FOCUS

RESEARCH & INNOVATION IN LUXEMBOURG

SURFING THE DIGITAL WAVES

N°11
10/2016

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EDITORIAL

This edition of *FOCUS – Research and Innovation in Luxembourg* highlights the variety of ways in which Digital Lëtzebuerg is driving the diversification of the Luxembourg economy.

Fifteen years ago, two things were often said about Luxembourg. One – that for a small country, it punches way above its weight – is truer than ever. The other – that the national economy is too narrowly focused – is emphatically no longer the case. The shape of our economy and its future potential are changing rapidly due to a long-term strategy guided by forward-thinking policies. A continuing growth in innovation is underpinned by Luxembourg's outstanding ICT infrastructure, which offers secure, high-speed stocking and data transmission as well as high-level cybersecurity expertise.

Luxembourg is a sought-after environment for groundbreaking work in areas such as healthcare, ICT, ecotechnologies and logistics. Innovation is happening across the board, and the country has the technological infrastructure to turn ideas into reality. In stem cell research, computational biologists are developing tools that could lead to breakthroughs in the treatment of spinal cord injury, stroke, heart disease and cancer. In software engineering, researchers are devising smart verification and validation techniques to ensure that the software behind self-driving cars, e-banking transactions and countless other products and services is safe, secure and reliable. In fintech, new solutions based on blockchain technology offer secure digital wealth management for banks. Also emerging in Luxembourg are exciting new applications such as Foobot, which measures pollutants in indoor air and provides advice on how to combat them, and the smartphone app developed by telematics spin-off Motion-S, which helps drivers improve their skills.

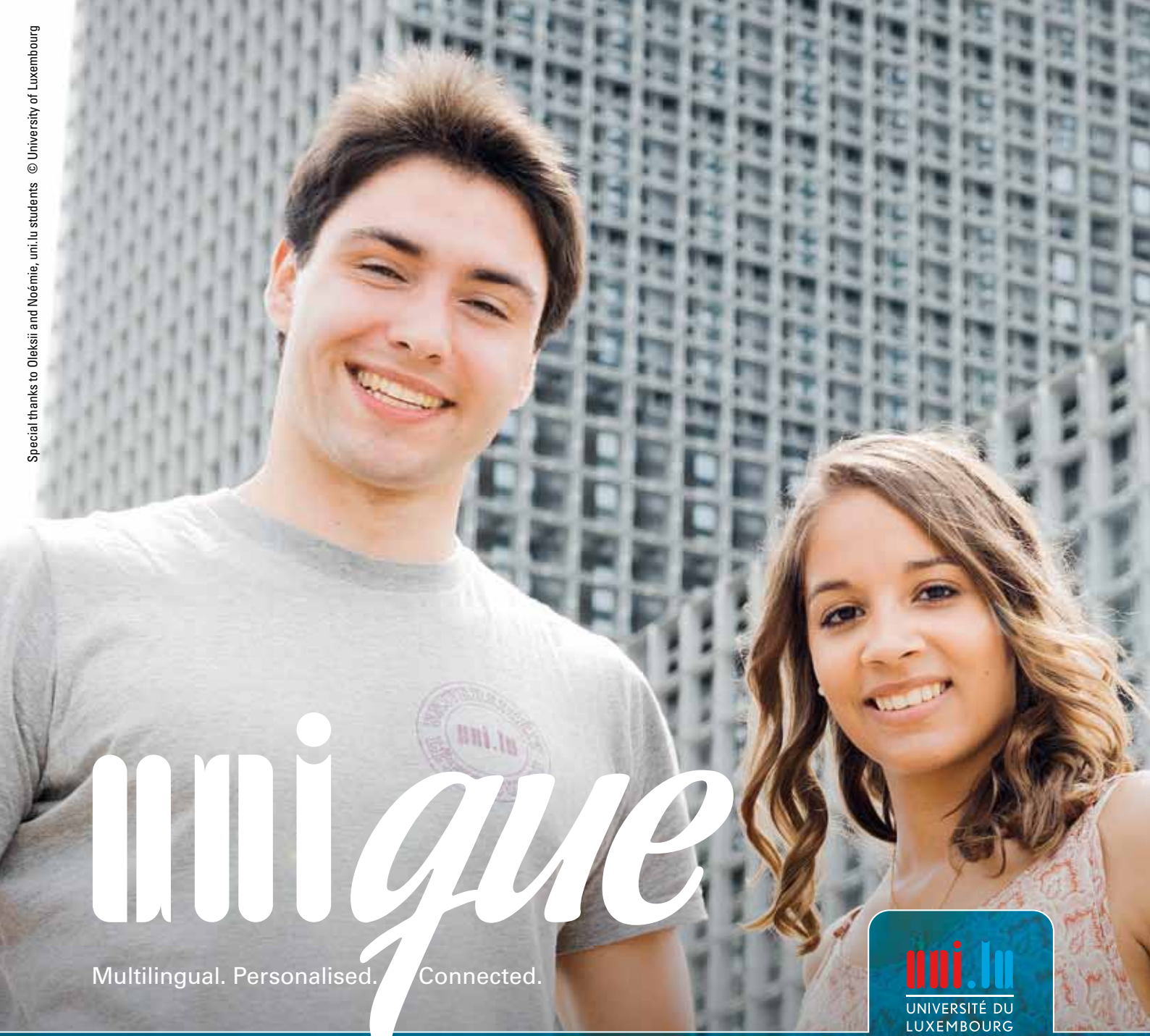
Elsewhere, a team at the Luxembourg Centre for Systems Biomedicine (LCSB) is developing and applying new bioinformatic modelling methods for more accurate analysis of the cancer cell genome. Meanwhile, NATO is near to completing its Luxembourg Tier IV data centre, which will be used to improve the disaster recovery capability of its Support and Procurement Agency. In medicine, the Luxembourg Institute of Science and Technology has worked with clinical professionals to develop GECAMed, a secure, open-source data management application giving doctors rapid access to patient and practice management information and the national e-health platform. Behind the multitude and scope of the projects coming out of Luxembourg – many of which are gaining international visibility – is a welcoming and supportive environment offering competitive advantages in a variety of sectors.

Also in the high-tech arena, the Interdisciplinary Centre for Security, Reliability and Trust at the University of Luxembourg (SnT) secured €4 million in Horizon 2020 research and innovation funding last year, as well as approval for nine projects. Meanwhile, Luxembourg firm KYC3 is building an international clientele with its information monitoring app, which trawls and analyses tens of thousands of online sources at very high speed to provide detailed know-your-customer data for financial and other organisations.

Perhaps because of its limited domestic market, Luxembourg is unusually well attuned to business opportunities both in Europe and further afield. With a legal framework that removes as many obstacles as possible, outstanding infrastructure, a multilingual, multinational workforce and committed practical support for the most outstanding ideas and entrepreneurs, economic diversification is well underway.

The role of Luxinnovation is to be a catalyst that supports the growth of innovative R&D concepts into real-world products and services. We welcome interested and committed entrepreneurs and investors and offer our services towards successful establishment in Luxembourg.

Jean-Paul Schuler
CEO, Luxinnovation
National Agency for Research and Innovation



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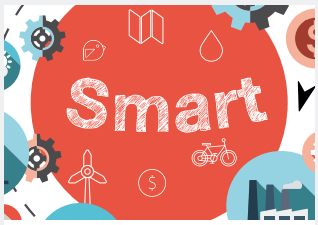

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LUXINNOVATION

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NEWS
FROM INNOVATIVE LUXEMBOURG

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BIOINFORMATIC MODELS ENHANCE CANCER CELL MAPPING

The Computational Biology research group of the Luxembourg Centre for Systems Biomedicine (LCSB) has developed a bio-informatic modelling method to enhance the accuracy of cancer cell genome analysis. Cancer is caused by changes in the DNA, so an understanding of the DNA structure of tumour cells is key to developing new drugs and personalised therapies.

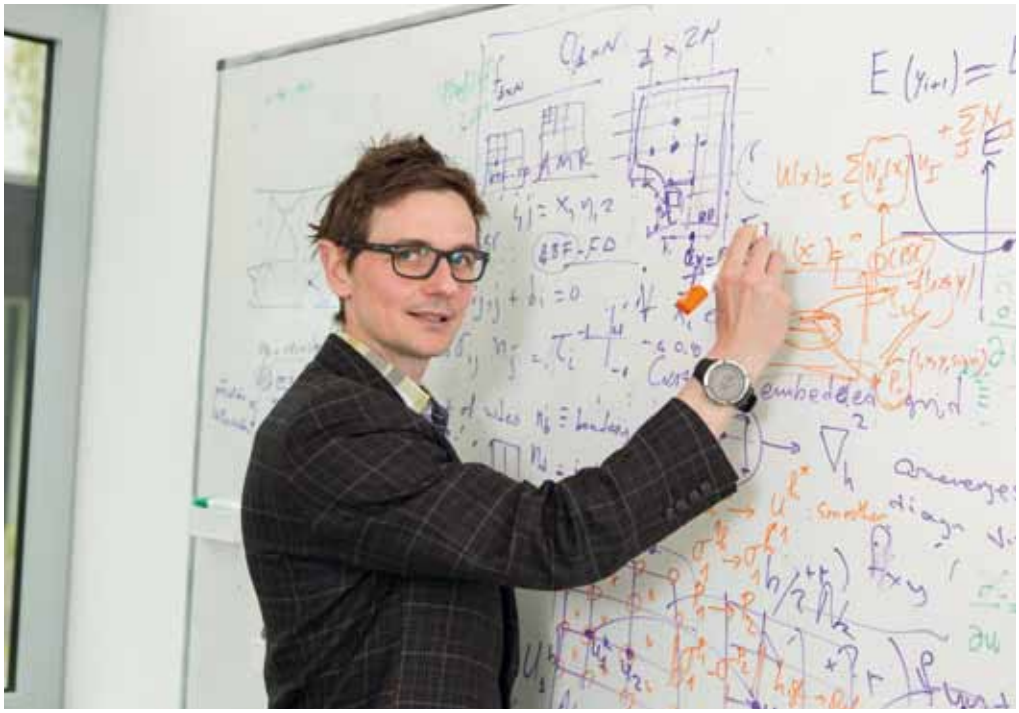
Researchers have been using microscopy analysis for decades to determine the chromosome structure of cancer cells, and sequencing technologies have led to far greater precision in the identification of many chromosome cell mutations. However, as sequencing only delivers data on very short DNA fragments, it is inadequate on its own for analysing the chaotic structural changes in the cancer cell genome. The LCSB's approach is to generate statistical models from multiple chaotic genome sequences to determine if these can show the structural changes. The centre hopes to further develop bioinformatics modelling for use in the analysis of other diseases with complex genetic causes, such as Parkinson's.

www.lcsb.lu

BETTER HEALTHCARE WITH DIGITAL DATA MANAGEMENT

Researchers at the Luxembourg Institute of Science and Technology (LIST) are continuing to develop and release enhancements to GECAMed, the open-source clinical and administrative data management system for general medical practices. GECAMed is the first clinical management system that provides integrated access to the DSP national database of digital healthcare records, enabling patient information to be shared between medical professionals. The aim of the DSP, part of the government e-health platform, is to improve the coordination and efficiency of data exchange within the healthcare system. GECAMed now provides access to full patient care histories, including lab tests, medical imaging and treatment records, and will be a valuable ongoing asset for LIST researchers. The system is fully secure and compliant with data protection and confidentiality legislation and international IHE standards.

www.gecamed.lu



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LUXEMBOURG SCIENTIST NAMED AMONG WORLD'S MOST INFLUENTIAL RESEARCHERS

Professor Stéphane Bordas of the University of Luxembourg has been listed on the Thomson Reuters 2015 "World's Most Influential Scientific Minds", a citation analysis identifying the 3,000 scientists who have made the biggest global impact in their fields.

