-Chair

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

Candi Carrera
Owner, 36 Square Capital (Espagne)

Isabelle Kolber
Head of Laboratory at SEBES (Syndicat des eaux d'Esch-sur-Sûre - Luxembourg)

Steve Kremer
Director of First Class Research at the Nancy National Institute for Research in Digital Science and Technology (INRIA - France)

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Managing Director of Exigo SA (Luxembourg)

Marie-Christine Mariani
CEO of MCM SARL (Luxembourg)

Diane Wolter
President of CBM Luxembourg Foundation

EXECUTIVE MANAGEMENT

Dr Thomas Kallstenius
CEO

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Director, Environmental Research and Innovation (ERIN)

Dr Kathryn Hadler
Director, European Space Resources Innovation Centre (ESRIC)

Francesco Ferrero
Director, IT for Innovative Services (ITIS)

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

HUMAN RESOURCES

Kristel Wiliquet
Human Resources Director

FINANCE & ADMINISTRATION

Dr Thomas Kallstenius
Administrative and Financial Director
ad interim

BALANCE SHEET AS AT 31 DECEMBER 2022

APPROVAL OF ACCOUNTS

The accounts were audited by statutory auditors KPMG and approved by the Board of Directors during their meeting of 28 April 2023.

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

Assets (in euros)	2022	2021
Fixed assets		
Intangible fixed assets	722.546,03	692.085,78
Concessions, patents, licences, trademarks and similar rights and assets	722.546,03	692.085,78
Tangible fixed assets	40.384.156,30	28.649.828,80
Land and buildings	92.209,95	209.293,29
Plant and machinery	23.054.613,42	21.660.284,72
Other fixtures and fittings, tools and equipment	2.610.895,50	2.461.630,58
Payments on account and tangible assets under development	14.626.437,43	4.318.620,21
Financial fixed assets	468.832,74	468.832,74
Shares in affiliated undertakings	415.938,20	415.938,20
Amounts owed by affiliated undertakings	-	-
Securities held as fixed assets	52.894,54	52.894,54
Total fixed assets	**41.575.535,07**	**29.810.747,32**
Current assets		
Inventories	567.570,88	512.659,04
Raw materials and consumables	567.570,88	512.659,04
Receivables	32.208.997,94	33.273.972,55
Receivables from the sale of goods and services	3.825.568,62	4.903.295,41
Other receivables	28.383.429,32	28.370.677,14
Cash at bank and in hand	69.129.536,08	73.084.941,24
Total current assets	**101.906.104,90**	**106.871.572,83**
Accruals	2.185.990,99	1.350.809,81
Balance sheet total (assets)	**145.667.630,96**	**138.033.129,96**

Equity and liabilities (in euros)	2022	2021
Equity	95.469.279,78	95.805.865,66
Capital contributions	37.518.673,70	37.518.673,70
Reserves	58.287.191,96	50.520.865,96
Profit or loss brought forward	-	3.365.217,31
Profit for the financial year	-336.585,88	4.401.108,69
Provisions	180.000,00	320.000,00
Liabilities	43.753.136,69	37.574.449,82
Payments received on account for orders where not separately deducted from inventories	28.595.040,55	27.774.252,04
Trade creditors	7.788.186,99	3.821.098,86
Other liabilities	7.369.909,15	5.979.098,92
Tax liabilities	23.559,22	1.504.803,32
Social security liabilities	1.848.555,47	1.750.617,65
Other liabilities	5.497.794,46	2.723.677,95
Accruals	6.265.214,49	4.332.814,48
Balance sheet total (equity & liabilities)	**145.667.630,96**	**138.033.129,96**

PROFIT AND LOSS ACCOUNT FOR THE FINANCIAL YEAR 2022

	2022	2021
Net turnover	6.797.698,87	7.274.166,23
Other operating income	81.140.226,56	75.869.195,81
Raw materials and consumables, and other external expenses	-19.925.540,73	-15.362.225,78
Raw materials and consumables	-6.511.280,82	-5.232.580,20
Other external expenses	-13.414.259,91	-10.129.645,58
Staff costs	-57.933.144,64	-53.504.911,99
Salaries and wages	-51.203.727,06	-47.217.795,12
Social security expenses	-6.595.026,16	-6.163.519,69
covering pensions	-4.004.195,16	-3.731.276,38
other social security expenses	-2.590.831,00	-2.432.243,31
Other staff costs	-134.391,42	-123.597,18
Value adjustments	-7.419.742,73	-7.062.132,46
on formation expenses, and intangible and tangible fixed assets	-7.373.577,73	-6.859.563,63
on current assets	-46.165,00	-202.568,83
Other operating expenses	-2.962.295,39	-2.765.218,89
Other interest and financial income	51.249,77	16.071,38
derived from affiliated undertakings	-	-
other interest and financial income	51.249,77	16.071,38
Value adjustments in respect of financial fixed assets and in respect of transferable securities held as current assets	-	-
Interest and other financial expenses	-85.037,59	-63.835,61
concerning affiliated undertakings	-	-
other interest and financial expenses	-85.037,59	-63.835,61
Profit after corporate income tax	-336.585,88	4.401.108,69
Profit for the financial year	**-336.585,88**	**4.401.108,69**

IMPRESSUM

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Luxembourg Institute of Science and Technology

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Luxembourg Institute of Science and Technology

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