



years of research

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Björn Ottersten is the director of the
Interdisciplinary Centre for Security,
Reliability and Trust (SnT)

Message From The Director

More than ten years ago I was invited to lead a new institution with the goal of creating a cutting-edge research centre. Years later, at the celebrations of our tenth anniversary in 2019, I realised how far SnT has developed beyond my initial expectations. We have achieved significant success in three distinct areas.

PARTNERSHIPS

In the space of a decade SnT has developed partnerships with almost 50 public and private institutions in Luxembourg and abroad, now representing about 20% of our turnover. These collaborations leverage our high-quality research expertise to address each organisation's specific innovation challenges, enabling them to become more competitive. In Luxembourg we focus on areas that are relevant to the local economy, such as fintech and space systems, to encourage economic growth locally. We play a crucial role in this ecosystem by identifying synergies between public and private R&D investments locally, while also attracting international investment.

TALENT

Our focus on industry partnerships sets us apart from other research institutions – academics are drawn to SnT because of the real-world impact of our work. We attract top talent from around the world, and I am proud to lead such a skilled and diverse team. The same elements that bring these individuals to SnT also motivate many to stay in Luxembourg once they leave us; in the past ten years 36% (more than 130 people) have stayed here. In many cases they take jobs with our partners or create a start-up, continuing to fuel tech innovation within the Luxembourgish economy.

RESEARCH EXCELLENCE

Throughout these ten years our pursuit of research excellence has been constant, and we are only beginning to see the results of our dedication to high-calibre scientific work. The University of Luxembourg is now ranked in the top 100 Universities globally for Computer Science, according to [the Times World University Rankings](#). We have also received three advanced grants from the European Research Council (ERC), a significant achievement that underlines the value of what we are doing at the European level. The FNR, Luxembourg's research funding body, also recognises our work having awarded three of their prestigious PEARL grants to SnT.

LOOKING TO THE FUTURE

In 2019 these three elements continued to enable our success. We welcomed five new partners – the [CSSF](#), [Megeno](#), [PayPal](#), [Ripple](#), and [Vail Systems](#), three of which are companies based in the US. International collaborations such as these will be a focus area as we look towards the future. Additionally, we will continue to build our momentum in fintech while diversifying into the service industry; pursuing more partnerships with the insurance sector and regulatory bodies, as well as moving into legal tech.

Through cutting edge scientific research, we will become even more crucial in the next ten years as a driver of innovation in the country, and with the strong foundation we have put in place I am confident that we are ready.

Prof Dr Björn Ottersten
Director,
Interdisciplinary Centre for Security, Reliability and Trust

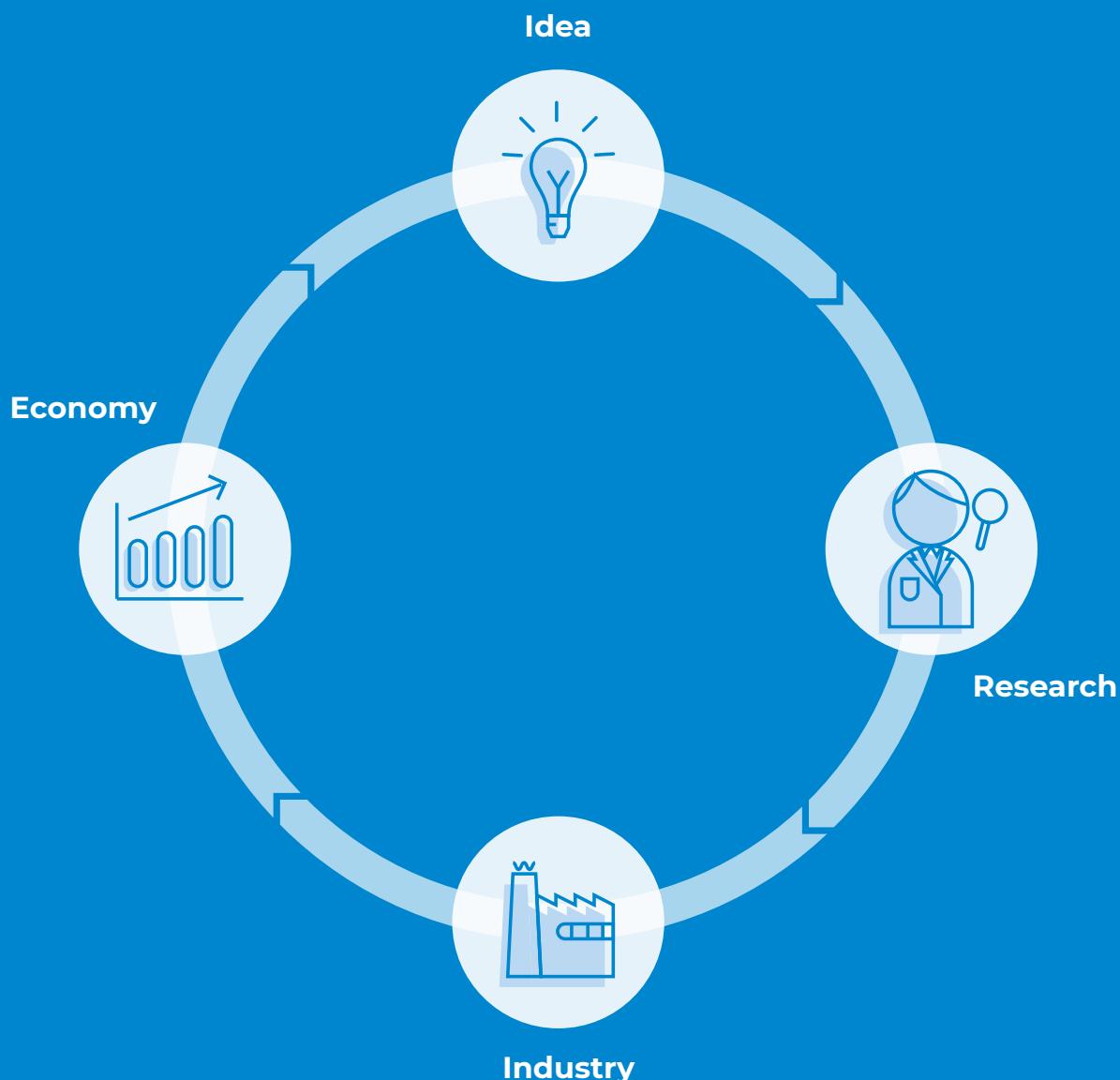
About SnT

We are a research centre that is focused on scientific innovation for today's ICT challenges.

Our work is defined by a collaborative model where we work with partners to solve a challenge they have. This allows partners to gain access to high quality fundamental science, while at the same time we gain access to real-world data and systems that inform our research agenda. Together we develop prototypes that the partners can take to market.

The excellence of our research and the innovative model we work with attracts bright academic minds from around the world.

Our talent pool and industry-focused approach make us an integral part of the local economy, while our cutting-edge research introduces Luxembourg to the world.



Our Six Strategic Research Areas



FINTECH

As regulations become increasingly complex, ICT tools are necessary for cost-effective, compliant solutions for the financial, legal, and insurance sectors. Our research teams develop solutions to ensure security and trust in these sectors.



CYBERSECURITY

Cloud-based infrastructures are the future for much of the service-based economy, offering flexibility, scalability, and affordability. We develop designs for systems to ensure resilience against faults and human error, as well as to resist security attacks.



AUTONOMOUS VEHICLES

Autonomous driving promises to be more efficient than traditional transport, introducing a new era of disruptive change in mobility. We are focused on creating secure and safe infrastructure solutions for this highly complex and dynamic technology.



INTERNET OF THINGS

Whether in use for smart homes, cities, or manufacturing, IoT offers tremendous opportunities to build services to improve our lives. To make this a reality we are building smart, secure, and private IoT solutions and data analytics.



SPACE SYSTEMS

The revolution in space technology is driving new and innovative business models. Our expertise in satellite communications, autonomous operations, and mission critical software makes us ideally placed to work with actors establishing R&D activities in Luxembourg.



SECURE AND COMPLIANT DATA MANAGEMENT

The new economy is data driven, and current data protection and privacy regulations create an opportunity for Luxembourg to establish itself in the domain. Our research into scalability, security, affordability, and compliance for the management and protection of data is crucial to this initiative.

SnT in Numbers



People



Alumni that stay
in Luxembourg
36%

Research excellence



34
FNR Projects granted
in 2019



267
FNR Projects
since 2009

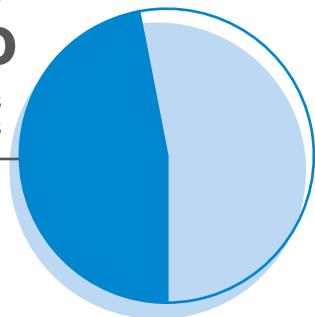
7
EU/ESA Projects granted
in 2019



80
EU/ESA Projects
since 2009

47%

of Doctoral candidates
on industrial projects



External Funding
in 10 years

149 million EUR

Partnership

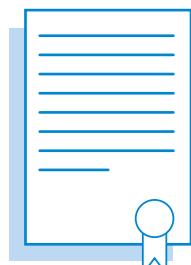
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Partners



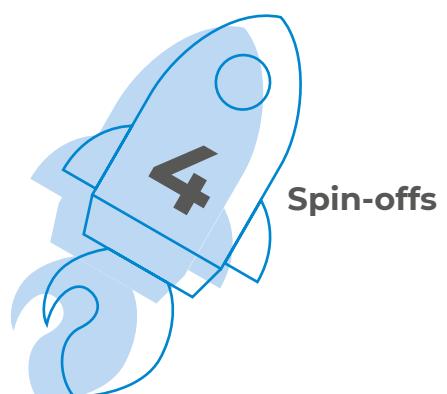
70

Partner
projects



37

Patents



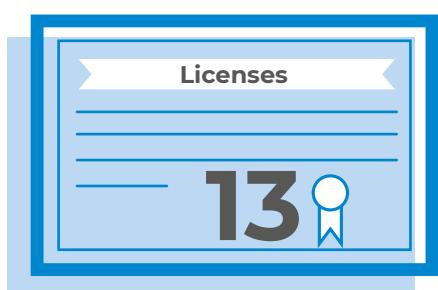
Spin-offs

Innovation



92

Invention
Disclosures



Licenses

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Sallam Abualhaija and Damiano Torre are developing a tool to assist corporations across Europe comply with GDPR rules. Find out more about their current research collaboration with Linklaters on P. 20



Research Unleashed



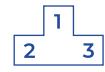
SnT in Orbit

Luxembourg is a country with its eyes on the stars – and SnT is helping it turn its science-fiction dreams into an economic reality. Our researchers explore the challenges and opportunities of space, hand-in-hand with industry-leading partners. From Earthbound satellite receivers, to state-of-the-art nanosatellites and autonomous lunar robots, researchers at SnT infuse Luxembourg's vibrant space industry with new perspectives and innovative solutions. We are proud to be part of the most dynamic ecosystem for applied space innovation in Europe.

LUXEMBOURG



Luxembourg contributes more per capita to the European Space Agency (ESA) than any other member state.



Luxembourg was the first European country to develop a legal framework for the utilisation of space resources.



Luxembourg's space industry is outpacing its neighbours in both relative investment and growth – and already accounts for 2% of the national GDP.



Cooperation with 14 entities from the space sector.