Professor Bordas, who coordinates the university's Strategic Computational Sciences Priority, leads a multidisciplinary team using computational methods to simulate the mechanical behaviour and properties of different materials. Projects include the development of real-time simulators for surgical interventions, designed to help physicians plan for complex operations. The team has received over €7 million in funding, including a €1.3 million Starting Grant from the European Research Council. The unit will focus next on investigating the interface between Big Data and computational modelling, with the aim of defining the most accurate models to estimate uncertainties and errors in biomechanical simulations.

www.uni.lu

FOCUS ON DIGITAL HISTORY RESEARCH

The new Institute of Contemporary History at the University of Luxembourg will be the first in the field of European research to prioritise digital techniques in its research and communications. The focus of the institute, which is the university's third interdisciplinary centre after the centres for Security, Reliability and Trust (SnT) and Systems Biomedicine (LCSB), will be on contemporary Luxembourg history and the history of European integration.

The University is absorbing four national research centres whose work focuses on the application of digital technologies to aspects of contemporary European history. The new institute, while largely autonomous, will benefit strongly from the work of these bodies, in particular that of the CVCE, the Luxembourg centre for research into European integration. The institute will make full use of technology to record and store information and to analyse and visualise big historical datasets, and will disseminate its research via social media and other internet channels.

www.uni.lu

LIST STRENGTHENS RESEARCH AND TECHNOLOGY COLLABORATION WITH FINNISH VTT

LIST and VTT Technical Research Centre of Finland have reinforced their existing cooperation agreement with a new Memorandum of Understanding. Future collaboration will prioritise areas that are of strategic economic importance to Luxembourg and Finland and in which both countries have recognised knowledge and expertise. Fields selected to date include ICT, smart industry and advanced manufacturing, smart cities and smart citizens, energy efficiency, advanced and bio-based materials and the bioeconomy. The two research centres have also committed to strengthen their collaboration with industry through European research projects, especially those funded by Horizon 2020.

www.list.lu
www.vttresearch.com

NEW NATO DATA CENTRE FOR LUXEMBOURG

NATO is to set up a Tier IV data centre in Luxembourg to augment the disaster recovery capability of its Support and Procurement Agency (NSPA). Specifications for the centre have been drawn up in close collaboration with the State IT centre (CTIE) and the Ministry of Defence. Testing will take place in autumn 2016 and completion is expected by the end of the year.

www.nspa.nato.int

SNT OBTAINS RECORD HORIZON 2020 RESEARCH FUNDING

The University of Luxembourg's Interdisciplinary Centre for Security, Reliability and Trust (SnT) secured €4 million in Horizon 2020 funding last year, as well as approval for nine projects. This was a dramatic improvement over previous years, attributed by SnT to its strategic drive to attract world-leading scientists and prioritise the professional development of young researchers.

Competition for Horizon 2020 funding is extremely intense and project evaluation takes into account relevance to the wider economy as well as scientific excellence. One of SnT's main aims is to make a significant contribution to the development of the ICT sector, both in Luxembourg and across Europe as a whole. "We have placed great value on intensive cooperation with both industry and public sector partners since the very beginning," says SnT Director Professor Björn Ottersten. "This is how we have established our excellent position in the international research environment."

www.uni.lu/snt

FULL HIGH-PERFORMANCE INTERNET OF THINGS FOR LUXEMBOURG

Luxembourg has become the fifth European country to achieve full Internet of Things (IoT) coverage via SIGFOX, an ultra-narrow band technology which offers economical, energy-efficient two-way transmission of small quantities of data over long distances. The project was implemented via a three-way partnership between leading national postal and telecom services supplier POST Luxembourg, international provider SIGFOX and mobile application developer RMS.lu. The partnership aims to supply local authorities with smart city applications such as smart parking.

POST, in partnership with global IoT leader Jasper, also offers a combined network and IoT platform that allows companies to easily launch, manage and monetise IoT services. One of Europe's largest car manufacturers has migrated the management of its fleet of 1.1 million connected cars to POST's M2M Control Centre.

www.post.lu

DIGITAL INFRASTRUCTURE, BY DEFAULT

"The ultimate goal is to create an information society that benefits each and every one of our citizens."

Xavier Bettel

It is a measure of the importance the government accords to information and communications technology that the Prime Minister is also the Minister for Communications and Media. "Digital technology is no longer just an economic sector," says Prime Minister Xavier Bettel. "It is the lifeblood of our economy, an essential element of competitiveness and crucial for society as a whole." The Luxembourg government is 100% committed to embedding technological innovation throughout every sector of society.

Mr Bettel is firmly of the view that government should play a leading role in defining national direction. Central to this is the Digital Lëtzebuerg initiative, which he describes as a "horizontal, cross-cutting drive towards greater digital transformation of society that will give positive shape to the way we do business, the way we do government and the way we interact as a country."

Pro-business ecosystem

Luxembourg has been a communications pioneer for several decades, partly as a result of successive governments' commitment to strong practical support for innovative companies. Digital Lëtzebuerg is built around creative, open-minded ICT business promotion policies and initiatives. The Digital Tech Fund and Luxembourg Future Fund act in effect as venture capitalists, taking a share in promising innovative companies to help them leverage private sector investment, while Fit for Start offers business advice and seed funding for ICT start-ups. In addition, the government has several co-funding schemes supporting a wide range of innovative businesses and a number of diverse research and development projects.

Connections and capacity

This all takes place against a backdrop of a first-rate ICT business infrastructure. Located at the crossroads of the major European internet hubs and exchanges, Luxembourg has low latency network connections serviced by a range of Tier 1 and Tier 2 carriers offering round-trip times of around 5 milliseconds to Amsterdam, Brussels,

Digital Lëtzebuerg for a smart nation

Digital Lëtzebuerg is "a community of people eager to realise their dreams in a supportive environment," says Mr Bettel. The initiative was set up in order to develop best practice, act as a forum for new ideas, strengthen and consolidate the country's ICT capacities and make a powerful contribution to economic diversification. Ambitions do not stop there, however. "The ultimate goal of Digital Lëtzebuerg is to create an information society that benefits each and every one of our citizens," says Mr Bettel.

Companies in Luxembourg are currently working on IT innovation in fintech, e-skills, e-government, high performance computing, open data, e-mobility and e-health. "These different strands come together holistically to boost the Grand Duchy's capabilities and reinforce our status as a modern, open, well-connected country ready to take on any new economic and social challenge," says Mr Bettel.

STRENGTH AND SUSTAINABILITY: THE NEXT ECONOMIC REVOLUTION

© Ministry of the Economy

How can mature economies grow strongly and sustainably in a world faced with climate change and a scarcity of resources? The solution may lie in new digital technologies, materials, robotics and processes such as 3D printing. Dubbed the "third industrial revolution" by celebrated American economic and social theorist Jeremy Rifkin, concepts such as these point the way towards a socially and environmentally sustainable world, and Luxembourg is determined to be in the vanguard.

While the first and second industrial revolutions introduced mechanisation and mass production, the third will be about sustainably meeting precise individual demands. New materials and information technology will enable buildings to not only consume energy but produce and sell it. An "energy internet" will store power in high-performance batteries and use it to supply the exact amount needed to power homes, vehicles and highly specialised community-based industries.

The long view

"It is time to make the third industrial revolution our own," says Étienne Schneider, Deputy Prime Minister

> "Luxembourg could become the ideal laboratory for testing innovative and intelligent ideas."
>
> Jeremy Rifkin

and Minister of the Economy. "With the depletion and increasing rarity of fossil energies and other raw materials, the economic system that has served us so well until now is no longer either sustainable or equitable. We need a long-term – in fact, a very long-term – economic vision, and we need a strategy for the decades to come that is adapted to the particular conditions of our country."

In autumn 2016, the government will unveil the national third industrial revolution strategy for Luxembourg, developed in collaboration between the Ministry of Economy, Chamber of Commerce and IMS Luxembourg, under the guidance of Jeremy Rifkin.

A national living lab

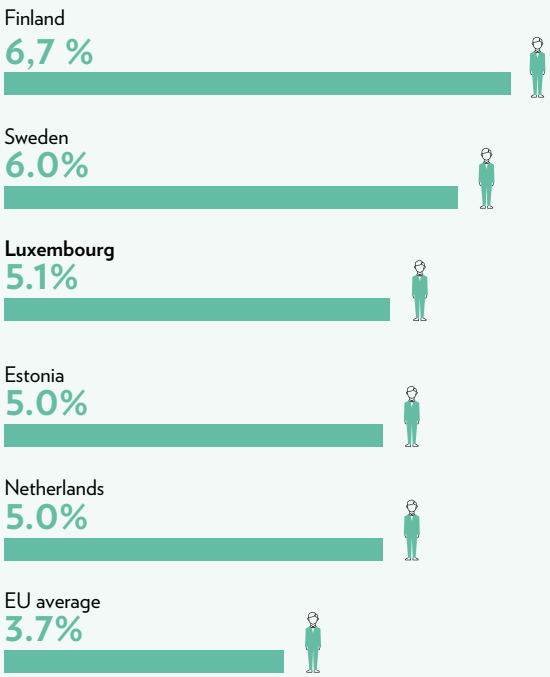
"Luxembourg could become the ideal laboratory for testing innovative and intelligent ideas on a national scale," Mr Rifkin has said, and the first of these tests will be the implementation of a completely interconnected economy. Technology aside, long-term success will depend on the involvement of all sectors, including business. Luxembourg is an open and innovative society, however, and potentially well-equipped to become what Mr Rifkin envisions as a "living lab that could be the precursor of necessary solutions to meet future challenges."

"Progress has already been made," adds Étienne Schneider. "For the last 10 years, we have been pursuing an active development and diversification policy, with excellent results in areas such as ICT, eco-technologies and logistics. We will not only build on that, but deploy the necessary technological infrastructure to give form to Mr Rifkin's ideas."

Frankfurt, London and Paris. The country also has ample data centre capacity, two-thirds of which meets the highest Tier IV specifications. LU-CIX, the Luxembourg Commercial Internet exchange point, offers short, fast and efficient routes to the major European Internet networks. An upgrade – LU-CIX 2.0 – is currently in the pipeline.