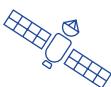
Interdisciplinary Space Master launched in September 2019.



Three dedicated labs: LunaLab, CubeSat Lab, Concurrent Design Facility.



33 doctoral researchers working on space topics.



Internationally recognised – in 2014 SnT researchers received the IEEE Satellite Communications Distinguished Service Award.

SnT

Special feature: SnT in Orbit

Projects with Impact

SnT researchers work closely with industry partners on cutting-edge research for both established space businesses and NewSpace start-ups. Together we are pioneering the industry of the future.



SnT researchers are working with [iSpace](#) on lunar robotics solutions. Their shared mission is to develop robots that can navigate using on-board sensors while on the lunar surface, to address the challenges of managing a lunar rover from earth. A robot that can act with a higher degree of autonomy on the moon will get us closer to extracting water on the moon's poles, which is key to developing more extensive human activity in space. It is state-of-the-art research that will help make space Earth's next economic frontier.



[Luxspace](#) is a leading microsatellite manufacturer based right here in Luxembourg. Microsatellites are ten times bigger than nanosatellites but ten times smaller than a mid-sized traditional satellites. These compact satellites are capable of executing a variety of missions, from monitoring ocean traffic, to relaying data from the moon. SnT researchers collaborate with Luxspace to research methods for expanding micro-satellites' capabilities with the goal of developing space-based solutions for an ever broader market.



The [LiveSatPreDem](#) project is a joint research initiative with the satellite operator [SES](#). Through this project, SnT researchers have developed a new signal-coding technology that will exponentially increase the carrying capacity of a satellite network, to make broadband over satellite faster and more accessible. The project is supported by the European Space Agency (ESA) and will begin testing in 2020.



Interdisciplinary Space Master

SNT and the Faculty of Science, Technology, and Medicine jointly launched the Interdisciplinary Space Master (ISM) in the autumn of 2019, with the support of the Luxembourg Space Agency. This two-year programme offers students a unique project-based learning experience and strong links with national stakeholders, including industry. ISM alumni are equipped with technical and business abilities enabling them to enter the space sector with confidence upon graduation.

Dynamic Teaching and Study



Learn from industry experts as well as academics

ISM students benefit from a diverse teaching team that includes researchers and professors as well as experts from industry partners. Among a number of visiting lecturers and researchers, we are welcoming Spire CEO Peter Platzer to our classrooms in 2020. He will share his entrepreneurial ethos as well as his technical expertise with the next generation of NewSpace industry leaders.



Research for the real world

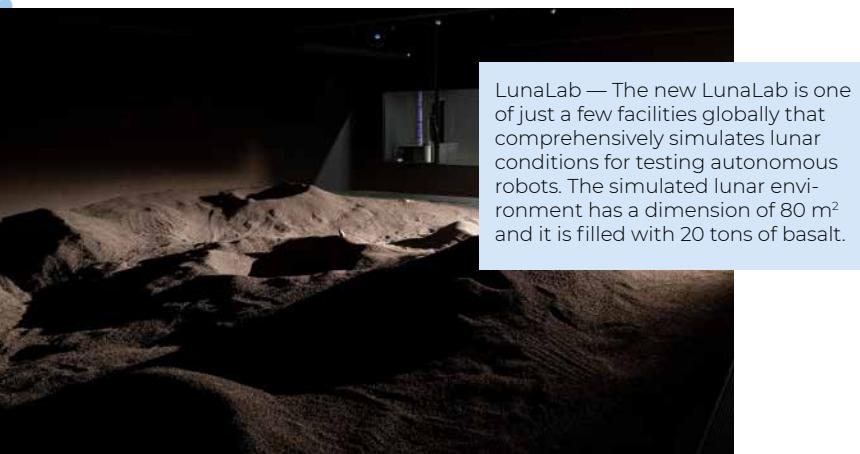
The entire ISM programme is grounded in the context of SNT's research with industrial partners. Our centre's research projects offer students the opportunity to visit commercial facilities, analyse real-world datasets, and grapple with industry challenges while remaining immersed in a rigorous academic environment.



Think across disciplines

ISM brings together researchers and lecturers from a variety of backgrounds including space systems engineering, satellite communications, and autonomous robots. The interdisciplinary collaboration and exchange that students experience at ISM gives them the methodological foundations they need to choose the best approaches to continue in this tradition long after leaving SNT.

State-of-the-art Research Facilities



Our Space Experts



Prof Dr Holger Voos

HEAD OF THE AUTOMATION & ROBOTICS RESEARCH GROUP AND
ISM PROGRAMME DIRECTOR

"It's amazing how many complex challenges we can solve thanks to our interdisciplinary approach."

Prof Holger Voos's research group investigates intelligent approaches to automatic control for applications, ranging from self-driving cars and unmanned aerial vehicles to distributed energy or manufacturing systems. His recent work on the space sector focuses on cooperative control of constellations or formations of microsatellites deployed in orbit. He has been a professor at SnT since 2010 and teaches, among others, Guidance, Navigation, and Control for Space Systems as part of the ISM.



Prof Dr Miguel Angel Olivares Mendez

HEAD OF THE SPACE ROBOTICS RESEARCH GROUP (SPACER)

"It's like something out of science fiction — every kid would like to grow up and work on space robots."

Prof Miguel Angel Olivares Mendez is SnT's professor for space robotics and Autonomous Space Systems in the ISM programme. He has published over 90 contributions to the field of autonomous robotics research in scientific books, journals, and at conferences. His research and innovation topics focus on autonomous navigation and multi-robot interaction for both planetary and orbital robotics, using machine learning and other novel techniques for perception and control. He oversees the design and development of SnT's state-of-the-art space robotics labs.



Prof Dr Symeon Chatzinotas

CO-HEAD OF SATELLITE COMMUNICATIONS RESEARCH GROUP

"It's so motivating to think of all the ways that our work will impact people's lives around the world."

Prof Symeon Chatzinotas has been researching and teaching at SnT since 2010. He was a lead researcher in the SnT's Satellite Communications Research Group (SIGCOM) when it was awarded IEEE's 2014 Satellite Communications Distinguished Service Award. In 2019, he became a full professor and co-head of SIGCOM. Since 2014, Professor Chatzinotas has won six best paper awards and has patented six new satellite communications technologies.



Prof Dr Tonie van Dam

HEAD OF THE REMOTE SENSING APPLICATIONS RESEARCH GROUP

"We are watching the NewSpace era unfold before our eyes. It is very exciting to be building this new research focus."

Prof Tonie van Dam is an internationally acclaimed geophysicist. In 2019, she was awarded the Vening Meinesz Medal from the European Geosciences Union in recognition of her pioneering research and innovative use of space geodetic observation techniques. She has served as a leader in numerous professional and academic associations, including at the American Geophysical Union, where she served as the Geodesy Section Secretary, as well as at the European Geophysical Society, where she served as the President of Geodesy Section.



beSat Lab — Here students have an environment where they can design, develop, and test their own custom nanosatellites. Students learn about satellite mission design and execution, as well as satellite hardware configurations.



Satellite Communications (SATCOM) Laboratory — This setting gives researchers and students in satellite communications the opportunity to test and validate their algorithms in conditions that reflect the challenges and constraints of real-world communications platforms.





Predicting Flash Floods from Interference



Ahmad Gharanjik launched Databourg in 2017.

"It is like a curse," Patrick Achten of Ermsdorf told the Luxembourg *Wort*. "On those nights [when the rain comes down hard] you can't sleep well, all of my neighbours on this street feel the same." Achten spoke to the newspaper two years after a downpour flooded his neighbourhood in part of Luxembourg's Mullerthal region. That July 2016 flood washed away bridges and cars and led to over 300 calls to emergency services. The local mayor reported that the flood caused "millions" of Euros in damage and that the town was "really lucky that there were no fatalities." Just two years later, in June 2018, a neighbouring valley was also struck. "I think we are already in the thick of climate change," Dr Jean-Paul Lickes, Luxembourg's Director of Water Management, told the *Wort* in 2019. "We need to start adapting to the new situation. It would not be right to wait."

Flash flooding presents a real challenge to Luxembourg, heightened by the fact

that flash floods can be surprisingly difficult to predict. Christine Bastian, co-chair of Luxembourg's Department for Hydrology and Water Management, said shortly after the 2018 flood that "with this sort of very localised event, there just isn't data because there simply aren't any measuring devices in the area. That makes predicting these events, which is already very difficult from a meteorological and model-technical point of view, an impossibility."

That might be about to change thanks in part to SnT alumnus and entrepreneur, Dr Ahmad Gharanjik. "While working as part of the SatComs lab here at SnT, I saw the patterns in satellite signal fluctuations and weather conditions. So, I began to wonder whether it might be possible to develop an algorithm to extract more precise details about the interference's cause," said Gharanjik. It was a thought that continued to preoccupy him through both his PhD and his postdoctoral research. "In time, I devel-

oped a machine-learning algorithm that takes data from a satellite signal and returns precise, minute-by-minute data about rainfall." Gharanjik's technique would increase the potential rainfall data collection points in Europe from under 2000 to over 200 000, without requiring the installation of even one new piece of hardware.

To bring his technology to the world, Gharanjik has founded a new company, [Databourg Systems](#). Supported initially through the FNR Proof of Concept (PoC) programme and SnT's [Technology Transfer Office](#), the future of the company is bright as it is gaining traction. It has an ongoing collaboration with the European Space Agency to develop a flash flood warning system for Luxembourg, and is currently negotiating new contracts with American businesses. On top of that, Databourg is hiring new employees, and its technology patent is pending.

"There is a clear public interest in improved rainfall measurements, but there are many business applications for the data too," explained Gharanjik. "That's why we are looking into a two-pronged product model. We want to find a way to provide public weather services and emergency response teams with localised severe rain event notifications on a non-profit basis. At the same time we want to provide specific businesses with data optimised for their use cases too." Those use cases run the gamut, from logistics, to agriculture, to construction, to insurance, and beyond.

"It is really exciting to be part of bringing technologies out of the research lab and into the real world," added Jacek Plucinski, Technology Transfer Officer at SnT. "I think that getting research-driven solutions out into the wild is an important part of the ethos here at SnT. We strive to develop innovations with impact. And that is exactly what Databourg represents." •



Laying the Foundations for Smart Factories

In 1989, *Star Trek: The Next Generation* introduced the world to one of the greatest sci-fi villains of all time: the Borg Collective. A species of cyborgs with a collective intelligence, their technology was capable of automatic adaptation, update, and repair. They were nearly invincible – what could possibly stand in the way of machines that can repair themselves? Their advanced technology seemed beyond human capacity. Now that is starting to change. Today, 30 years after the pop-culture debut of self-repairing machines, Paul-Lou Benedick, Julien Polge, and Dr Jérémie Robert, right here at SnT, are working on technologies that would easily fit-in on those formidable Borg ships.

"Getting the factory configured in such a way that it can repair itself is our hope for the future," project leader Dr Jérémie Robert explained. Their project partner, industry-leading parts manufacturer **Cebi**, called on Robert and his team to help get their complex factories ready for industry 4.0. Together, they envision a future where their factories can identify and resolve malfunctions independently (much like the Borg). These factories of the future will be robust and flexible. They will produce a wider variety of products, with minimal waste and improved quality.

The road to self-repair is a two-pronged process, explained Robert. "First we need to develop a method for compiling data from separate machines into a single intelligent overview, and then we need to improve our understanding of the root causes of factory downtime." To tackle these challenges, the team uses an interdisciplinary approach, examining both networking and machine-learning solutions.

"I was surprised that some of the machines didn't have built-in ports to interface with," said doctoral researcher Paul-Lou Benedick, describing his part of the project to get all the machines successfully networked. "We are finding ways to connect all the machines and to get them speaking the same language. Once we have that, we can develop an AI to analyse factory data and make suggestions for optimisation."

The stakes for that first half of the project are high. Network quality could have a big impact on their final AI results. "If network quality impacts data quality, which I believe is the case," Benedick continued, "then the AI running on a poor network could act on wrong data. We could end up with a situation where everything might look good from the operator's dashboard, but the situation on the ground could be very different. So we need to create the best network possible. That's the foundation we will build on."

Building on that strong foundation is doctoral researcher Julien Polge, whose machine-learning algorithms will ultimately replace the hard-coded programs currently running on many factory machines. "The first step was to identify which



Jérémie Robert, Julien Polge and Paul-Lou Benedick are collaborating with Cebi to prepare factories for the future.

types of machine-learning solutions will have the greatest impact," Polge explained. With dozens of fundamentally different machine-learning approaches to choose from, the task was far from trivial. "I found that the hypothetically best off-the-shelf machine-learning solution didn't yield the best results under real-world conditions," Polge said. To solve the problem, he has begun adapting off-the-shelf solutions for real-world factory conditions.

"The solutions need to accommodate shifting environmental conditions and ensure a robust, automated manufacturing process," said Polge. To achieve this, he will introduce data preprocessing that will account for the factory's continually changing environment. "Preprocessing will help make machine-learning solutions more effective under real-world conditions," Polge continued. After that, he will add sensors to the machines and the factory floor. "These sensors will provide some additional contextual data that will help improve the performance of the machine-learning solutions." Ultimately, Polge's solutions will allow the factory to manufacture more products flexibly and will reduce factory downtime by helping operators respond rapidly to malfunction or error.

Flexible-yet-rapid parts manufacturing will revolutionise the way our supply chains work – and factories that can self-correct will keep these increasingly complex environments running smoothly. What could possibly stand in the way of an economy that runs like that?•



Creating a Digital Twin of Luxembourg's Electrical Grid



Together with Creos, Maxime Cordy develops smarter methods for understanding and managing the flow of electricity on the grid.

The looming green energy revolution will turn our current electrical grid system upside down – introducing new, distributed sources of energy, as well as new patterns of demand. Our hundred-year-old electrical infrastructure is designed to move electricity like water in a single direction downstream to consumers, but new patterns of production and demand could bring this grid to its knees.

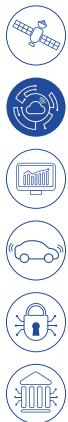
Yet it doesn't have to. Here at SnT, a research team is helping to put new tools into the hands of experts responsible for the future of the electrical grid. "Our partner, [Creos](#), operates the majority of the electric grid in Luxembourg," Project lead Prof Yves Le Traon explained. Creos has partnered with Le Traon, Dr Maxime Cordy, and their team to develop smarter methods for understanding and managing the flow of electricity on the grid.

"You'd be surprised how complicated managing the electrical grid can be – there are a lot of unknowns to contend with," Cordy, project Technical Investigator, said. "The grid is highly configurable. You can close or open fuses that act as 'doors' for the electrical current and define the path it follows along the grid. Different configurations are needed to handle different situations and prevent power overloads, but it can be challenging to determine efficiently which configuration to use and when." Legacy hardware and imperfect documentation is another part of the problem. After a hundred years of expansion, repair, and modernisation, corporate restructuring and multiple generations of employees, there are details that have simply fallen off the radar. New smart meters offer the opportunity to develop a much better map of the grid and how electricity moves along it, but it isn't quite as straightforward as it sounds, because even brand-new smart meters are not perfect.

"Even smart meters might occasionally report an inaccurate reading," said Cordy. "So no matter how much we improve the physical grid and the maps we have of it, we will always need to accommodate a degree of uncertainty." That's where their new methodology for including uncertainty in calculations about the flow of power comes in. "We've developed a way to represent uncertainty in a dataset," said Le Traon. They now use a language to model and reason about power flow on the grid that accounts for uncertain conditions and can calculate probabilities in a way that adapts to the situation.

This new mathematical language is the engine that powers their project's final goal: a digital twin of the actual electric grid. This twin will reflect the actual conditions on the grid, and will have a user interface that guides operators through the labyrinthine process of determining an optimum configuration. It will guide operators by making recommendations based on real-world data obtained from smart meters across the grid. "The magic will happen in the background," Cordy explained as he described what this means for Creos' professionals. "The user who ends up looking at the final results and recommendations that our models produce doesn't need experience working with probability theory. Our algorithm will do that all behind the scenes and then point to the result."

It is a system that already accounts for the unknown all the time. While the green energy revolution will bring new, unanticipated challenges as it unfolds in our communities, thanks to Cordy and his SnT team, Luxembourg can count on the continued reliability of its electric grid, no matter what surprises arise along the way •



The Intersection of Standards, Entrepreneurship, and Technology



Grégoire Danoy, Pascal Bouvry, and Matthias Brust believe in the twofold power of standards to protect consumers from shady transactions and to enable new business models.

On warm Friday mornings in the town of Alkmaar in the Netherlands, tourists gather to watch something rather unusual. A bell rings, and men dressed all in white move six huge wheels of cheese at a time until 30,000kg have been ceremonially weighed. It is the opening of the cheese market; a weekly drama Alkmaar has hosted since it acquired its first official cheese scale in 1365. To this day the motto of the cheese-carriers' guild remains "a false balance is an abhorrence in the eyes of the Lord".

Society has an enduring interest in ensuring that we all get what we pay for. Official scales, like the ones in Alkmaar, were some of the earliest attempts at implementing standardisation across a large European marketplace. Over time, these standards grew to ensure order and efficiency across increasingly complex markets. By 1991, a data communication protocol developed by a scientist at CERN was accepted as a voluntary standard for all Internet communications. That communication protocol is called HTTP, and while most of us do not think much about it, it is a standard that ensures that we can open any website, regardless of device, browser or internet provider.

Our markets and many of the goods we sell on them may have become increasingly abstract since the early days of Alkmaar's cheese market. (Indeed, perhaps the quaint simplicity of it helps explain the cheese market's continued appeal.) But the historical relationship between standards, entrepreneurship, and

technology is as powerful as ever – and it is at the heart of a new research-and-teaching group at SnT, led by Prof Pascal Bouvry, postdoctoral researcher Dr Matthias Brust, and in collaboration with [ILNAS](#) (*Institut luxembourgeois de la normalisation, de l'accréditation, de la sécurité et qualité des produits et services*).

"What our group's first research project looks at," said Brust, "is the development of a method for working with biomedical data, which is almost always very big and very private." That project *Biotechnological Big Data: Security, Privacy, and Standardisation* was awarded the Project of the Year Award at Security Made in Luxembourg's Information Security Day 2019. In it, Brust laid out preliminary research outcomes that are already directly contributing to technical standardisation efforts. "Our approach aims to ensure that this complex biomedical data is widely compatible with new analytical tools, such as machine learning and other AI techniques, while simultaneously ensuring the preservation of privacy."

This research project is one of the first produced as part of the group's research-and-teaching collaboration with Luxembourg's own standardisation board, ILNAS. "Working with ILNAS ensures that we as researchers have direct lines of communication with the different stakeholders involved in shaping how new technologies are used," said project leader Prof Pascal Bouvry. This open communication is a big part of what the team calls "technopreneurship", a concept at the heart of both their research and teaching missions. "A technopreneur is a multi-disciplinary thinker who can move creatively between technological innovation, technology standardisation, and challenges around security, privacy, trust, or reliability," explained teaching lead Dr Muhammad Umer Wasim. "Our researchers and students don't necessarily have to come from a tech background. We're also working with lawyers and businessmen who have innovative ideas."

What brings the team together is their shared belief in the twofold power of standards to protect consumers from shady transactions (the way the Alkmaarer cheese scales protected consumers from fraudulent weights), and also to enable new business models (the way HTTP ensured the internet could be universally accessible, creating the largest marketplace on earth). "In another twenty or forty years, when artificial intelligence, big data, IoT, cloud computing, machine learning, and all the rest have yet again changed how we do business, we'll be glad to look back and see the thought that went into establishing standards for data privacy and system security," said Dr Grégoire Danoy. "Because standardisation means trust."

It is a unique approach that will undoubtedly encourage students to produce the innovative, trustworthy tech we will depend on tomorrow •



A Smart Approach to GDPR Compliance

"This," Dr Damiano Torre explains, letting a hefty printout of the new EU GDPR law fall with a soft thud next to his keyboard, "is the most important piece of paper in my office." The 'piece of paper' would be better referred to as a book, and with Post-its sticking out of it and well-thumbed pages covered in yellow highlighter. The day-to-day nature of his use is evident from looking at it.

Torre is a research associate at SnT with a background in ensuring software consistency for safety-critical systems. He has scrutinised every word of the new GDPR law. "This was my first time working with a natural language, English, rather than a formal computer language. But English turned out to be simpler than what I was used to," Torre continued. "I am really



“I am really glad to be working on something that could play a big role in protecting our human right to privacy”

glad to be working on something that could play a big role in protecting our human right to privacy.”

Torre and six of his colleagues from the Software Verification and Validation group work in close cooperation with lawyers from the prestigious law firm [Linklaters](#). Over the next three



years, as part of the FNR-funded project Artificial Intelligence-enabled Automation for GDPR Compliance (ARTAGO), they will develop a suite of tools to guide legal professionals through the GDPR law, helping to ease the adjustment to the new European privacy standards.

“At Linklaters being innovative means doing things differently, unleashing our imagination to challenge the present and shape the future. By teaming up with SnT, we are combining our firm’s legal excellence with cutting edge AI technology,” said [Katrien Baetens](#), Managing Associate, Linklaters Luxembourg. “The solution is unique in that it is driven by model engineering. As such, the tool will assist corporations across Europe required to comply with GDPR rules by reducing human efforts and enhancing automation. We are looking forward to the launch of this tool and an even greater collaboration with the team at SnT for the benefit of our clients.”

The project will harness techniques from the research area of software consistency and use them to analyse legal documents. The approach is a completely new way to tackle the challenges of GDPR compliance. “There are a lot of tools claiming to do this already on-line, but most are little better than checklists. What we’re doing here is something really different,” Torre said. “Our first tool uses a model of the GDPR’s privacy requirements section — the first of its kind to ever be systematically developed — and actually checks the contents of a given document against that model.” The tool then points out any omissions or inadequacies. The methodology powering the tool is the same used when dealing with safety-critical systems. It lets users be certain whether a document complies with the GDPR’s privacy requirements. And if it does not comply, it will tell them exactly why. Currently, Torre and his team are determining how to best automate the privacy policy compliance review process. “At first, we wanted our tool to be completely automated. But as time went on, we realised that a fully automated tool might actually be less useful to the people using it.” After adding a few questions for the user to answer at the very beginning of the tool’s workflow, Torre and his team reached a balance. It is just the right amount of automation to streamline the process without compromising accuracy.