> "We make sure that all our new laws are digital by default."
>
> Xavier Bettel

Share of ICT specialists in the EU Member States 2014 (as % of total employment)



Source: Eurostat

ICT share of GDP, 2013


13%
Ireland


7%
Luxembourg


6%
Sweden


6%
Romania


6%
Malta


4%
EU average

Source: European Commission

Knowledge economy

Luxembourg has, over time, developed the technology-focused economy it needs as a world leader in cross-border finance, an industry heavily reliant on fast, secure international IT connections. A European communications capital since the founding of broadcaster RTL in the 1930s, it is home to global satellite company SES as well as hundreds of high-value-generating smaller firms. In addition, much of Europe's online services industry passes through Luxembourg, where Skype, Amazon and eBay all have key hubs.

ICT Development Index 2015


1
Republic of Korea


2
Denmark


3
Iceland


4
United Kingdom


5
Sweden


6
Luxembourg


7
Switzerland


8
Netherlands


9
Hong Kong, China


10
Norway

Index based on 11 indicators concerning the access to ICT, ICT use and skills linked to ICT.

Source: International Telecommunications Union, United Nations

An extremely high proportion of the national workforce are IT professionals, and measures have been put in place to reduce delays and red tape for non-EU ICT specialists requiring work permits. Luxembourg can also boast a world-class academic, applied and theoretical research sector: computational sciences are a high research priority for the University of Luxembourg, while ICT is a key focus at the Luxembourg Institute of Science and Technology. Both institutions have significant experience of working with industrial partners on real-world applications, a factor that attracts new talent and keeps skills up to date.

Digital healthcare is another area benefiting from the combined impact of technology and sustained economic support. The country has substantial resources to deploy in this direction, not least of which is a long-standing respect for data privacy, and Luxembourg has created an environment that is working well for both start-ups and long-established research institutions.

Switched on society

Due partly to state investment, IT awareness among the general population is well above average. Free wi-fi is available throughout the capital, while almost every home has a broadband speed of at least 30 mbps and many have a fibre optic connection. Work is currently ongoing to transform Luxembourg into the first ultra-high bandwidth, full fibre optic country in Europe.

The legal environment also takes digitalisation into account. Data protection law is strict, but has the flexibility to

DEFENDING THE DIGITAL FRONTIER

Decades of protecting the security of private financial information have given Luxembourg ICT companies considerable expertise in building secure, trusted systems with the capacity to withstand malicious attack. This knowledge and experience is now being put to good use throughout the private and public sectors, and with cybersecurity a national research priority, the government is working systematically to maintain the trustworthiness and security of all the country's systems and data.

"To succeed, new technologies need to be trusted, and Luxembourg has invested heavily in IT security research," says Xavier Bettel, Prime Minister and Communication and Media Minister. The Luxembourg Institute of Science and Technology has a focus on IT security as a strategic research priority, as does the University of Luxembourg, via its Interdisciplinary Centre for Security, Reliability and Trust and the Laboratory of Algorithmics, Cryptology and Security.

Cooperation is key to effective protection and the development of new and better tools. "We bring different players together to form a community which works together to gauge threats and vulnerabilities and provide timely, targeted information about cybersecurity issues," says Pascal Steichen, CEO of SECURITYMADEIN.LU.

> "We bring different players together to provide timely, targeted information about cybersecurity measures."
>
> Pascal Steichen

A national cybersecurity strategy

The government has set up a series of national platforms, working closely together but each focusing on a specific aspect of cybersecurity defence. The Luxembourg emergency response community CERT.LU – a member of the international CERT network – monitors and manages cybersecurity incidents on a national basis, defends essential infrastructure, exchanges critical information with other countries and raises awareness. SECURITYMADEIN.LU promotes Luxembourg internationally and acts as an information and strategy forum for the national community of cybersecurity companies. On the ground, its two main divisions CASES and CIRCL provide tools, diagnostics and training to ensure that businesses and public sector organisations are aware of potential threats and have the means to protect against, detect and mitigate any risk to their systems and data.

The Prime Minister takes personal responsibility for information security regulation; he chairs the national Cyber Security Board and receives direct reports from the High Commission for National Protection. There can be no stronger sign of how seriously the government takes this priority.

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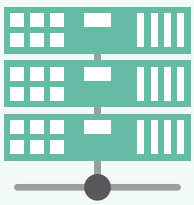

23
data centres, including
8 with Tier IV certification

Luxembourg hosts
40%
of all European
Tier IV data centres

28
international fibre routes
to main European hubs

Low-latency rates of
4–8
milliseconds

Source: Luxembourg for Business and Innovation

enable interested parties to make a legal claim for access to data hosted by a bankrupt company. "We make sure that all our new laws are digital by default," says Mr Bettel. "This means that we take into account the challenges of the digitalisation of the economy while ensuring that new businesses are not hampered by legal uncertainty."

International focus

Given its limited domestic market and multilingual, multinational workforce, the country is extremely well-attuned to business opportunities both in Europe and further afield. In particular, Luxembourg aims to take a strong role in the EU's emerging digital single market.

"We compare well to other countries, but that is not an end in itself," says Prime Minister Bettel. "We realise we have to be vigilant and ready to act to support existing companies, attract new investment and encourage young business. Technology is at the heart of Luxembourg's future, and our government understands that our role is to enable growth without intervening unnecessarily. We do this because we want to improve our way of life even more."

Ministry of State
Media and Communications Department

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Communication paths in OECD countries per 100 inhabitants 2013

1	2	3	4	5
Luxembourg	Italy	Finland	Switzerland	Austria

Includes analogue and ISDN lines, DSL, cable modems, fibre and mobile connections.

Source: OECD

Digital start-ups

SURFING THE DIGITAL WAVES

Digitalisation opens the gates to an avalanche of possibilities, notably the capacity to analyse staggering amounts of data with unprecedented accuracy and speed. For the creative entrepreneur, this is a different world, and fertile ground for pioneering brand new services, products and business models.

Many Luxembourg-based start-ups are active in the ICT sector and taking full advantage of these new opportunities. Not surprisingly, several of these are concentrating on fintech, but others are working in more diverse fields, including Internet of Things-enabled services and smartphone applications. Meanwhile, the country's high-level research expertise in fields such as cybersecurity and bioinformatics is leading to growing numbers of very interesting commercial spin-offs.

Luxembourg's high-performing, secure ICT infrastructure, dynamic economy, stable political and social climate and well-developed start-up support system attract numerous entrepreneurs from abroad. With its multicultural profile and central location, it is the ideal base for new companies eager to reach international markets.

AN EVOLUTION IN SCIENCE COLLABORATION

Biotech engineer Dr Virginie Simon co-founded MyScienceWork in Paris in 2010 as a free online network for professionals, students and others needing to keep up with scientific research and developments. Two years later, her company relocated to Luxembourg, and since then, MyScienceWork has evolved into a global platform for 500,000 scientists, offering a suite of collaborative tools for sharing and promoting scientific content and access to 60 million scientific papers.

The decision to move to Luxembourg in 2012 provided Dr Simon and her co-founder Tristan Davaille with the opportunity to significantly expand the functionality and capabilities of MyScienceWork. With a combination of private investment and matched funding from the Luxembourg government, Dr Simon, who has a PhD in nanotechnology in cancer therapy, was able to develop MyScienceWork into a global scientific platform fully equipped for collaboration and promotion between scientific institutions, universities and research centres. "Luxembourg is at the centre of Europe, a truly multilingual country offering plenty of opportunities for entrepreneurs," says Dr Simon, who has been included on the Hundert list of 100 outstanding female start-up founders.

Shared, connected and secure

MyScienceWork offers a number of free collaborative tools enabling researchers to share and promote their publications. In addition, in 2014, the company released Polaris, a paid-for platform aimed at scientific institutions. Polaris provides a secure digital archive for the storage of existing research, with the option to link to other repositories such as DSpace, HAL and ORBi. It also offers tools for presenting new work and assessing the impact of publications on the scientific community. Its dashboard gives easy access to statistical information – number of downloads, searches performed and so on – and comments.

Polaris is a turnkey solution; as soon as it is implemented, it is ready to go, with department and employee profiles already in place and users able to connect without delay to others across the network. The system has seen an impressive take-up with research institutions – its client list includes Stanford University's AIMS and the Institut Henri Poincaré – and also with individual researchers, who can retain their personal professional profiles and connections even if they change jobs. "Individuals bring life into the platform," says Dr Simon. "As soon as they started to see how many people were reading their papers, commenting on them and sharing their work, they were hooked."

A democratisation of science

Luxembourg's LBMCC (Laboratoire de biologie moléculaire et cellulaire du cancer) is a privately-funded cancer research laboratory specialising in early detection and differentiation therapy. The lab, which is based at Kirchberg Hospital, works in close collaboration with universities in Europe and other international research institutions. LBMCC makes full use of Polaris as a platform for its research publications,

"Luxembourg is at the centre of Europe, a truly multilingual country offering plenty of opportunities for entrepreneurs."

Virginie Simon

opening them up to the 500,000-strong global MyScienceWork network and widening opportunities for peer review and offers of collaboration. In addition, its findings may feature on OmniScience, MyScienceWork's popular science pages, which promote the dissemination of scientific knowledge and the democratisation of science.

The Polaris database currently hosts around 60 million scientific papers from over 2,500 repositories and publishing houses. Of these, over 25 million are open access papers, free of charge to any MyScienceWork user. A recent partnership agreement between MyScienceWork and DeepDyve has gone some way to reducing the cost of paid access, down in some cases to under a dollar a day for the right to browse the millions of articles available.

The agreement with DeepDyve came as a result of Dr Simon's work in Silicon Valley, where MyScienceWork recently set up a new office with Luxembourg government support. Dr Simon is keen to develop better scientific contacts between Europe and the USA, and her efforts have been very well received. In the world of democratised, freely available, non-hierarchical scientific knowledge, there is no place for borders.

MyScienceWork

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www.mysciencework.com

CROSSING BORDERS WITH NEW FINTECH

As a world-class financial centre with technological expertise and a cross-border mindset, Luxembourg is uniquely placed to both contribute to and benefit from the fintech revolution. Fintech is a priority growth area for industry and government, and according to the Luxembourg Bankers Association, at least 80 local fintech companies are working on new ideas and technologies that could bring a range of very interesting new developments to the financial sector.

"The success of Luxembourg's financial sector is due to its unique ability to find cross-border solutions," says Marc Hemmerling of the Luxembourg Bankers' Association (ABBL). It is almost certainly true that the country's small size has led it to develop the international skills and ICT expertise that contribute so strongly to its investment funds, wealth management, insurance products, pensions, reinsurance, renminbi business, Islamic finance, microfinance and philanthropy.

"Luxembourg is an excellent place to conduct groundbreaking work, as the country is so used to financial innovation."

Laurent Kratz

"Fintech is the latest wave of innovation, embracing recent concepts such as crypto-currencies and payments, digital onboarding of customers, Big Data and the online distributed ledger technology known as blockchain," adds Mr Hemmerling. It is also about expanding and developing the type of financial services on offer. Some fintech companies are attempting to challenge incumbents; others are finding more efficient ways to supply services. Three Luxembourg-based start-ups – Nowina, Scorechain and KYC3 (see page 21) – have elements of both.