“Next we want to look at ‘consent’,” Torre said. “Building tools that will help empower people to make informed choices about their private data is gratifying. Protecting our identity and our private data ought to be just as important to us as protecting our physical safety. It is important that we, in the EU, keep doing everything we can to build a system where technological advances don’t come at the cost of our privacy.” •

Left to right: Orlando Amaral, Sylvie Forastier (Linklaters), Sallam Abualhaija, Peter Goes (Linklaters), Katrien Baetens (Linklaters), Damiano Torre at the Linklaters offices on Kirchberg.



Bringing European Values to Airport Security

"You never know where inspiration will come from," Dr Aurel Machalek said. "Two years ago, I was recruited as an extra for a movie. They needed a man with a beard you see," he explained touching a hand to his wiry chin and smiling. "And that was why I thought of using extras when it came time for the final test of our **FLYSEC** airport security system."

For that field test, one hundred extras descended on Luxembourg's airport. With perplexing tickets for destination "Luxembourg" in hand, they made their way towards the security lines – and some began to behave suspiciously. Despite the complex inundation, passenger speed through airport security that afternoon actually improved. "The security personnel set out very strenuous requirements for the test, and many were sceptical that it would even work," Machalek explained. "So when they said that they thought the test was a success, that was one of the best metrics I could have wanted." It was the first time any smart security solution was tested during opening hours at a fully operational airport.

The system they tested that day, called FLYSEC, is the product of an international, interdisciplinary consortium. It was designed to improve the efficiency of airport security for both passengers and staff. FLYSEC has, therefore, both a security-facing and passenger-facing interface. "The data is displayed to the security staff in real-time," Machalek said. To do this, the FLYSEC system uses visual sensors throughout the airport to monitor foot traffic. It then compares that data with a sophisticated behavioural model developed by Machalek and his team at SnT. When a behaviour deviates too far from the model, the FLYSEC system alerts airport staff. Security professionals can investigate in response to alerts and decide how to proceed. The system is thorough and unbiased – and on top of that, it is private. "No data is ever saved," Machalek

assured, "and data is only revealed once a critical threshold in the behavioural model has been crossed." That means that passenger privacy is built-in.

While the FLYSEC airport staff benefit from the improved security monitoring, passengers can enjoy a calm, quick jaunt through airport security lines. FLYSEC does this by providing passengers with their own app. This app gives passengers the option of scanning their flight tickets at the beginning of their journeys. Using only the information on the ticket, the app sorts participants into three security-levels: "Trusted, Casual and Enhanced". Then it directs the passenger to the shortest line for which they are eligible. "A passenger whose passport is about to expire, for example, would probably be sorted into the enhanced category," said Machalek, "the categories are based on whose documents need the closest inspection and will, therefore, need the longest to get through security." Sorting passengers this way keeps wait times down for everyone, no matter which line they are directed to. Finally, by the time the passenger has taken off, their data is erased from the FLYSEC system.

"It is really important that we, as Europeans, keep building privacy into our technological capabilities," explained Machalek. "We are unique in the world in acknowledging the extent of the human right to privacy. If we do not develop our own technologies around it, Europe will be stuck either choosing between Chinese and American tech solutions or trying to compete without the same capabilities." The European Commission, which awarded the project with a rarely granted grade of "excellent", seems to agree. Thanks to Machalek and the FLYSEC project, we can all look forward to a new European way of travel that is more connected, more secure, more private – and a lot less stressful. •

Aurel Machalek led the FLYSEC field test at Luxembourg's Findel airport.

“It is really important that we, as Europeans, keep building **privacy** into our technological capabilities”





Space Invaders and Security Guards

When visiting Dr Miguel Olivares Mendez's office, the first thing that immediately jumps out at many is a stack of A3 papers printed with what look like giant Space Invaders. Black and white and coarsely pixelated, the mysterious figures covering his desk are in fact his latest drone research project.

"In fact these are ArUco augmented reality markers, not Space Invaders" Mendez explained. "We can place them on the building we are interested in and train the drones to use them as stable reference points. They are different enough from the rest of the environment that they cannot be mistaken for anything in the natural world. But that is as close to anything 'alien' as they get."

These augmented reality markers are important tools for Mendez and his team, who are developing a new drone navigation system for secure environments where WiFi and GPS – the backbone of current navigation technologies – are unavailable or unreliable. Their research is being conducted in partnership with [LuxConnect](#), who operate two large data centers here in Luxembourg, and

are investing in the project as part of their ongoing upgrades to their facility's security.

"You might think that most centre employees would be IT professionals. But they aren't. Data centre teams are actually made up of mostly *security* professionals," said Mendez. That's because data centres are responsible for storing and securing data for hundreds (and maybe thousands) of customers, and in the information age, data is the new gold. "It is a constant race to stay one step ahead of hackers," said Mendez, "And if the bad guys can use drones to exploit blind spots in security camera systems, then the good guys need to find a way to preempt that."

LuxConnect's security drones will rely on the algorithms Mendez and his lab are developing to run autonomously. Should an anomaly be detected along the building's perimeter, the drone will automatically alert the security team and provide a visual feed. This will keep the staff out of harm's way and focused on their most important tasks. For this to work, the drones need very sophisticated

situational awareness, without access to the technologies typically used for the task (WiFi and GPS). That is where Mendez's newest research – as well as the "Space Invaders" – come in.

"Data centres are usually covered in a metal exterior to protect their WiFi from hackers. This bounces GPS signals around and makes them less accurate. On top of that, it also disrupts the drone's compass," said Mendez. "It is a problem that also exists in cities, which researchers call 'urban canyons'. Our research is developing an alternative navigational method that can be used in these types of environments." To do this, they combine computer vision technology, machine learning, and deep learning with more conventional drone tech, like *light detection and ranging (LiDAR)*. The "Space Invaders" covering Mendez's desk are essentially training wheels, used to provide benchmarks for testing the accuracy of this new spatial awareness technology. Ultimately, when this technology matures, it will no longer need them – but it may nonetheless look a little bit like something out of science fiction •

“It is a constant race to stay one step ahead of hackers, and if the bad guys can use drones to exploit blind spots in security camera systems, then the good guys need to find a way to preempt that”



Claudio Cimarelli and Miguel Olivares Mendez collaborate with LuxConnect to keep critical infrastructures safe from hackers with smart drones.



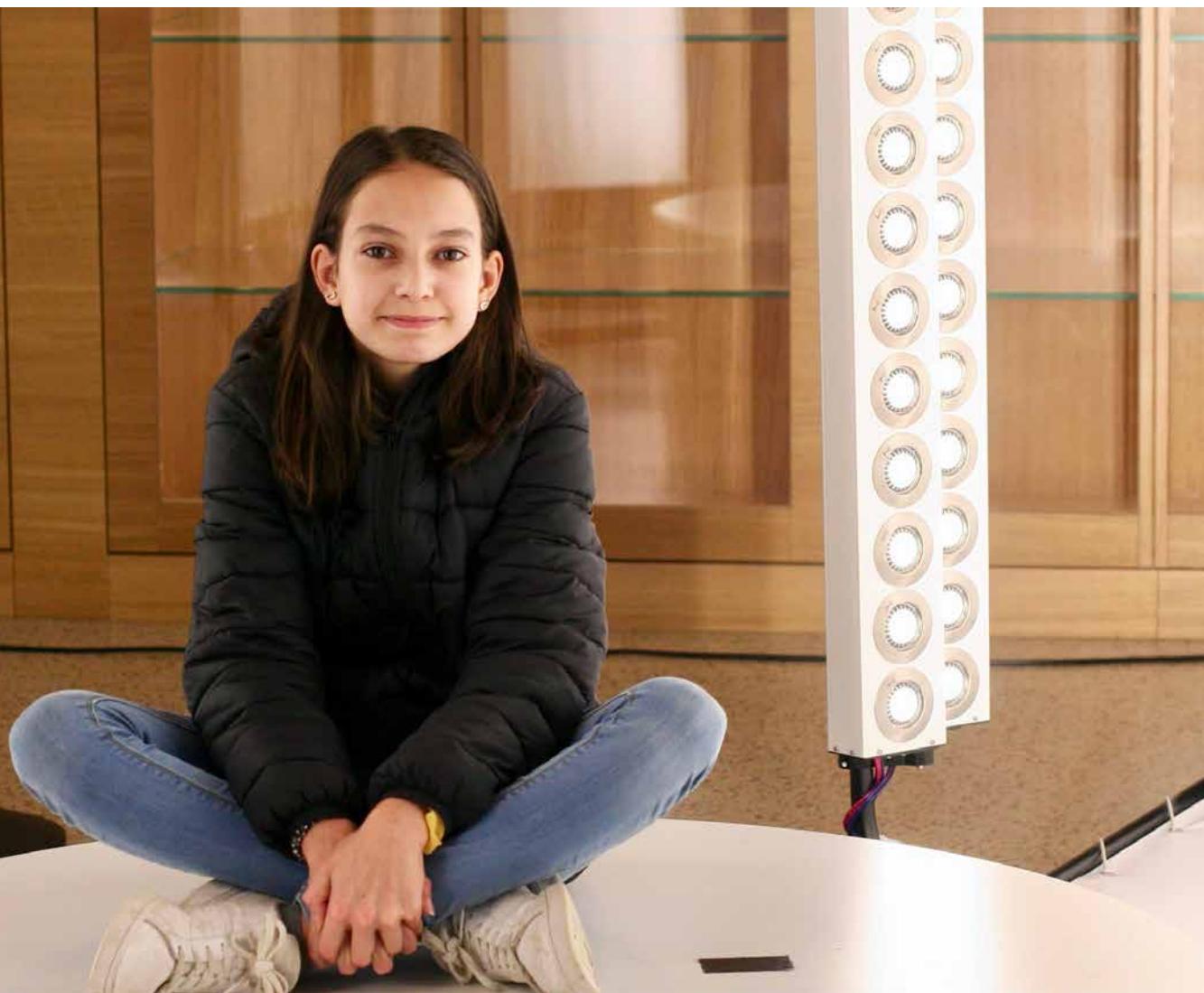
Preparing Today's Students for a High-Tech Future

"We need to get children interested in the impact that technology can have on almost anything they could pursue. So, we're not teaching them how to code. We're teaching them how to include technology in their thought processes," said Dr Kassem Al Ismaeil. He is part of a team of SnT researchers working on the [Smart Schoul 2025](#) project, an FNR PSP Flagship funded initiative to give children in Luxembourg's public schools an education that includes digital literacy. The project is led by SnT's Dr Djamila Aouada, and conducted in collaboration with FNR, SCRIPT (the Ministry of Education's Service to coordinate research and innovation in pedagogy and technology), Lycée Edward Steichen at Clervaux (LESC), Artec3D, and DataThings. It was launched in 2019 and gives teachers, educators, researchers, and of course, students themselves the unique opportunity to explore the educational possibilities that computer vision and artificial intelligence (AI) technologies can bring to the classroom.

"We want to expose the children to cutting-edge research – to spark their curiosity and get them thinking about exploring computer vision and AI research," explained Aouada. Interacting with the SnT research team, as well as having the chance to actually use state-of-the-art technologies in their school projects, will inspire students to start investigating the rich possibilities of computer vision and AI. It is a project that meets kids where they are and uses their natural interests as a chance to invite them to delve deeper into computer science.

One way the students will participate in the Smart Schoul 2025 project is through the 3D scanning booth (called the "Shapify Booth") that has been installed in the front lobby of LESC. Students will have the opportunity to use the scanner to augment their projects in other classes, whether that's by 3D printing figurines for a board game or checking their pos-

A student gets shapified at the Lycée Edward Steichen in Clervaux





Djamila Aouada leads the Smart Schoul 2025 project.

ture in athletics. "We want the Smart Schoul 2025 project to grow with the students. That's why we're ensuring that the student-portal, a WebApp our partners at DataThings are building for the kids, is modular," Aouada added. "As the project develops, we can continue listening to what educators and students want to do and find areas where computer vision and AI technologies, as well as research, could enhance their learning experience."

The Smart Schoul 2025 project is about a lot more than just showing kids how to use any single tool. It is an interdisciplinary project designed to help teach kids to approach and integrate new technologies into their studies. It will help teach kids about the importance of protecting privacy, and the impact technology can have on subjects beyond computer science. "Just because images and videos are handled securely or

privately doesn't mean they are handled ethically," said Al Ismaeil. "The project is going to introduce students to a lot of these sorts of nuances." It can even be used as a launching point to begin a conversation about brand-new social and ethical challenges, such as so-called deep fakes.

Smart Schoul 2025 will help prepare students for a future in which the power of computer vision and AI will touch our lives in ways that we cannot fully predict. "We hope to introduce technologies like this to students in more schools across Luxembourg," said Aouada. "The importance of digital literacy in preparing our children for the future just cannot be overstated. Giving students a tool that gets them excited to explore what technology can enable is a powerful step towards getting children to think both creatively and critically about the power of technology in our lives." •

“We want to expose the children to cutting-edge research – to spark their curiosity”



Introducing Reputation to Blockchain Systems

By the end of the day on 22 May 2018, an unidentified hacker had made off with \$18 Million in [Bitcoin Gold](#). Over the long weekend leading up to that Tuesday, they had rented enough computing power to become the single most powerful member of the Bitcoin mining network. They used their newly bought power to commit fraud, making off with millions. The hacker was never caught, and today almost all blockchains remain vulnerable to the same type of attack.

"The initial problem with blockchains," Prof Paulo Esteves-Veríssimo explained, "is that they tried to solve a distributed systems problem relying only on cryptographic methods. I thought that if I could get a cryptographer to work with me on re-approaching the challenge, we could significantly improve the technology." That's how security expert Dr Jiangshan Yu joined Esteves-Veríssimo's research group as a postdoctoral researcher at SnT in 2016. Together, they have developed a brand-new blockchain technology – and made blockchain's

vulnerability to the type of attack that happened in 2018, referred to as a 51% attack, a thing of the past.

They call their technology "Repucoin". Unlike traditional blockchains (such as Bitcoin and Ethereum), Repucoin distributes power based on a user's demonstrated reliability, which they call their "reputation". "On a traditional blockchain," Yu explained, "you need to trust the simple majority [as measured in terms of computing power]. We are saying, rather than trusting based on computing power alone, we should trust who has contributed the most often and most reliably". Esteves-Veríssimo added "what we are creating here is a system built on trustworthiness. It is as concrete and dependable as physics: power equals work over time. That's the equation." Yu and Esteves-Veríssimo call this "integrated power", as opposed to the "instantaneous" power relied on by traditional blockchains.

With Repucoin, network participants slowly build their personal reputation scores over time. Then it uses these reputation scores to power its consensus finding. In order for an action to be agreed to on the network, it must have the support of participants whose collective reputation scores account for at least two thirds of the sum of all reputation points. Participants' whose activity is found to be in bad faith take a hit to their reputation score, lowering their relative power on the network. "In a world that is too fast, we've reintroduced the value of slowly built trust," said Esteves-Veríssimo. It is the first instance in which an articulation of trustworthiness has been built into a proof-of-work network (Bitcoin is also a proof-of-work network).

"Repucoin not only resists a 51% attack – it is robust against an 85% or even a 99% attack," continued Esteves-Veríssimo. Given the effort required to build reputation on the system, any such attack becomes exorbitantly expensive. In fact, it would be over five-thousand times more expensive to attack Repucoin than Bitcoin, and as the network ages, Repucoin's resilience will only improve.

"We want Repucoin to be more than just another blockchain. It is a system upgrade to any existing blockchain," Yu explained over Skype from his office in Australia, where he is Associate Director of Research of a new interdisciplinary centre working to develop the blockchain ecosystem. The centre, called the Monash Blockchain Technology Centre ([MBTC](#)), is helping to introduce blockchain into other disciplines and industries who can benefit from the technology, as well as working to continue improving blockchain's suitability for real-world applications.

The resilience that Repucoin brings to blockchain significantly increases its viability for many real-world applications, such as fintech, energy, food supply chains, health care, and smart cities. Moreover, insights gained through Yu and Esteves-Veríssimo's work on Repucoin have been included in a survey of blockchain technology, which is now used as a teaching material by several universities. And that's sure to be just the beginning. Thanks to support of an FNR PEARL Grant, and the ongoing collaboration with Yu's Monash University team, we can be certain to hear a lot more about Repucoin's impact on the blockchain revolution in the future •



Jiangshan Yu joined SnT in 2016 to work on blockchain security. Today he is Associate Director of Research at the Monash Blockchain Technology Centre (Australia).

**“In a world that is too fast,
we’ve reintroduced the
value of slowly built trust.”**



Paulo Esteves-Veríssimo is an FNR
PEARL Grant holder and leads
a research group at SnT.



Secure by Design

"What we're working on here is a paradigm shift in system security design and analysis," said Borce Stojkovski, a doctoral researcher at SnT.

Stojkovski is one of a handful of SnT researchers looking at the intersection of user experience (UX), usability, and security. He and his colleagues have a particular focus on applying this to systems where privacy is a central concern. "We want to show that secure systems can still offer good user experiences. In fact, improvements to user experience can empower users to better protect their own privacy."

In an increasingly connected world where everything from refrigerators to health records are on-line (and where, very often, you unwittingly pay for services with private data), designing systems that make controlling privacy and security choices easier will have an enormous impact. A secure system can only be effective if users can consistently use it correctly.

For that to happen, it needs to be well designed. "People used to think that complexity was an unavoidable characteristic of computer security. But secure, private software does not have to be extremely complicated to use. Rather than training and retraining users on convoluted software, we need to start designing these critical systems more thoughtfully," Stojkovski said. And that is just what he is doing.

Stojkovski's work currently focuses on Malware Information Sharing Platform ([MISP](#)), an open-source platform developed and driven by Circl, part of the Security Made in Luxembourg ([SMILE](#)) initiative. The MISP platform allows closed communities to privately and securely share data about attacks, viruses, trends, or threats with peer institutions. For user communities such as NATO, this secure sharing platform means that allied

military forces can benefit from their NATO partners' intelligence in a centralised and searchable format. Other communities, such as financial institutions and law enforcement cooperations can also use MISP to create collaborative threat databases.

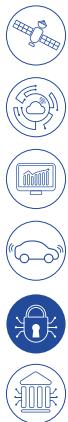
Stojkovski's research focuses particularly on understanding the challenges users face when they first start working with MISP. "Our partners at Circl are very supportive, both of their users and of our research. They regularly hold training sessions for new users and are always looking to improve the platform. My research is part of that. My initial user surveys show that mastering the software is daunting, so I want to figure out exactly why. The problem here is that if users do not fully understand the software, they might share information with a larger community than they originally intended. Or, perhaps, they might reveal more information than they ought. MISP's users need to feel more comfortable and more in control. And they need to feel that way more quickly."

"Improvements to MISP's design will empower the platform's users," added Prof Gabriele Lenzini, Stojkovski's thesis supervisor. "This is about ensuring that users understand their options and the consequences of their choices on the platform. We want everyone who uses it to feel that they are in full control of their data. It is part of our socio-technical approach to security."

The problem is an interdisciplinary one, requiring Stojkovski to consider and balance findings from computer security, software development, psychology, and aesthetic design. "My research portfolio is broad, so for me, the newest piece of the puzzle is working within the technical boundaries inherent in privacy and security contexts," Stojkovski explained. "It is really exciting to be part of bringing human-centred design to such an important field." •

Borce Stojkovski works at the intersection of user experience (UX), usability, and security.





A Step Towards Better Whitebox Encryption



Aleksei Udovenko's focus is whitebox encryption.

A skilled hacker only needs a toe in the door; a password to a forgotten account. A cell phone number. A date of birth. Hackers can leverage even the seemingly smallest pieces of data to gain access to their target. So in 2017, when the security research firm Fallible discovered hundreds of secret encryption keys hard-coded in Android apps, security professionals took notice. Some of these keys could be used to gain control of the company's cloud server, while others granted access to private customer data. The takeaway was clear: "think hard if you really need to hardcode this [API key/token]..." and whenever possible, build workarounds.

Yet "advice... is generally judged by results and not by intentions." For many companies, this piece of "good" security advice has not yielded the results they need, especially when it comes to developing tools for digital rights management (DRM) and mobile payments. Workarounds can slow down response

times or be incompatible with legacy systems (if, indeed, workarounds are even feasible at all). Companies are not looking for "good" advice that is incompatible with real-world considerations, they want solutions that yield results. They want a way to make encryption with hard-coded keys more secure.

That is how [the 2019 WhibOx Contest Edition 2](#) competition came into existence. "Many companies use encryption with hard-coded keys," SnT postdoctoral researcher and contest winner Dr Aleksei Udovenko explained, "and they want to find a way to make these existing systems more secure." While companies have made attempts at securing their hard-coded encryption keys, the WhibOx Contest Edition 2 encouraged researchers to apply state-of-the-art techniques to the problem. "With this type of encryption, the public has access to the code the key is stored in. That's why it is called a 'whitebox', the container is transparent, so to speak. So we

needed to hide the embedded encryption keys as well as possible in that transparent box," said Udovenko, describing the competition format. "So, each team submitted their own implementations. Then, once everything was submitted, we all got started trying to hack the other competitor's methods." By the end of the melee, Udovenko and Prof Alex Biryukov were the last team standing.

Their winning technique was a two step process: first, they applied an improved variant of a traditional masking technique, which mixed the key with decoy information to make the true key more difficult to spot; second, they applied their new method, structured obfuscation. "We split the encryption procedure into smaller pieces, then applied an obfuscation technique to those smaller pieces rather than to the cipher as a whole. Finally we introduced shuffling, which makes it harder to follow the correct cipher's execution path in the program," said Udovenko.

This divide-hide-and-shuffle technique is innovative and effective, but not perfect. "Our method resisted state-of-the-art automated attacks, people had to actually sit down and personally invest time into cracking it." Next, the team will continue working towards fully uncrackable whitebox encryption. "We can build on this to improve the efficiency of fully homomorphic encryption – where the computer executes a calculation on data without decrypting it at all. Someday if we achieve full-whitebox encryption, we could apply this to help create what's called functional encryption, which would allow users to decrypt just select pieces of larger encrypted datasets." In a world where more and more of our private data, right down to our medical records and even our genomes, depends on encryption to protect it from prying eyes, Udovenko and Biryukov's success is a win for us all •



Tokenising Venture Capital



Radu State and Wazen Shbair helped design the blockchain solution that VNX Exchange relies on to store transaction records.

"Giving users easy access to many different kinds of digital assets on the blockchain and, particularly, tokens that are linked to assets in the real world, is crucial to seeing blockchain adoption reach the next level," Ethereum creator Vitalik Buterin said soon after the launch of the first tokenised asset service. That service was an investment platform that backed each of its tokens with one gram of gold – the most concrete asset of all. Tokens (which are simply digital blockchain records) can track ownership of investments which are far more dynamic and just as real. Here in Luxembourg, the newly created [VNX Exchange](#) is giving the world a glimpse of how blockchain technology will change how we invest and trade.