Unique approach to eSignatures

David Naramski is a partner at Nowina Solutions, which offers solutions incorporating eSignature, enabling clients to provide legally binding, verifiable electronic approvals from a PC, tablet or smartphone. "This digitalisation is central to our services," says Mr Naramski. "A great deal of our clients' work is carried out digitally, but approvals need printed paper and written signatures and this slows everything down. eSignature solutions remove this physical step and streamline the full process for maximum efficiency."

The eSignature can be linked to national ID cards, passports, security tokens and various other identification methods used worldwide, giving it considerable flexibility. It can be applied to transactions of any size and between any parties – consumers, companies, groups or business partners – as well as to eGovernment services. In addition, the level of proof required can vary, from relatively light for day-to-day approvals to much stronger for major

contracts. "This improves efficiency and trust between partners and clients and contributes to citizen engagement with governments," says Mr Naramski.

Where technology meets knowledge

While technical innovation in cryptography and security is behind the availability of new tools such as these, they would not work in the absence of significant commercial knowledge and a clear understanding of different legal codes. "Working in Luxembourg makes a huge difference," says Mr Naramski. "In a big country there is a tendency to focus on the national market, but the cross-border expertise available here has been a great help in developing solutions for international applications." In fact, Nowina has relatively few clients operating solely in Luxembourg. Although set up only two years ago, it already has around €1m turnover from a roster of ten clients that includes EU institutions, national governments, insurance companies and banks. All of these are cross-border operations.

Nowina Solutions offers both standard products and made-to-measure solutions. Naturally, close cooperation with clients is essential, and a base in Luxembourg makes it easy to meet customers and discuss their needs. Another factor is the country's multinational workforce, a strong advantage for companies developing products for international markets. Nowina has three managing partners, two Belgian and one Luxembourgish, and its ten employees are drawn from both Luxembourg and neighbouring countries.

Adding value to Bitcoin

The virtual currency system Bitcoin functions because its users trust the comprehensive transaction information provided on the publicly-accessible online ledger Blockchain. Luxembourg start-up Scorechain, based in the Belval innovation zone, is developing a range of tools to enable companies and individual users to track their Bitcoin activities and monitor their holdings. An option to generate

"The cross-border expertise available here has been a great help in developing solutions for international applications."

David Naramski

detailed analytical activity reports will also assist virtual currency operators to comply with regulatory requirements.

While there has been concern about the use of Bitcoin in crime, its advocates point to the fact that virtual currencies are simply a private sector, online version of the traditional "fiat" currencies which are guaranteed both by state institutions and in law. Scorechain CEO and co-founder Pierre Gerard is confident that fears are exaggerated: "Cash is completely anonymous," he says, "but the blockchain provides real transparency about how the currency is being used."

Scorechain is also working on products designed to develop smart contracts, computer protocols that trigger virtual currency transactions as soon as an event occurs. Proponents claim that these could revolutionise the financial industry, allowing trades and payments to be made instantly online without passing through an intermediary.

A FINTECH FORERUNNER

"We were fintech experts before anyone even came up with the name," says Marc Hemmerling of the Luxembourg Bankers' Association (ABBL). "Luxembourg has been open to innovative ideas for decades, and our financial firms have developed sophisticated unique high-tech ICT systems." PayPal has had a full banking licence here since 2007, and Amazon Payments Europe has been operating in Luxembourg for several years.

"We were fintech experts before anyone even came up with the name."

Marc Hemmerling

Making it happen

"Luxembourg is an excellent place to conduct groundbreaking work like this, as the country is so used to financial innovation," says Scorechain's other co-founder Laurent Kratz. In fact, Luxembourg was one of the first countries to recognise the legitimacy of virtual currencies; its Financial Sector Surveillance Commission (CSSF) began regulating them early in 2014. Meanwhile, Scorechain is also working with major players in the Luxembourg investment fund sector to define whether blockchain can be used for complex functions related to transfer agency, custodian services and know-your-customer registers.

According to Mr Hemmerling of the ABBL, there are over 80 fintech companies in or around Luxembourg that could be of interest to the banking community, plus more operating in other sectors. Changes are afoot, and Luxembourg has a vibrant ecosystem of local players working to make them happen.

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FINDING INTELLIGENCE IN DATA

Failure to complete "know your customer" (KYC) checks can cost financial firms dear, with fines of €1bn or more not uncommon for doing business with customers on international criminal and terrorist blacklists. The financial industry desperately needs an alternative to the expensive, largely manual background checks that can take up to a month for a single client. Luxembourg-based KYC3 is attracting clients from Switzerland, France and the UK with its own fully-automated instant solution.

High-tech Luxembourg firm KYC3 has developed an application that continually monitors around 55,000 online news sites, national company registries, international blacklists and other reliable information sources. The data obtained is used to populate a dynamic, intelligent database which provides instant responses to client searches. The service currently offers around 120 million records of people, companies and addresses of potential interest to KYC departments, and the company intends to expand this to include listings for every individual, organisation and address that appears online or in official publications.

Unravelling Big Data at speed

"Our core product reads text like a human being, in the sense that it can quickly unravel the 'who, what, when, and where' context of a range of documents," says CEO Jed Grant. "It scans public information on the web, as well as other online sources that are harder to access. The difference

> **"Our core product reads text like a human being, in the sense that it can quickly unravel the 'who, what, when, and where' context of a range of documents."**
>
> Jed Grant

with our system is that it can read and evaluate volumes of information in seconds rather than years."

When a KYC3 client runs a search on the database, the system returns a highly-detailed document about the person under scrutiny, with links to each source of information. This allows KYC3's clients to assess the results for themselves, thus avoiding false positives and ensuring that no-one is wrongly identified as a problem customer. Companies also have the option to connect the KYC3 database to their own customer relationship management system, allowing them to continue to monitor their current customers' activities.

Extending resources

Clients tend to use the KYC3 application as an add-on to the various sources they already use to perform background checks and demonstrate proper due diligence to the regulatory authorities. The database can also provide intelligence about potential clients' philanthropic, artistic or sporting interests, enabling financial advisors and wealth managers to suggest services tailored to individual interests.

A supportive environment

Although the company was only founded in 2014, it is already making waves outside Luxembourg. The KYC3 project was one of only eight selected from 140 applications to join the BNP Paribas Group's L'Atelier technology and innovation advice and support programme, and the only non-French operation chosen.

Mr Grant gives Luxembourg full credit for the support provided during the company's start-up phase. "With the help of Luxinnovation, I presented my proposals to the Ministry of the Economy before we even launched," he says. "They were impressed by my preparatory work on algorithms and coding, and offered substantial research and development support." The company also obtained a place at the lux future lab, an ICT-focused business incubator.

Further ambitions

With local and international clients already on board, Mr Grant has no complaints about progress so far, but also no intention of treading water. "We want to create a fully outsourced KYC service, where you input the customer's name and receive a definitive answer about their identity," he says. Theirs is not the only organisation working to build complete service "KYC utilities", but according to Mr Grant, KYC3's technology-driven approach has a better chance of succeeding than top-down consortium-driven efforts.

The company is seeking a further capital injection to finance this next stage. "Luxembourg is already home to an important financial services utility, the international clearing and settlement house Clearstream," says Mr Grant. "Why not do something similar with KYC?"

KYC3

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SMART APPLICATIONS MADE IN LUXEMBOURG

Two Luxembourg companies are using Internet of Things-enabled technology to develop apps that can directly contribute to health, safety and possibly even personal finances. Telematics spin-off Motion-S has released a smartphone app that helps drivers improve their skills, while Airboxlab's Foobot measures pollutants in indoor air and provides advice on how to combat them.

"Telematics solutions combine computer science, telecommunications, electronics and vehicular and transport technologies," says Motion-S co-founder Dr Raphael Frank. "Our leading product is a smartphone app which helps drivers handle their cars more safely and efficiently. It's a bit like a game – it measures your braking, speed, acceleration and so on, tells you your score and provides feedback to help you improve it."

Motion-S is one of the spin-offs set up to commercialise ideas emerging from research at the University of Luxembourg's Interdisciplinary Centre for Security, Reliability and Trust (SnT). It was the first company to receive a National Research Fund Proof of Concept grant, which it used to finance the development of the initial prototype. It was also able to take advantage of the hosting available at the non-profit business incubator lux future lab.

Internet of Things

The Internet of Things (IoT) refers to the ever-expanding number of internet-enabled physical objects and the networks that connect them. It encompasses a wide range of objects and systems, among them industrial plants, power stations and grids, healthcare facilities, transport systems and consumer goods. It enables the exchange and control of information between objects and human beings, or between the objects themselves.

Optimising insurance costs

The safe driving app may also help to reduce its users' insurance premiums. Motion-S is working with insurance companies to allow drivers to link their policy charges to their app scores. "To comply with local data protection law, only the aggregate score – not the specific data – is revealed to the insurer," says Dr Frank.

Motion-S telematics solutions, among them driver training and vehicle health monitoring, can also be applied to fleet management. Fleet analytics on offer range from basic usage statistics to customised data visualisation.

A guardian of air quality

Airboxlab CEO and founder Jacques Touillon named Foobot, a smart indoor air quality monitor, after the 'foo' lion statues that stand guard over China's imperial palaces, tombs and temples. "I think of it as a modern-day guardian for homes and offices," he says. The inspiration for Foobot came to him when his young son developed baby asthma. "I felt helpless, as I didn't know the cause. The experience made it obvious that indoor pollution exists and has consequences, but at the time there was nothing to measure it except expensive gadgets that gave only a single reading."

Mr Touillon realised during the course of his research that air inside a building frequently contains even more pollutants than the air outside. With the emergence of modern sensor technology and the Internet of Things, he was able to develop a device that can assess indoor air quality. The Foobot sensors measure temperature and humidity and detect levels of volatile organic compounds such as formaldehyde, benzene, xylene and toluene as well as particulate matter and carbon dioxide. The results are transmitted to the user's smartphone along with personalised advice on ways to remedy problems.

"We chose Luxembourg on the grounds of its total commitment to innovation and support for the whole start-up spectrum."

Jacques Touillon

"Our leading product is a smartphone app which helps drivers handle their cars more safely and efficiently."

Raphael Frank

Smart networks

Airboxlab initially considered France and Germany as a base, but chose Luxembourg on the grounds of its "total commitment to innovation and support for the whole start-up spectrum." Mr Touillon connected with a business angel after only ten days at the Technoport business incubator, and later set up a partnership with researchers at the Luxembourg Institute of Science and Technology (LIST) to develop predictive analytics on the pollution data gathered by the device.

Foobot can be purchased online and connected to other smart appliances and systems, including the Nest Learning Thermostat, Amazon's Echo voice control system and the web platform IFTTT, which links web services and smart devices. Mr Touillon and his sixteen-strong team are now working to position Foobot "not as a 'nice to have' but a 'must have'".

Airboxlab

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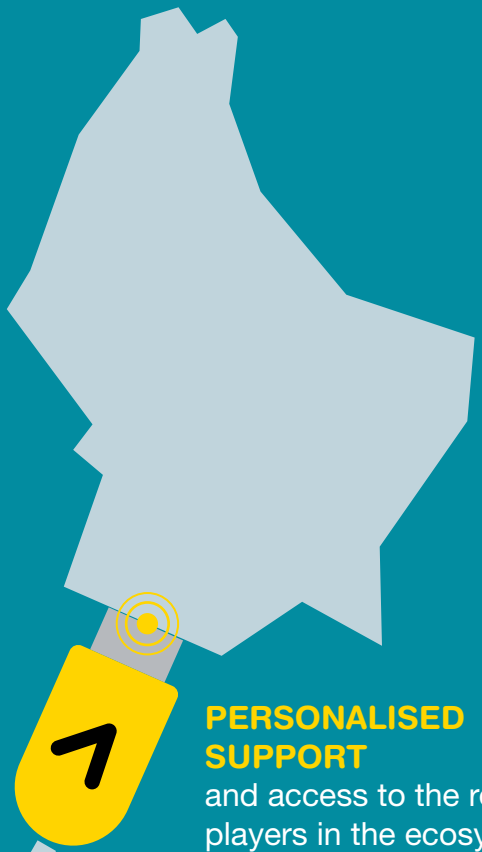
Luxembourg ecosystem for ICT start-ups



PERSONALISED SUPPORT
and access to the relevant players in the ecosystem

Public and private
BUSINESS INCUBATORS
and co-working spaces

Tailor-made
accelerator programme
FIT FOR START

AWARDS and PITCHING COMPETITIONS
Visibility and financial rewards

Free-of-charge
COACHING AND ADVICE
Business plan, mentoring, formal procedures

FUNDING
Government R&D and innovation grants
Digital Tech Fund
State bank loans
and participating interest

PRIVATE INVESTMENT
Business angels and venture capital investors

State-of-the-art
ICT INFRASTRUCTURE
Data centres, low latency hub, data protection laws

Close connections with the
FINANCIAL SECTOR

Multi-modal
LOGISTICS HUB

Multicultural, multilingual
WORKFORCE

INTERNATIONAL NETWORK
Partnership with
Silicon Valley accelerator,
Luxembourg Trade
and Investment Offices

LUXEMBOURG ICT CLUSTER
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COACHING, FUNDING, SUCCESS

The best high-tech start-ups will have at least one brilliant idea, some very impressive skills and a certain amount of courage. Even so, it can be difficult to find the best way to package, present and promote a new service. The aim of Luxinnovation's new Fit for Start programme is to help fledgling ICT companies overcome early hurdles and develop into successful, sustainable businesses.

"Our aim is get start-ups on the right track," explains Programme Manager Antoine Hron. "We have always supported new business, but young ICT companies have to move like the wind to get their prototypes out to the market. We realised there was a lot we could do to improve their chances in this extremely competitive and fast-moving area."

Fit for Start is an intensive 16-week programme that targets Luxembourg-based companies with a strong innovative idea and high development potential. It offers weekly coaching by Lean Start-Up experts and a €50,000 Ministry of the Economy grant. To qualify, at least one team member must work full-time on the programme and the company needs to secure €10,000 of its own equity in advance.

Long-term viability

Participants are admitted through calls for projects, with the final selection decided by a jury of experienced entrepreneurs. "Our first open call attracted 100 applications,"

says Mr Hron. "The quality of the projects amazed us – we had no idea there was so much latent potential, and this reinforces our conviction that Luxembourg is well-positioned to attract start-ups."

Fit for Start guides companies through the process of identifying their first clients, creating a "minimum viable product" and validating it with customers. "In my opinion, the most important thing we do is help participants ensure their business model is viable over the long term," says Mr Hron. One example is Houser, an online platform providing real estate analytics. Launched as a service for individuals, it initially failed to make progress, but during Fit for Start it switched to a B2B model targeting real estate agents. The new approach has led to a partnership with Luxembourg's real estate chamber, a financial injection from its first external investor, web project accelerator Linc, and real prospects for international expansion.

Client-centred environment

"The key is knowing your clients and being able to explain exactly why they need your product," says Mr Hron. "We help our participants to make a systematic analysis of their first clients' feedback and then to use that to figure out what is and isn't working. They also have various opportunities to pitch their projects to different audiences, which gives them practice in presenting briefly and convincingly and helps them develop their negotiating skills. We constantly stress that the whole process is about the client, not the technology."

"The most important thing we do is help participants ensure their business model is viable over the long term."

Antoine Hron

Vincent Pedrini is co-founder of Nomoko, which is aiming to map the entire world in 3D models for use in virtual and augmented reality. The company is developing a compact camera that can capture extremely high resolution images and a software application to transform those images into 3D models so lifelike that the human eye perceives them as real. "There are a lot of potential customers for our product," says Mr Pedrini, "but Fit for Start showed us we had to define which of them needed it most. We realised we should target the new entertainment industry and aim our first release at the major gaming and animation studios."

Nomoko has developed two proofs of concept and its hardware team is working on the camera design. "We want to collaborate with the best, and are signing an agreement with a Japanese original equipment manufacturer," says Mr Pedrini. "By the end of 2016, we aim to have built a prototype that we can state is the best camera in the world." The hope is to sign the first client contracts by mid-2017.

Luxembourg as a platform

Nomoko was originally set up in Switzerland, where its R&D team is located, but decided early on to establish a presence in Luxembourg. "We want to sell data, so we need high-speed connections and data centres that can be accessed by clients all over the world," says Mr Pedrini. "Luxembourg combines excellent infrastructure with good data legislation and is an ideal platform for accessing the European market."

Other factors influenced this decision; two of the company's three founders are from Luxembourg, over 50% of its initial funding was provided by Luxembourg investors and one of Europe's few supercomputers is hosted at the University of Luxembourg campus in Belval. "The Luxembourg embassy in Tokyo was incredibly helpful when we were setting up our partnership in Japan, and Luxinnovation gave us the opportunity to be part of an official state visit to Finland," says Mr Pedrini. "I strongly doubt a young start-up would get this kind of support anywhere else."

> “I strongly doubt a young start-up would get this kind of support anywhere else.”
>
> Vincent Pedrini

Applying to Fit for Start was a natural decision for Nomoko. “As a start-up founder you tend to run, and sometimes you need to refocus. Getting an external view from coaches you speak to at least once a week is very valuable,” says Mr Pedrini. “We also appreciate being part of a community of Fit for Start participants. We support and advise each other, and I think that will continue after the end of the programme.”

Growth, growth, growth

The next step for Nomoko is to raise funds to finish developing its technology. The Ministry of the Economy offers an additional €100,000 to start-ups that have both successfully graduated from Fit for Start and managed to raise at least €50,000 private equity. “This might not be enough, but improves participants’ growth perspectives in the medium and long term,” says Mr Hron, with a reminder that Luxembourg also offers complementary instruments such as the Digital Tech Fund.

Mr Hron’s vision for the future can be summarised in three words: growth, growth and growth. “We want to increase the number of applications and make the programme much better known internationally. At first, most of the participants were from Luxembourg and the surrounding countries, but we are working to make sure that good applications from further away won’t be blocked by unnecessary red tape. We also strive to enhance the programme content and to expand the network of partners that can open new doors for the start-ups.”

FIT FOR START

Fit for Start targets ICT start-ups that are either in the process of forming a company or were incorporated in Luxembourg less than 12 months before joining the programme. Participants must have a business concept with an innovative slant and a team of at least two people. The programme offers:

- 16 weeks of expert coaching in Lean Start-Up, a structured methodology for rapid product and service development;
- free access to co-working space in a business incubator;
- a grant of €50,000, to be matched by €10,000 of equity.

www.fitforstart.lu

Luxinnovation

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INVESTING IN INNOVATION

Luxembourg has created a new €20 million fund to provide critical venture capital support for promising early-stage high-tech start-ups. Backed by a high profile public-private partnership that includes the Ministry of the Economy, the Digital Tech Fund is part of a determined drive to diversify the economy and carve out a prominent role in global ICT.

The Digital Tech Fund was launched in April 2016 to back ICT start-ups in areas such as cybersecurity, Big Data, fintech, digital health, the Internet of Things and next-generation communications networks. The Ministry of the Economy, which has contributed €5 million, is leading a partnership that includes the state investment bank Société Nationale de Crédit et d'Investissement (SNCI), Arendt & Medernach, Banque Internationale à Luxembourg (BIL), SES, POST Capital, High Capital, Proximus and fund manager Expon Capital.

"The fund will fit in well alongside programmes designed to support ICT entrepreneurs, such as Fit for Start," says Michele Gallo of the Ministry of the Economy. "It is an element of the Digital Lëtzebuerg initiative to promote the diversification of Luxembourg's economy, which at present relies heavily on the financial services sector. In addition, the fund will work closely with the University of Luxembourg's Interdisciplinary Centre for Security, Reliability and Trust (SnT) to support the creation of successful research spin-offs."

"The fund will begin by selecting three or four companies a year and investing a minimum €100,000 in exchange for a 20-30% stake."

Jérôme Wittamer

Tough competition, long-term support

The fund is managed by Expon Capital and targets innovative companies up to seven years old that have produced a working prototype of their product or service. Managing Partner Jérôme Wittamer explains: "The fund will begin by selecting three or four companies a year and investing a minimum €100,000 in exchange for a 20-30% stake. Companies that continue to perform to our expectations will receive further investment over time of up to €1.5 million."

The fund manager has a straightforward approach. "We meet the team and examine the value proposition," says Mr Wittamer. "If the company looks promising, we will perform due diligence, make the investment and in most cases, take a seat on the board. Expon has decades of experience and has developed a global network of experts, so we are in a position to make useful introductions."

The Digital Tech Fund is now operational and applications can be made via the website or by contacting the Expon Capital team. "We expect the Digital Tech Fund to be a success and to make a significant contribution to the further development of a vibrant start-up ecosystem in Luxembourg," concludes Mr Gallo.