VNX, founded by venture capitalist and CEO Alexander Tkachenko, is an innovative marketplace for investors to buy and sell positions in venture capital funds. Through its online marketplace — the first for venture capital fund posi-

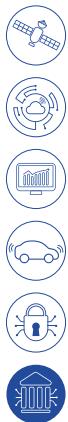
tions — VNX allows investors to buy and sell their positions in venture capital funds years before they would otherwise be possible. Transactions are then recorded on a state-of-the-art blockchain. The company, which opened in November 2019, describes its mission as "bringing liquidity and access to the venture capital market, [stimulating a global influx of capital into technology, innovation, and entrepreneurship](#)". It is fintech that plays to Luxembourg's strengths and is bringing the Grand Duchy to the front lines of the tokenised asset revolution.

Working with VNX on the technical end is SnT's Prof Radu State, who is overseeing a collaboration that will soon expand to include two new PhD students. "It is exciting to be part of such an ambitious project," said State. "The team is really dynamic and motivated." A spirit that is contagious. So far, State and his team have helped design the blockchain solution that VNX relies on to store transaction records, taking special consideration

for security. Blockchain stores the assets in plain sight — that's important, because otherwise there wouldn't be an enduring record of asset ownership. Yet storing records this way also introduces special challenges: it complicates privacy and it makes these assets an appealing target for hackers. State and his team needed to find novel ways to hide sensitive data from prying eyes, [to balance both GDPR and know-your-customer \(KYC\) compliance](#), as well as implement security measures against potential hackers. Most importantly, they needed to find a way to store users' private encryption keys, the passwords that confirm their identity on the blockchain and allow them to execute transactions, so that they are very secure. It was a challenge that required State's team to consider not only blockchain implementation, but also cloud computing security and trusted execution environment solutions.

"Working with [Vladimir Khanumyan](#) has been amazing. He gave me the best introduction to the world of venture capital. It is really valuable because with this understanding of the business side, it allows us to make better tech decisions," said State. "The project is exciting since it's a two-way communication channel. We develop technology but also learn new use-cases and application domains, which are not mainstream for computer scientists. The best technological solution has to be meaningful to the people who operate it and striking this balance between user acceptance and technology soundness makes it innovative and interesting."

With State and SnT, VNX is bringing the blockchain revolution to the world of venture-capital fund investing — and ensuring that their innovative new system is built on security, reliability, and trust •



Unmasking Blockchain Scams

"New disruptive technologies come from the fringe," Netscape founder and prominent investor Marc Andreessen told the Washington Post in 2014, "Bitcoin is the classic instance of that. ... We're quite confident that when we're sitting here in 20 years, we'll be talking about Bitcoin the way we talk about the Internet today." Since Andreessen's prediction, Bitcoin's underlying technology – blockchain – has taken off. By 2018 Diar reported that venture capital investment in blockchain and crypto companies was up by 280%.

Investment in blockchain is up, but the technology is still dogged by its "fringe" roots. In 2017, a research paper found that around 10% of smart contracts on the innovative Ethereum blockchain were Ponzi schemes. It is clear that before this technology becomes a part of our everyday lives, the public will need to develop a lot more trust in the ecosystems that surround it.

Blockchain may have been a wild west, but that is changing. SnT's doctoral researcher Christof Ferreira Torres is one of the people introducing the rule of law in this landscape, having developed an innovative tool to analyse the code on a blockchain. This year, Torres successfully applied the tool to identify a type of trap found on the Ethereum blockchain known as a "honeypot". Therefore, it seemed fitting to call the new tool HoneyBadger.

"Honeypots started out as a tool that security experts in networking used to understand hackers' tactics and to quarantine malicious behavior," Torres explained. "Yet on a blockchain, where economics and software always go together, their negative impact really outweigh their potential as a security tool. When a user is lured into a honeypot their money is effectively stolen."

Honeypots on the Ethereum blockchain are seen by the community at large as little more than scams – traps laid by hackers. The point is most poignantly illustrated by a word cloud Torres created from comments on the Etherscan website, where "WARNING" and "SCAM" loom large next to "HONEYBOT".

"Without HoneyBadger, there was too much code for any one person to examine and analyse. So it was impossible to reliably identify these scams. Our tool combines symbolic execution with cash-flow analysis to automatically identify honeypots from the sea of code on the Ethereum blockchain," Torres explained. "It is a technique that no one else has used and which we were pleased to present at the 2019 USENIX Security Symposium."



Vytautas Tumas, Flaviene Scheidt De Cristo and Lucian Trestioreanu's work is part of the University Blockchain Research Initiative funded by Ripple.

"We want to help users feel more secure when they interact with a blockchain system," said Torres's supervisor, Prof Radu State. "Our work is part of Ripple's framework for developing the broader blockchain ecosystem – the University Blockchain Research Initiative (**UBRI**). Our peers at universities like MIT, Stanford, and Northeastern, just to name some of our American colleagues, are working on their own projects designed to flush out complementary aspects of this new technology."

Ripple, a company focused on changing global money transfer protocols through blockchain, has funded the UBRI to continue its blockchain research for the next four years. "We were recently joined by PhD candidates Flaviene Scheidt De Cristo, Vytautas Tumas and Lucian Trestioreanu to work together on the project and collaborate as part of the impressive academic consortium Ripple has put together," State said. "Next, we will focus on developing technical aspects of a protocol called Interledger, which enables interactions between separate blockchains, for example between Ethereum and Bitcoin. Interledger will be an important step towards developing a blockchain ecosystem that is accessible and useful for the public at large. It is really exciting to be part of a project that could so fundamentally change the way we do business." •



A Collaboration of Competitors

"Yes, this could make life a lot easier for expats once it is implemented," Robert Norvill said with a warm laugh. His know-your-customer blockchain-based database project, conducted in collaboration with Luxembourg Bankers' Association (ABBL), has been met with real enthusiasm in Luxembourg, where many people have international backgrounds and complex banking needs. Indeed, for many, one of the biggest — and most unyielding — challenges of living abroad is navigating their relationship with banking institutions.

For years, international professionals of all backgrounds have been receiving "Dear John" letters from their bank, terminating relationships because they simply come with too much red tape. In fact, according to a 2018 global survey conducted by the International Chamber of Commerce, 93% of banking institutions view "regulation and compliance", especially know-your-customer (KYC) regulations, as the biggest obstacle to future trade finance growth. According to a 2019 survey conducted by BNY Mellon, in which a third of respondents reported an accelerated transaction rejection rate, the situation is continuing to get worse. That same BNY Mellon survey found that in 71% of declined trans-

actions, KYC regulations were given as the sole or secondary reason.

The problem is a complicated one, but Norvill's project presents an unexpected ray of hope. Some day — and thanks to the support of an FNR Pathfinder grant, perhaps even some day soon — expats will be able to update personal information with one bank and then share it as needed at the click of a button. For banks, the ease and trustworthiness of this process will make relationships with international customers more feasible, increasing the number of services and products available.

The solution is built on a private-permissioned blockchain, developed in close cooperation with bank-industry technologist Christophe Medinger and the ABBL team (especially Marc Hemmerling, Jean Hilger and Andrey Martovoy). It will allow banks, governments, and customers to securely — and privately — collaborate to improve the collection and organisation of KYC-compliance data. In fact, the blockchain is already connected to numerous government and banking networks.

The technology Norvill and his PhD supervisor Prof Radu State are developing offers a unique solution to the chal-

lenges of easing KYC compliance. "One of the biggest challenges here is creating a data-sharing system that works even in an environment of intense competition," explained State. It is a situation where potential participants may see the value of sharing information but don't want to give their competitors a free leg up. "On a private-permissioned blockchain like ours, each institution retains control over their own data," explained State. That means the banks do not need to trust a centralised third party with their customer databases. That is good for the overall participation rate, as well as for customer privacy. "Customers retain full control over who has access to their data, and data never ends up in the hands of unauthorised third parties," said Norvill. That makes their solution fully aligned with the GDPR.

"Ultimately participating banks will be able to accept more clients and transactions than they currently can," Norvill continued, "because our solution improves the efficiency and accuracy of KYC compliance, keeping costs down and enabling new, more attractive banking products." So expats can look forward to a near future with less red tape, and more freedom of choice in meeting their complex financial-service needs •

“Customers retain full control over who has access to their data, and data never ends up in the hands of unauthorised third parties”



Robert Norvill focuses on KYC compliance,
he works together with Luxembourg's
Banker Association (ABBL).



Intelligent Financial Regulation with AI

"What we need to do is to capture regulators' brains," said Dr Domenico Bianculli. "The tool needs to have the way regulators think built into it. That's why we will develop it in close cooperation with the financial regulators themselves."

Bianculli is a research scientist at SnT and the lead scientist on a new project with the [CSSF](#), Luxembourg's financial sector regulatory body. Called *Automated Compliance Checking and Query Answering for Fund Documents*, the project is the first ever cooperation between the CSSF and SnT, as well as a brand-new application domain for model-driven engineering. It is an exciting collaboration that will have a real impact on the heart of Luxembourg's economy: the financial sector.

"We are working with artificial intelligence, model-driven engineering, and automated verification technologies to develop a system that regulators can use to check the compliance with fund-document regulations," Bianculli explained. "Right now an agent has a huge checklist to go through. With our

approach, they will have a much leaner process." For the CSSF, the collaboration is an important part of their "CSSF 4.0" strategy, which aims to incorporate the latest AI advances into the regulatory process to "enhance the transparency and speed" of the overall regulatory process.

The envisioned tool will use natural language processing and machine learning to extract key information that it can use to build a model of the fund document's contents. Then, Bianculli and his team will develop the tool's capacity to check whether the fund-document's model conforms with compliance rules; rules that will reflect the regulations that financial-service providers must comply with when offering a new product. [The tool will be able to rapidly indicate whether a document submitted for approval meets regulatory requirements.](#)

"We want to create a system that highlights where humans need to act," Bianculli said. That's why an essential feature for the tool will be its capacity to indicate exactly why it identified an error in the document. Ultimately, it will

be able to indicate which specific passages, words, or omissions need regulators' attention. To achieve this, the tool will pick up on textual nuances that link passages to particular regulatory concepts. This feature will also make their tool a powerful aid in the versioning process, allowing regulators to check whether requested changes have been incorporated into resubmitted documents. This will speed-up the oversight process, improve the time-to-market for Luxembourgish financial products, and simplify the compliance process for financial service providers.

Thanks to the collaboration, financial regulatory professionals at the CSSF can look forward to a more efficient workflow that will make executing their rigorous financial regulation smoother. As Claude Marx, Director General of the CSSF wrote in the commission's [2018 Annual Report](#), "new technologies will... contribute to build a financial system that is more efficient, cheaper, less vulnerable and more inclusive." Together with Bianculli and his team at SnT, they are making sure that the financial system of the future belongs to Luxembourg •

“The tool needs to have the way regulators think built into it. That's why we will develop it in close cooperation with the financial regulators themselves.”



Domenico Bianculli (pictured on Kirchberg) is the lead scientist on a project with the CSSF, Luxembourg's financial sector regulatory body.



José Soares, Gabriele Lenzini, Davit Chokoshvili (Megeno) and Erica Monfardini (University of Luxembourg) at the SnT-Megeno partnership launch event.

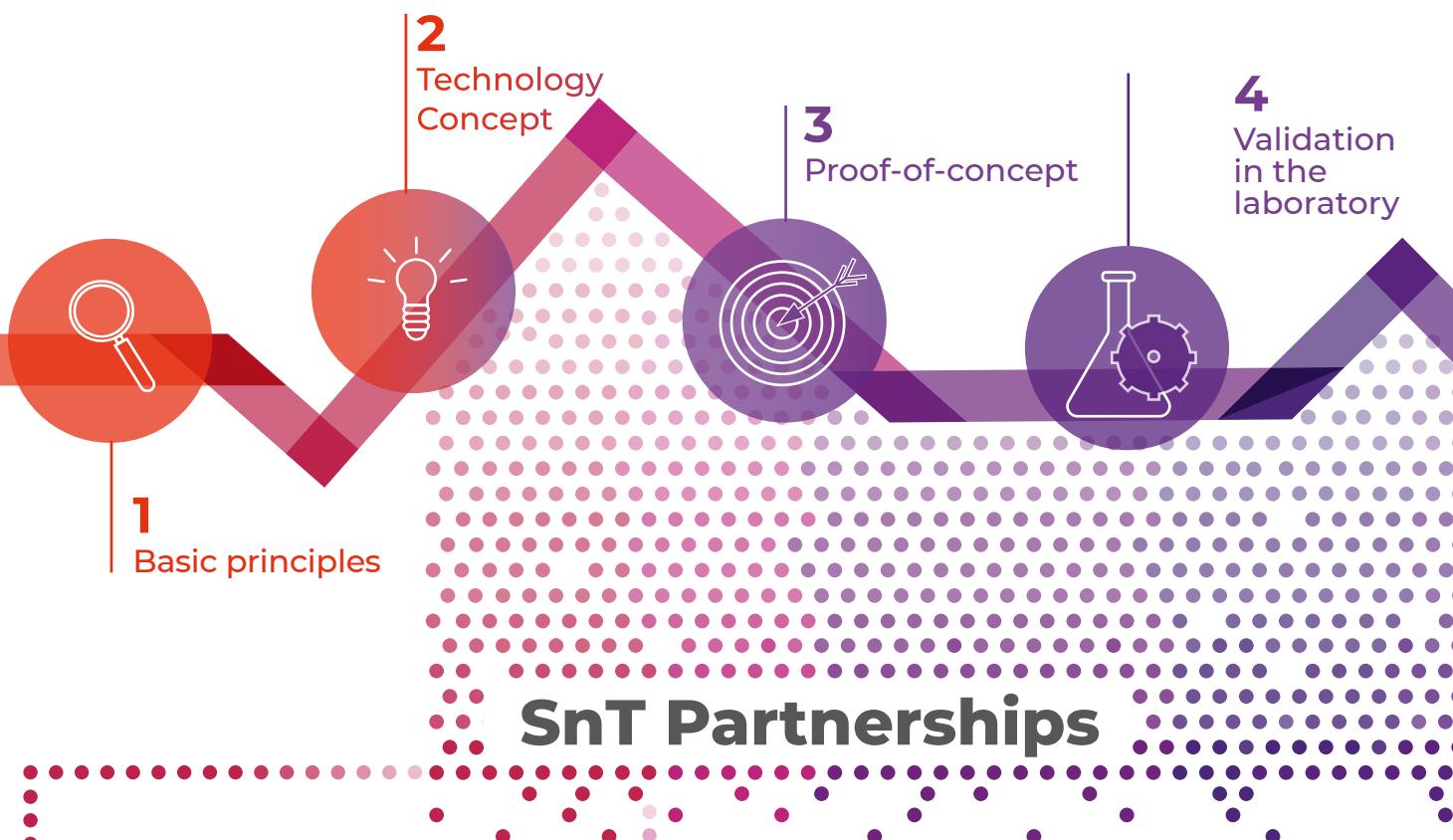
A photograph of a social gathering. In the center, a man with short dark hair and a light beard, wearing a dark pinstripe suit, a white shirt, and a patterned tie, is smiling and looking towards the camera. He is holding a clear glass in his right hand. To his right, a woman with curly blonde hair tied back in a bun is leaning in close, also smiling. She is wearing a dark blazer over a light-colored top. In the background, another person's arm and shoulder are visible on the left, and a window with horizontal blinds is on the right. The lighting is warm and slightly dim.

**Fueling
Innovation**

Our Partnership Programme

We are guided by the principle that excellent scientific research can address the most pressing challenges society faces, and support industry in developing solutions. This foundation defines our set-up. We have a [partnership model](#) that enables truly collaborative exchanges, allowing us to have access to relevant challenges, real-world data, and systems to test our research results. This approach creates a lively ecosystem that feeds the local talent pool, and supports the local economy.

Technology readiness levels



SnT Partnerships

● The Basics

Who are the partners?

Public or private entities that have a business challenge without an existing solution

What is a partnership?

A joint investment in a multi-annual research project with concrete outcomes

Where do partners come from?

All around the world but mainly from Luxembourg

Why partner with SnT?

Access to top-notch competence in ICT based on a proven collaboration model with industry

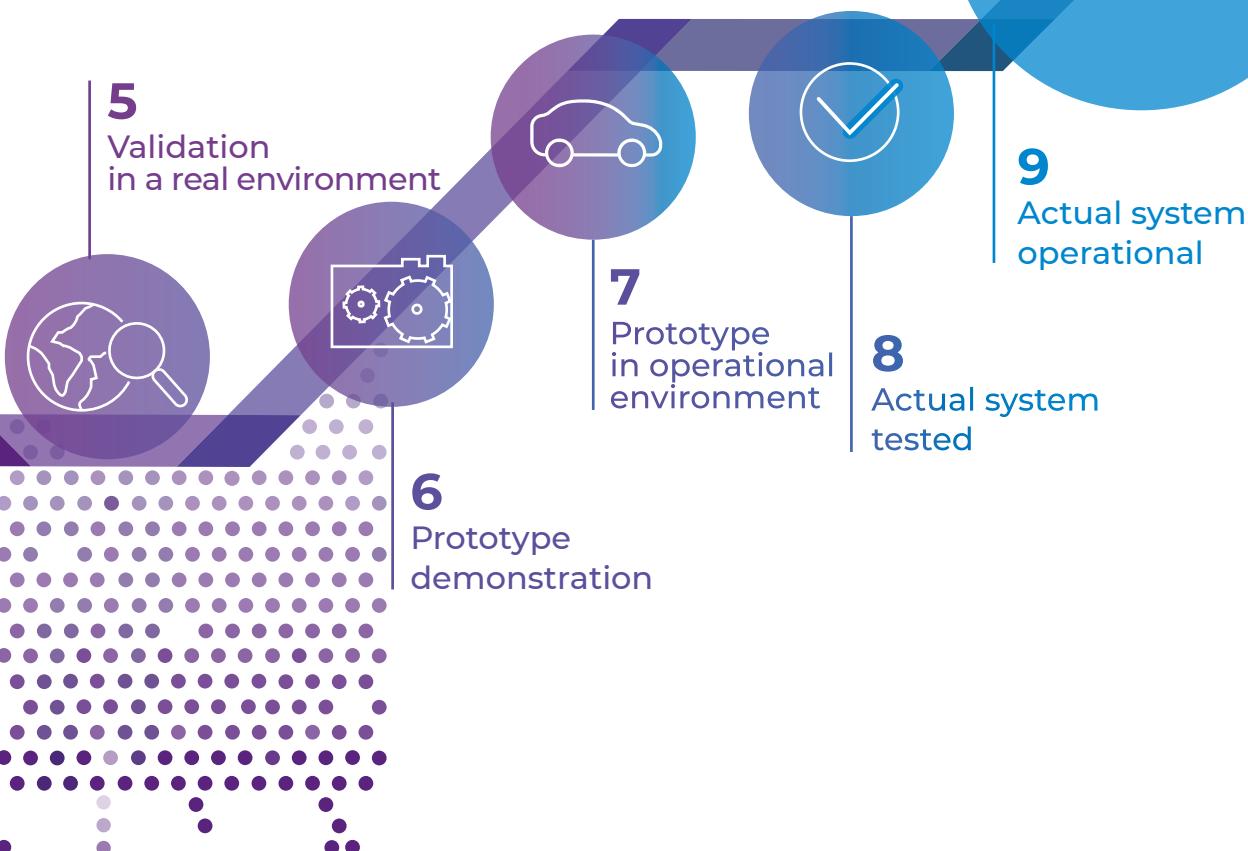
● Ready for Partnership?

Follow this quick checklist to assess whether a collaboration with us is relevant for your organisation:

- Lack of an existing solution for a business challenge
- Capacity to engage in multi-annual joint research
- Willingness to co-invest with SnT
- Looking for an edge over the competition
- Wish to gain access to creative minds and top-notch infrastructure

“Delivering on real-world challenges is in the DNA of SnT”

José Soares, Partnership Development Officer



In Practice

- Long-term partnerships that solve challenging industry questions
- SnT uses academic research to create a prototype that solves the challenge
- 50/50 Co-investment of both parties in the project
- SnT supports the acquisition of third party research grants
- Joint selection and supervision of project staff
- SnT staff will spend a significant amount of time at partner premises
- Outcome is typically a prototype working in the partners's real environment

SnT Partners 2019

Our partnership programme continued to expand in 2019, now featuring 47 members. Our partners span a variety of areas, including fintech and the space sector. We work with both public and private organisations in Luxembourg and around the world.

RESEARCH PARTNERS



Fondation
Alphonse Weicker



clearstream | DEUTSCHE BÖRSE GROUP



LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
Centre des technologies de l'information
de l'Etat

LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère d'Etat



NETWORKING PARTNERS



In 2019 five research partners and one networking partner joined our programme. Read about them here:

CSSF

The Commission de Surveillance du Secteur Financier (CSSF) is a public institution which supervises the professionals and products of the Luxembourg financial sector. The research project aims to incorporate the latest technology advances into the regulatory process to enhance transparency and speed.

Megeno

Megeno is a Luxembourg-based startup company turning human genome data generated by European clinical and research institutions into a lifelong asset. SnT researchers are supporting the development of their user-centred, transparent, and secure genome data services.

Paypal

PayPal has remained at the forefront of the digital payment revolution for more than 20 years. The partnership established between PayPal Europe, the FNR and the University of Luxembourg through the PayPal-FNR PEARL Chair, is set to encourage the development of a critical sector for the Luxembourg economy: digital financial services.



Ripple

Ripple is a provider of leading enterprise blockchain solutions for global payments. This partnership will develop the network communications necessary for micropayments, which promises to change the way we consume content on the internet.

Vail Systems

Vail develops innovative technology to enhance the way people communicate. They offer self-service applications and messaging using browser-based, voice, and mobile technology enhanced through Artificial Intelligence and Machine Learning models on natural language understanding and generation. The project with SnT focuses on the development of machine learning techniques to automatically predict fraudulent activities in call centre operations.

X-LANE

X-LANE supports companies in their conception of innovative projects and research projects. The aim is to strengthen the ability of its customers when difficult IT decisions have to be made as part of their innovation processes. As our network partner, they help identify technology projects that we can work on together.