Digital Tech Fund

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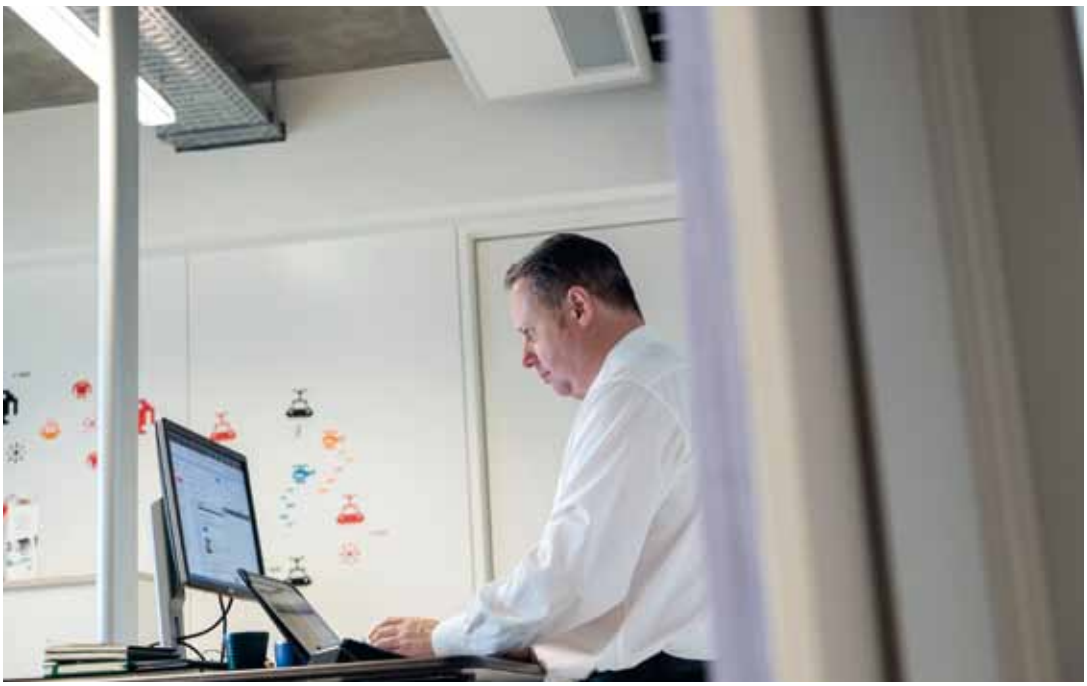
www.digitaltechfund.lu

EXTRACTING ORDER FROM CHAOS



It is virtually impossible to describe or even imagine the sheer volumes of data generated in the course of medical and pharmaceutical research. On top of that, none of it can be put to practical use until it has been properly organised and evaluated. The Bioinformatics Core, a computational research group at the Luxembourg Centre for Systems Biomedicine, is working with its spin-off company ITTM to ensure that every ounce of value is extracted from this vital information.

The Luxembourg Centre for Systems Biomedicine (LCSB) is one of two interdisciplinary research centres at the University of Luxembourg. Its staff comprises biologists, medical doctors, physicists, mathematicians and computer scientists, working in collaboration to advance biomedical research by closing the link between systems biology – basically, the modelling of complex biological systems – and medical research.

Filtering the tornado

The role of the centre's Bioinformatics Core is twofold. First, it deals with the physical handling and storage of massive volumes of data; as with all modern life sciences organisations, a huge proportion of its budget goes on processors and hard disks. Second, it develops and deploys computational systems that can link data flows from diverse teams of researchers and interpret and analyse their findings. "This involves the creation of automated workflows that filter the data so that we can focus on the

interesting bits and not waste time on the rest," says Dr Reinhard Schneider, the group's Principal Investigator. He adds that his team works "inside the tornado," where one tornado is equal to the Petabytes (10^{15} bytes) of data generated by contemporary medical research studies.

Technology and translational medicine

The work of Dr Schneider and his team has led to the creation of a commercial spin-off, Information Technology for Translational Medicine (ITTM). The company, which was founded with the assistance of Luxembourg's Ministry of the Economy and Luxinnovation, is based at the Technoport business incubator in Esch-Belval, conveniently adjacent to the LCSB.

Managing Director Andreas Kremer explains: "Translational medicine is a field in biomedical research that uses an interdisciplinary, collaborative methodology to develop new treatments and diagnostic tools for disease. It's called a 'bench to bedside' approach." He stresses that the company provides services, not products, all designed to support the optimisation and management of preclinical and clinical data: "The clients we are interested in are researchers, clinicians and the IT managers who work in the health care and pharmaceutical industries."

Data curation

Poor data readiness is a common issue when dealing with massive amounts of complex, non-standard raw data. "Billions of dollars are spent collecting data, but much of that data is wasted because it is not standardised, or it contains input errors, or it is not fully valorised," says Dr Kremer.

> **"ITTM can help extract the full value from data and increase its lifespan."**
>
> Andreas Kremer

ITTM offers various services to resolve these types of problems, including data curation tools to check for input errors and mapping applications to bring the data into conformity with industry standards.

A further issue is longevity. According to Dr Kremer, "Once used for a specific purpose, data is simply abandoned and much other useful information is lost. ITTM can help extract the full value from data and increase its lifespan." The company can link study data with a customised knowledge base derived from public databases and research literature, and implement electronic data collection, including study descriptions and other relevant information in the form of metadata. With ITTM support, data is standardised, easier to analyse and useable for a longer period of time.

Attractive location

Luxembourg's high-quality IT infrastructure and strict data privacy laws make it an attractive location for data services and ITTM has entered into partnership with POST Luxembourg's Teralink to offer platform setup services and data hosting, backup and archiving.

ITTM also offers a range of analytical tools for data visualisation and disease map development, some of which have already been used to develop maps for Parkinson's disease and Alzheimer's. For data management, ITTM uses tranSMART, a global, open source, industry-standard biomedical knowledge management platform. Dr Kremer notes that the LCSB is itself a tranSMART Centre of Excellence.

Dr Kremer, who is part of an ISO working group developing industry data standards, is convinced that not only medical research units and pharmaceutical companies but also hospitals and biobanks will begin to look to ITTM for clinical data services. As he says, "We will not be running short of data to work with anytime soon."

ITTM – Information Technology for Translational Medicine

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Do you have great business ideas, but not the means to realise them ?

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A HOME FOR GIANTS

The European headquarters of eBay, which manages online auction and shopping website eBay.com, are located in the centre of Luxembourg City. The same building also hosts the European HQ of former eBay subsidiary PayPal, one of the world's largest internet payment companies. PayPal has been run as an independent company since 2015 and has a staff of around 90 people in Luxembourg.

www.ebay.com
www.paypal.com


Microso

The best things about Luxembourg are the easy access to decision makers and the highly skilled people from a variety of cultures – exactly what's needed in high-velocity industries.

Candi Carrera, Country Manager, Microsoft Luxembourg

Skype first came up with its revolutionary voice-over-internet concept in 2003. In the same year, it established a company, secured its first investment from Luxembourg firm Mangrove Capital Partners and set up its headquarters in Luxembourg City. Microsoft, which acquired Skype in 2011, has a separate Luxembourg subsidiary employing around 70 people.

www.microsoft.com
www.skype.com

US e-commerce and cloud computing giant Amazon set up its European headquarters in Luxembourg in 2005. Over 1,000 staff are based here, running Kindle Direct Publishing, Amazon Web Services and various business IT solutions for the European market. Amazon's commercial, legal, human resources, marketing, marketplace support and IT management departments are also based in Luxembourg.

www.amazon.com

Luxembourg is a great place to live with excellent infrastructure and a pleasant natural environment, situated right at the heart of Europe. These considerations, combined with other business criteria, such as the highly educated and multilingual Luxembourg workforce, made us decide to establish our European headquarters here.

Xavier Garambois, Vice President EU Retail

AN HPC REVOLUTION FOR EUROPE

High Performance Computing (HPC) is revolutionising industry and digital business across the world, but Europe has been lagging behind. Now, Luxembourg is taking a leading role in a Europe-wide initiative to build the world's most powerful HPC infrastructure and to develop Big Data-enabled solutions for industry and research. Mario Grotz, Director General for Research, Intellectual Property and New Technologies at the Ministry of the Economy, and Johnny Brebels, Luxinnovation's Head of Sector Materials & Production Technologies, explain.

Why is high-performance computing so important for Europe?

Johnny Brebels: First, because HPC can transform industrial production. Creating a new product the traditional way means building a physical prototype, running a series of tests, building a second prototype, and so on. This is fine, but swallows significant time and resources. With computing, we can model the product and its operating environment down to the last detail, run test simulations and find and correct malfunctions. Only then do we start on the physical prototype. The end result is a much better and more competitive final product at the cost of far fewer resources, but because the models are so complex, we need incredibly fast and powerful computers to run the simulations.

Second, we need massive computer power for the analysis of Big Data, meaning data sets too large or complex for traditional data processing. We can use the information extracted from Big Data to make better decisions and improve products and services. More and more products, systems and environments are equipped with data capture sensors, and the intelligence from these can help us to develop smart systems that can analyse a real-life situation and take action where needed. For instance, we could build infrastructure for the road system that can detect a vehicle in a hazardous situation, send out a warning to surrounding vehicles or even take steps to prevent a collision.

Mario Grotz: We need both HPC and Big Data applications to maintain the competitiveness of our industry and our research organisations. As we stand, Europe is falling behind China and the US. Of the world's top ten supercomputing facilities, only one is in Europe, and even that was built with non-European components. There is a race on to develop the next generation of HPCs, which will run a thousand times faster than any machine available now. We have to catch up, we have to take an active part and we have to start benefiting economically from HPC-enabled applications.

How did the idea for an HPC project emerge in Luxembourg?

Johnny Brebels: HPC has been on Luxembourg's agenda since 2009. Research and development is fundamental to our economy and it is essential that we have the tools we

need for continued progress. As an example, the Luxembourg Centre for Systems Biomedicine uses the University supercomputer for complex dataset analysis. This is working well for now, but research needs will inevitably outstrip available processing capacity in the relatively near future. There's a similar situation in industry. Luxembourg-based companies such as tyre specialist Goodyear and automotive component producers Delphi and IEE of course use modelling and simulation techniques in their work – HPC and Big Data capabilities could lead them in fascinating new directions.

Mario Grotz: For the past several years, the Ministry of the Economy has been working together with Luxinnovation, relevant public sector organisations and private companies on a project to design a world-class HPC infrastructure for Luxembourg and to analyse ways of implementing and financing it over time. In the course of this process, the emphasis gradually shifted away from the high-performance computer itself and towards the country's needs in terms of HPC services and skills.

The proposed HPC project garnered huge interest from Luxembourg-based multinational companies and academics, and the government became convinced of the need to act. While we did include the project in the Digital Lëtzebuerg strategy, it became clear that it was simply not feasible to implement that level of infrastructure in a single European country. We therefore held discussions with the

As soon as the new infrastructure is up and running, we will put it to practical use in large-scale pan-European projects.

Johnny Brebels

European Commission with a view to fitting such a project into the wider European strategy, and presented the idea of a pan-European approach to the EU Council of Ministers in late 2015. We have since then joined forces with Italy, France and Spain, and in January 2016, launched a four-way

- **Important Projects of Common European Interest (IPCEIs)** are major projects that make a significant contribution to economic growth, jobs and the competitiveness of the European industry and economy.
- A **High Performance Computing (HPC)** infrastructure integrates HPC capability, high-speed connectivity and leading-edge data and software services.
- **Exa-scale**: the capacity to perform one billion billion calculations per second.

Important Project of Common European Interest (IPCEI) on HPC and Big Data-enabled applications.

What is the aim of the Important Project of Common European Interest?

Mario Grotz: Firstly, to develop HPC and data management technology. We aim to put in place a robust Europe-wide computing and data infrastructure supply chain, developing technologies in the course of this process that will serve as the basis for implementing the e-infrastructure itself. Each stage – from design and development through to implementation – will be achieved through European industry partnerships, with the ultimate aim of making Europe one of the world leaders in computing, data storage and secure data transport. The current generation of supercomputers has been built with research needs in mind – our ambition is to create an industry-oriented HPC infrastructure that, while available for the use of research and government institutions, will focus mainly on commercial applications of direct benefit to European economies.

Johnny Brebels: As soon as the new infrastructure is up and running, we will put it to practical use in large-scale pan-European projects. The plan is to set up ten pilot test beds and invite companies, research institutions and government bodies across Europe to work together on developing HPC solutions for smart city, smart energy, smart mobility, smart manufacturing, personalised medicine and other applications. Luxembourg aims to take the lead in the areas of fintech and smart space. We are confident that the outcome will be applications that go far beyond what even large groups could develop working alone. There will also be plenty of opportunities for SMEs able to develop specialised solutions and plug gaps in the value chain.

What time frame are you working with?

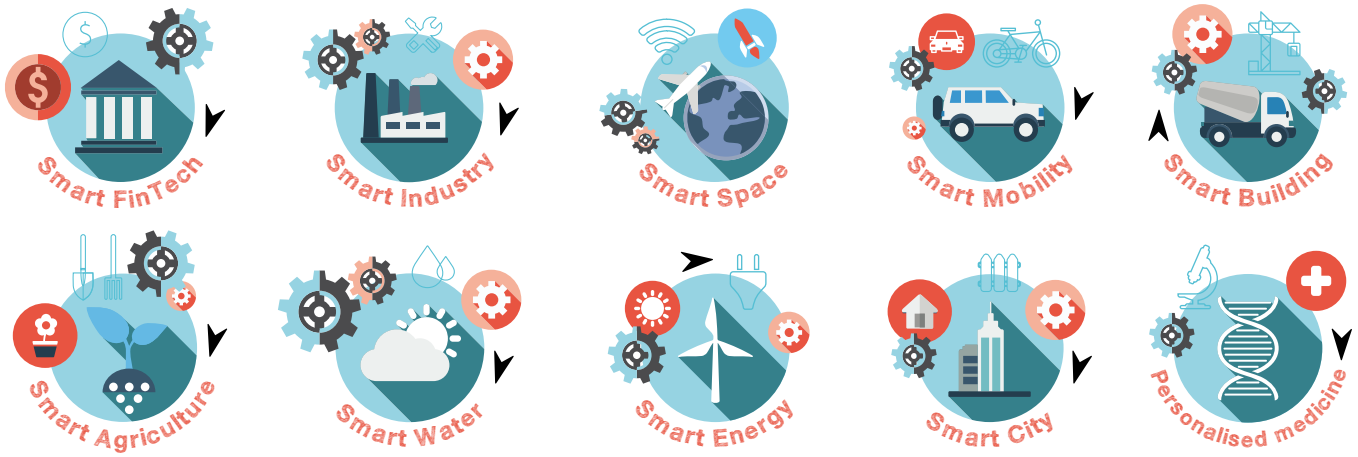
Johnny Brebels: The Ministry of the Economy, Luxinnovation and the Luxembourg Institute of Science and Technology (LIST) are currently heading the planning work in Luxembourg, with input from industrial partners. At present, we are finalising the European HPC roadmap with our colleagues in France, Italy and Spain and the European Commission, and this will serve as a basis for starting the detailed work programmes in early 2017.

Mario Grotz: During the period 2018-2020, a large proportion of the funding will be met by Horizon 2020, the EU framework programme for research and innovation. We expect to have the first high-performance computer up and running by 2018, but will continue to develop the core technology and exa-scale microprocessors for four years after that. By 2022, our target is to have one of the three most powerful HPC infrastructures of its type in the world.

What is the advantage of doing this at cross-border level?

Mario Grotz: In the past, there has been little coordination in this field, and European investments have gone into somewhat disparate projects with relatively small budgets. With the IPCEI, we aim to combine national, regional and European funding with private finance to make a very substantial, targeted investment. EU funding will come mainly from Horizon 2020, as mentioned, but also from the Juncker plan for investment in Europe, the European Structural and Investment Funds and the Connecting Europe Facility.

Johnny Brebels: Working together will also enable us to combine our data and expertise. Europe is the largest



Big Data-enabled solutions for industry and research

global producer of scientific data, but the data is often stored in national silos and therefore difficult to access across borders. The data from the large-scale pilots will, however, be accessible throughout Europe, albeit sometimes consolidated and anonymised to comply with privacy laws. The IPCEI will make a huge contribution to a single European digital market, and help science and technology professionals to store, share and reuse their data in new ways across borders and between different disciplines.

Does Luxembourg have what it takes to play a leading role in this initiative?

Mario Grotz: Absolutely. We have an enviable track record of fostering international cooperation in the business, research, institutional and political arenas. Our country is of manageable size and we can make fast decisions, enabling us to run large projects smoothly and effectively. Luxembourg can call on substantial high performance infrastructure and expertise: we have top notch data centres and our data transmission network has one of the lowest latencies in Europe, essential for storing and accessing huge quantities of data. We have the foundations on which to base a supercomputer project, and we are keen to mobilise our resources.

Johnny Brebels: We can also contribute the solid cybersecurity and data protection expertise we have developed over decades in the financial sector. Europe's position at the cutting edge of technological achievement is of huge benefit to our country. The more cross-border business using the latest technology, the better for ourselves and our neighbours in terms of economic growth, employment and competitiveness. Luxembourg is determined to be at the forefront of innovation in this new digital economy.

Our ultimate aim is to make Europe one of the world leaders in computing, data storage and secure data transport.

Mario Grotz

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ENTREPRENEURSHIP AND INNOVATION NEWS

IMAGE RECOGNITION TECHNOLOGY MONITORS BRAND PRESENCE

Talkwalker, one of the world's leading business social media intelligence platforms, has launched a proprietary image recognition technology able to detect over 30,000 company brand logos in images posted on social networks and other internet sites.

Unlike traditional social media monitoring platforms, Talkwalker searches for, identifies and analyses potential brand logos in the estimated 1.8 billion images shared daily on 10 social media and 150 million other sites. The technology, which was developed by Luxembourg-based Trendiction, offers companies a new level of accuracy in the monitoring of online visual presence.

www.talkwalker.com

FIRST FUTURE FUND INVESTMENT IN CYBERSECURITY FUND

The Luxembourg Future Fund has made a €20 million investment in a new cybersecurity fund, Paladin European Cyber Fund. This is the first investment by the fund, which is designed to attract innovative companies and entrepreneurs to Luxembourg and so encourage diversification and sustainable development. The Luxembourg Future Fund was set up in 2015 with backing from the European Investment Fund and Luxembourg public-law banking institution SNCI. It has €150 million over a five-year period to invest or co-invest in venture capital funds and in European SMEs active in ICT, cleantech and other technology sectors.

www.eif.org/what_we_do/resources/lff

FIRST EUROPEAN BITLICENCE FOR PAYMENTS START-UP

Luxembourg-based start-up SnapSwap International has become the first company in Europe to obtain a bitLicense to offer virtual currency payment services to companies and individual users in the European Union. The licence, issued by the Luxembourg Ministry of Finance, allows the company to provide payment, remittance and currency exchange services based on modern cryptographic technologies and internet protocols such as blockchain and open ledger consensus.

SnapSwap financial products include the Gloneta app, which allows users messaging someone to transfer money to them during the conversation from the same chat screen. The system uses blockchain technology to make the payment in real time. It can also convert the transfer into the recipient's preferred currency, making it possible to effect international money transfers without additional costs.

www.snapswap.eu

ROUGH CLIP TO MOVIE IN ONLY THREE CLICKS

Almost 90% of raw footage taken with smartphones, action cameras and drones is never used, mainly because of the time and skill required to edit it into attractive sequences. Start-up company HEEWOZ has released Klap, an iPhone app that converts video clips into movies with only three clicks. From any number of video clips chosen by the user, Klap selects the best moments, synchs them to the music and adds high-quality effects at precisely-selected points.

The entrepreneurs behind the new app are French, but chose Luxembourg as the launchpad for Klap. The company has a highly specialised team which has developed an ambitious R&D strategy to target the world's current 1.5 billion smartphone and 80 million action camera users.

www.getklap.com

TWITTER INTELLIGENCE FOR MARKET FORECASTS

Fintech start-up SESAMm offers an online service aimed at banks and hedge fund managers which uses comments made on Twitter and other social media sites to enhance the accuracy of stock market forecasting. SESAMm specialises in building innovative algorithms to capture relevant information, which it analyses with statistical tools and natural language processing methods to produce trading indicators. The company was set up in France by a group of engineering and business students and recently opened a new office in Luxembourg, which it describes as one of its "natural markets".

www.sesamm.com

SECURE, EASY BLOCKCHAIN INTEGRATION FOR BANKS

Blockchain is a peer-to-peer protocol for the exchange of trusted transactions over untrusted networks. It is a fast-evolving technology, of obvious interest to banks and financial institutions, but not yet considered immune to the threat posed by increasingly sophisticated cybercrime.

Luxembourg security fintech start-up BitBank is introducing VTChain, a blockchain product designed to form an integral part of the client's existing secure banking platform. BitBank offers secure blockchain nodes, and system APIs containing ready-to-use blockchain primitives – smart contracts – to facilitate seamless integration into the client's banking applications. BitBank secure nodes are also a feature of its Merkkur.io service, a cloud data storage solution for SMEs offering bank-grade security and encryption.

www.bitbank.lu
www.merkkur.io
www.vtchain.com

CUSTOM TESTING FOR REAL-WORLD RELIABILITY

Stock exchanges. Air traffic control systems. Electric power stations. Critical operations, and all dependent on software systems. As the world's reliance on technology grows, so does the need for security and dependability. The focus of the University of Luxembourg's Software Verification and Validation Lab is to ensure that whether the software powers a self-driving car or an e-banking transaction, it is safe, secure and reliable.

"Our approach to research may appear idiosyncratic," begins Professor Lionel Briand, head of the Software Verification and Validation (SVV) Lab of the University of Luxembourg's Interdisciplinary Centre for Security, Reliability and Trust (SnT). "Instead of purely academic research, we focus on the real-world problems that emerge from our partnerships with industry. All too often, there is no obvious, readily-useable solution to a software engineering problem, which makes it doubly important to work closely with our partners' very knowledgeable professional staff."

The SVV Lab's team of 25 PhD students, post-docs, research associates and senior scientists work with Luxembourg-based Delphi, IEE, SES, HITEC, CETREL and CTIE, the government's IT services department. The unit was formed in 2012 when Professor Briand was awarded a €4.6 million, five-year FNR (National Research Fund) PEARL fellowship. The unit receives further financial support via its partnerships with the private sector in addition to direct funding from the SnT.

Nothing is perfect

"The SVV Lab's work consists of what I call upstream and downstream activities," explains Professor Briand. "Upstream includes software application specification architecture analysis and quality assurance; downstream is basically the actual testing."

Professor Briand stresses that all software systems contain faults, however critical they are. Failures are frequent, even if rarely publicly reported, and trial and error testing is no longer adequate. Instead, testers rely on artificial intelligence and other smart analysis techniques to automatically root out bugs in software.

Collaboration across industry

One of the SVV Lab's recent collaborations was with automotive components supplier Delphi, which was looking for assistance with the software embedded in its Electronic Control Units (ECUs). This type of software is becoming more and more complex over time due to increasing requirements for reduced fuel consumption, lower exhaust emissions, better vehicle comfort and higher dependability. The SVV Lab was asked to develop a means of automatically generating test cases for the ECU software, including a test-selection strategy and failure detection mechanism.

Another recent partnership was with HITEC Luxembourg, which had developed a hardware/software communications suite for use in public safety and humanitarian aid situations. In these circumstances, rescue teams are reliant on a dependable communications system to minimise personal risk and give the victims the best chance of survival. The goal of the collaboration with HITEC was to produce a methodology for run-time verification to ensure the system's reliability and security.

Free test tools for any user

In the course of its work, the SVV Lab has developed a range of tools which are free to any user. These range from Xavier, which tests web applications and services for SQL injection vulnerabilities, to UMTG (Use case Modelling for Test Generation), a toolset that automatically generates executable and traceable system test cases from use case specifications.

A prestigious grant award

Professor Briand arrived at SnT with over two decades of research experience. He has worked in France, Germany, the United States, Canada and Norway and is an IEEE fellow and recipient of the IEEE Computer Society's prestigious Harlan Mills award.

In March 2016, Professor Briand received an Advanced Grant from the European Research Council (ERC). This is the most important of the grants awarded by the ERC and Professor Briand is the first Luxembourg-based researcher to receive it. Professor Briand is justly proud of the award, which will provide €2.3 million over a five-year period, and gives full credit to his team at SnT: "The SVV Lab will use the funding to expand our public-private partnerships both within Luxembourg and abroad."

"Instead of purely academic research, we focus on the real-world problems that emerge from our partnerships with industry."

Lionel Briand

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MODELLING STEM CELL BEHAVIOUR

An embryonic – undifferentiated – stem cell can divide and renew itself many times over, each time creating either a new stem cell or a differentiated nerve, muscle or other cell type. This process has profound implications for the treatment of complex diseases such as Parkinson's and Alzheimer's, but is not yet fully understood. The Computational Biology Group at the Luxembourg Centre for Systems Biomedicine is creating advanced computational models to analyse the biological processes behind stem cell differentiation and cell regeneration and make new advances in this field of experimental research.

Principal Investigator Professor Antonio del Sol heads the Computational Biology Group, part of the Luxembourg Centre for Systems Biomedicine (LCSB) at the University of Luxembourg. The group is a multidisciplinary unit of nine biologists, engineers, physicists and computer scientists, working in partnership to develop computational models that can help to explain how molecular networks mediate the processes involved in cellular differentiation and reprogramming.

The issue of differentiation

A current focus of stem cell research is to determine how to control differentiation; in other words, how to direct an undifferentiated stem cell to develop into a particular type of specialised cell, and how to control this process efficiently so it can be used for clinical purposes.

"Our research is very specialised and technical, so you may get a better idea of our work if I describe some of our projects," says Professor del Sol. "One of our studies focuses on cardio-progenitor cells, which have the capacity to form different types of cardiomyocytes – heart muscle cells – that could be used to repair damage to the heart. We are developing a network-based approach that we will use to identify the cell fate determinants that are the most efficient at inducing differentiation towards specific cell types." The team is working on the study in collaboration with Professor Christine Mummery of Leiden University in the Netherlands.

"We work very closely with biologists and clinicians, not just to create abstract theories but to develop tools that are driven by concrete biological and biomedical questions."

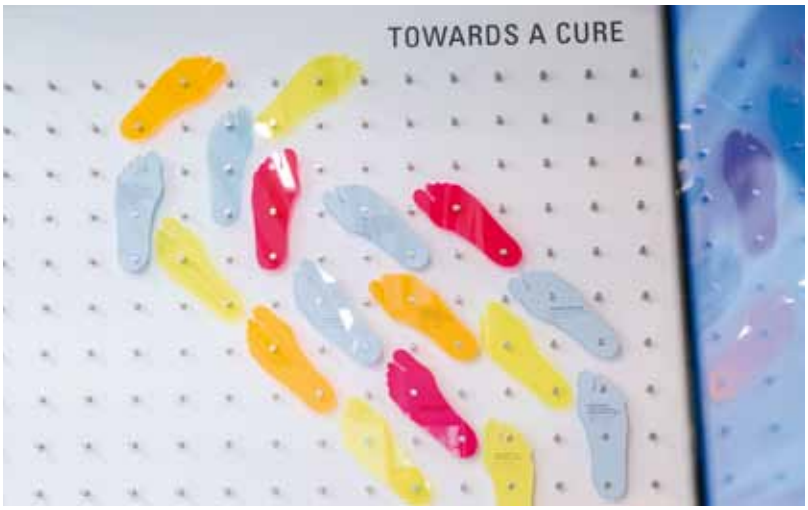
Antonio del Sol

WHAT IS IT ABOUT STEM CELLS?

Embryonic stem cells are unique in that they have the capacity to develop into muscle, blood or any other type of specialised cell. When a stem cell divides, the new cell may be another stem cell or a differentiated cell with a more specialised function.

A current focus of stem cell research is to understand how this process works. Cancer and a number of other diseases are caused by abnormal differentiation or cell division, so a better understanding of the molecular dynamics involved can provide invaluable information and form the basis for effective treatments.

The most important potential use of stem cells today is in cell-based therapies. With organs and tissue for transplants in short supply, stem cells made to differentiate into specific cell types offer a renewable source of tissue to treat spinal cord injury, stroke, heart disease and cancer.



Nerve cell activity in Alzheimer's

Another project is designed to gain a better understanding of Alzheimer's disease by analysing synaptosome behaviour. Professor del Sol explains: "A synaptosome is a bulb-shaped isolated synaptic terminal inside a neuron (nerve cell) which stores and releases the neurotransmitter molecules that communicate with other neurons. Changes in the proteome – the collection of proteins in the cell – reflect important changes in the cell as a whole. We use network analysis to study the complete proteomics data from the synaptosome. In this way, we can compare what happens in Alzheimer's disease to what happens in normal ageing." On this project, the team is working in collaboration with Dr Ronald van Kersteren and Professor Guus Smit of the Centre of Neurogenomics and Cognitive Research at VU University, Amsterdam.

New data, new theories, new tools

Professor del Sol first trained as a theoretical physicist. He later switched to computational biology and spent five years working for a pharmaceutical company in Japan before coming to the University of Luxembourg.

"Theoretical physics has gone so far beyond experimental confirmation that many physicists will never see the proof of their theories," says Professor del Sol, explaining his change of career. In biology, he says, the opposite is true. "There are large amounts of data about biological processes, but no solid theoretical background to explain them. We are importing ideas from different disciplines that allow us to build mathematical models capable of making sense of that data. I definitely think that we will come to the point where a new field will emerge, with new concepts and principles, that will explain the complexities of biological processes. The Computational Biology Group works very closely with biologists and clinicians, not just to create abstract theories but to develop tools that are driven by concrete biological and biomedical questions."

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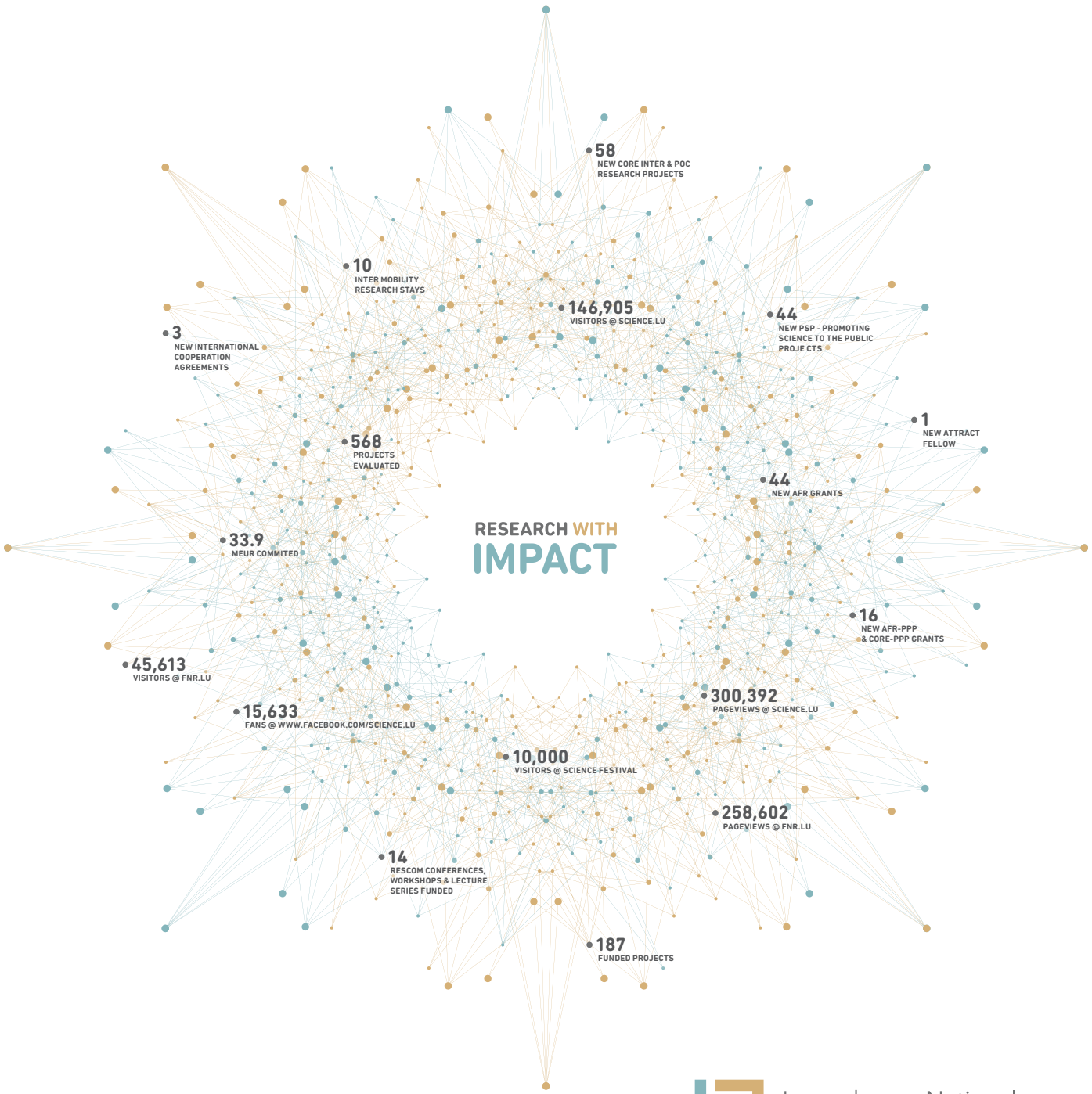
Luxembourg Portal for Innovation and Research

www.innovation.public.lu

FNR.LU

The FNR is the main funder of research activities in Luxembourg. We invest public funds and private donations into research projects in various branches of science and the humanities, with an emphasis on selected core strategic areas. Furthermore, we support and coordinate activities to strengthen the link between science and society and to raise awareness for research. We aim to establish Luxembourg as a leading knowledge-based society through science, research and innovation.



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