Start-up Launch Pad

Our researchers regularly develop exciting new solutions for real-world challenges. That is why we launched the research acceleration programme in 2019, which delivers a structured process to support our aspiring entrepreneurs. Its mission is to encourage scientists to pursue the commercialisation of their innovative ideas.

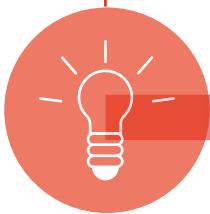
By following the programme, researchers receive support and guidance about the crucial steps of setting up a business, such as market research, amongst others. This assistance gives researchers the opportunity to develop skill sets that are needed as an entrepreneur, and to eventually launch a sustainable business if possible.

The programme also considers the protection of intellectual property (IP) rights. We support researchers if they need to secure IP through a patent application, or define different licensing models. By monitoring and securing IP from the very beginning we are able to support researchers more effectively, maximising their chances of launching a successful business.

By offering formalised in-house support to researchers SnT underlines its commitment to supporting the local economy by fuelling an innovative business climate. Our spin-offs are now becoming established companies with success stories that we are proud to share •

SNT RESEARCHER HAS AN IDEA

- Idea sourcing
- Technology scouting
- Identification of business advisors



MARKET VALIDATION

- Market study
 - Team setup
 - Market proofing
 - Industry feedback
 - Road-to-market & proof-of-concept (PoC) plan
- FNR PoC proposal

IDEA IS VALIDATED

- Light market feasibility check
 - Access to business advisors
 - Business mentoring
 - Project development plan
- FNR Pathfinder proposal



“There are so many great ideas here, but the execution of the commercial transfer is key. The team, the market study and the secured IP are as relevant as the technology itself. **”**

Jacek Plucinski,
Technology Transfer Officer



SnT Spin-offs

MOTION-S

 LuxAI



PROOF-OF-CONCEPT

- Business value chain defined
- Minimum viable product
- Pilot projects with industry
- IP package ready for licensing
- Business plan
- VC/Seed fund

 DATATHINGS

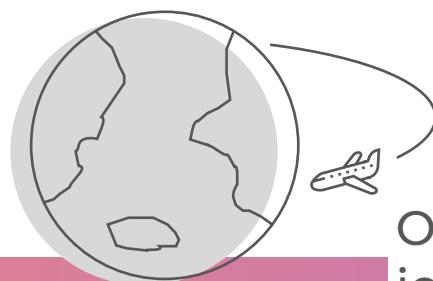
 Black Swan
LUX

Building a Talent Base

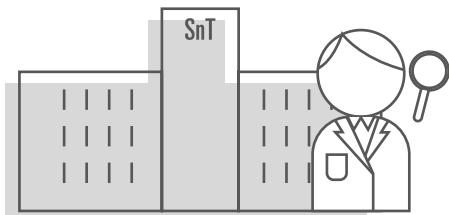
We attract PhD students and academics to our team from around the world, bringing top talent into the economy of Luxembourg.

A research project with an industry partner includes funding for a PhD student most of the time, and it is standard practice for this student to integrate into the technical team of the partner organisation – bringing their skill-set in-house for the project duration. In time, researchers leave SnT, and thanks to their close relationships with industry partners it is common to find them employed just down the road from our campus •

We attract top talent
from all corners
of the world



Over **62**
joined SNT
in 2019

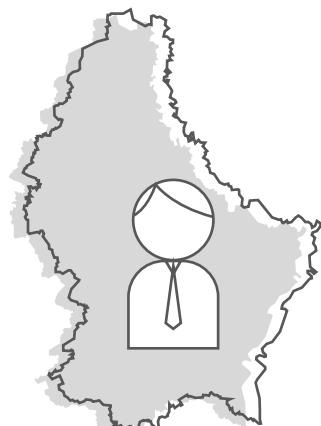


47%
of SnT's active PhD's
were linked to partner
projects in 2019

Researchers work
on partner projects
at SnT

Researchers enter
industry
in Luxembourg

36%
of SnT alumni
are employed
in Luxembourg



Meet Frederic Garcia

“If I had to pick just one word to describe my experience, I would say “opportunity””



Frederic Garcia (IEE)

Dr Frederic Garcia is a computer vision scientist at IEE, and an SnT Alumnus. As a PhD student and later research associate he specialised in the depth accuracy of low-resolution 3D cameras. He was recommended to our PhD programme by IEE, and while at SnT he worked on research partnerships with IEE, finally becoming a fully-fledged member of their team in 2014.

How did you end up in Luxembourg?

Originally, I came to Luxembourg for just one semester to do my master's thesis at IEE. After that project wrapped-up, my supervisor asked me to join the company, and I was interested, but I had intended to leave Luxembourg to pursue a PhD. That is when I found out about SnT, as he said I could do my PhD there and keep working with IEE through my doctoral research. It was a fantastic opportunity as SnT made it possible for IEE and me to continue a very fruitful collaboration.

What is your current job/responsibility?

I work on a number of research and development projects, including driver monitoring, 3D cameras, and 2D cameras. We

keep a startup spirit alive at IEE, and I really enjoy working on the small, energetic research and development teams we have. I am part of what we call the accelerator team, responsible for suggesting new innovations and developing proof-of-concepts from scratch.

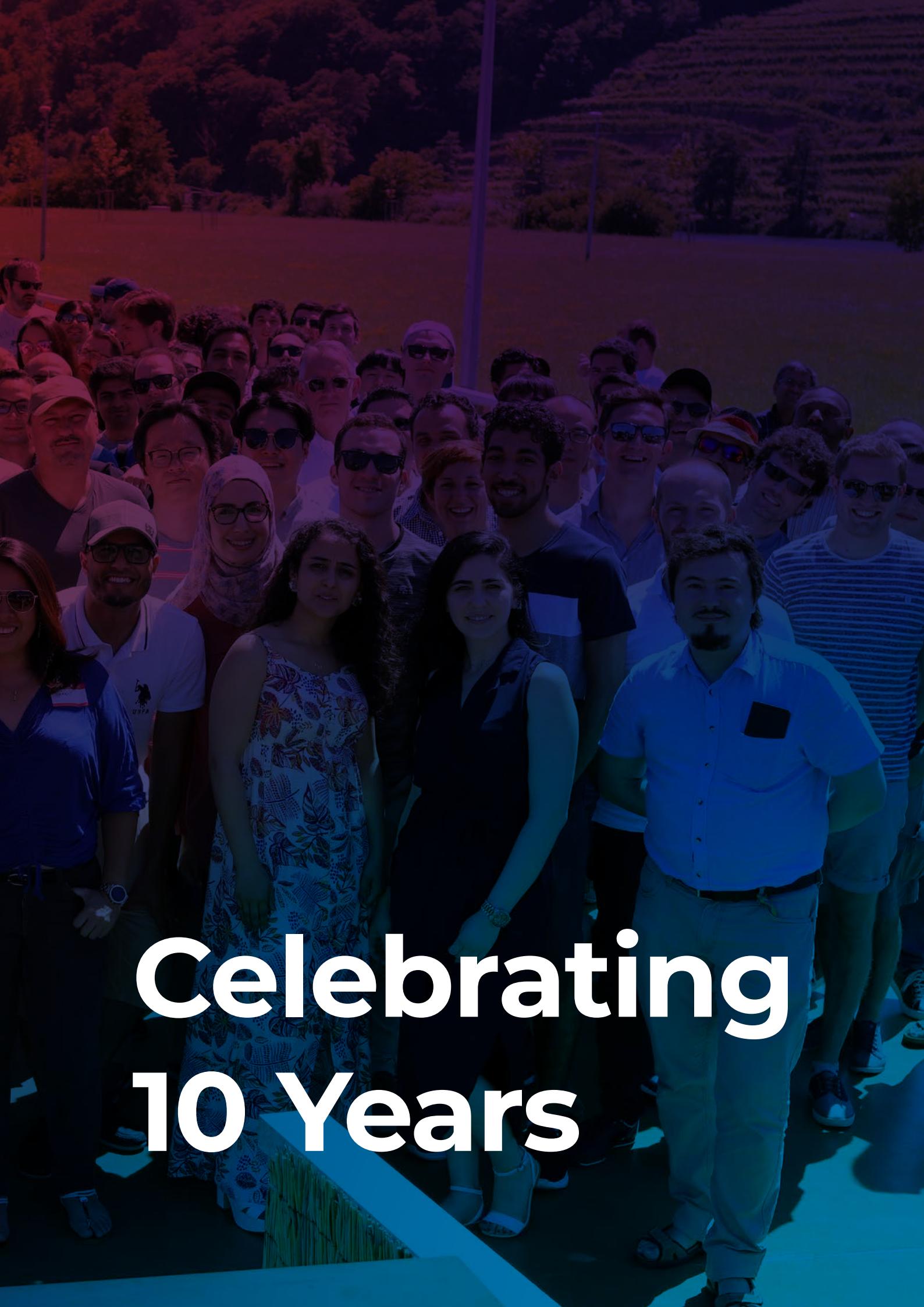
How has SnT defined your career?

SnT encouraged me to expand my horizons and that influences the way I think and work still to this day. The culture of SnT focuses on collaboration both internally and externally, which really supported me to get out and bring my ideas to peers around the world. I traveled frequently to conferences to present my work, and that helped me develop a unique international network.

And, of course, I still enjoy working with a small, dynamic team, which is exactly what we had at SnT. We weren't colleagues, we were friends. I have many fond memories of my time there, yet if I had to pick just one word to describe my experience, I would say “opportunity”. SnT and everything it offered translate into a world of opportunity for me •



The entire SnT staff at the centre's
10-year celebration.

A large, diverse crowd of people is gathered outdoors at night, standing in rows and smiling for a group photo. The scene is set against a backdrop of trees and a building, with artificial lighting illuminating the faces of the attendees.

Celebrating
10 Years

A Decade of SnT



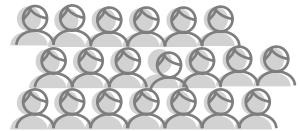
2009

- SnT is founded with Björn Ottersten as Director. First partners sign on – POST Luxembourg, Telindus, and SES.



2011

- First patent filed. Four awards for best paper.
- Ten projects with ESA and the EU.



2013

With more than 200 staff, we surpassed the original five-year target of 100 employees. Prof Yves Le Traon receives Google Faculty Research Award.



2012

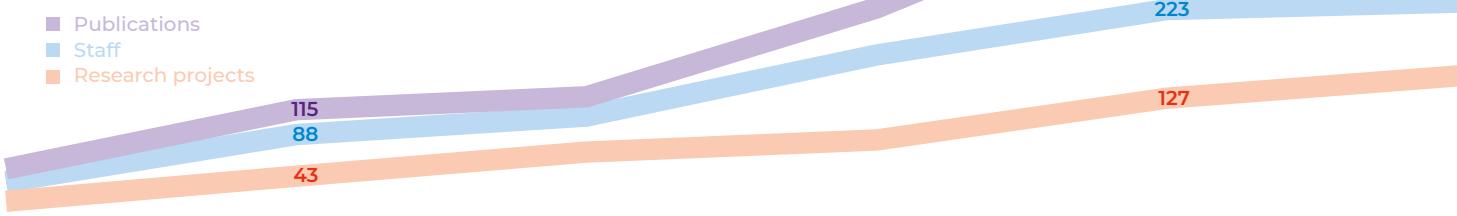
We received the University's First PEARL Grant from the FNR. Hosted the first Partnership Day.

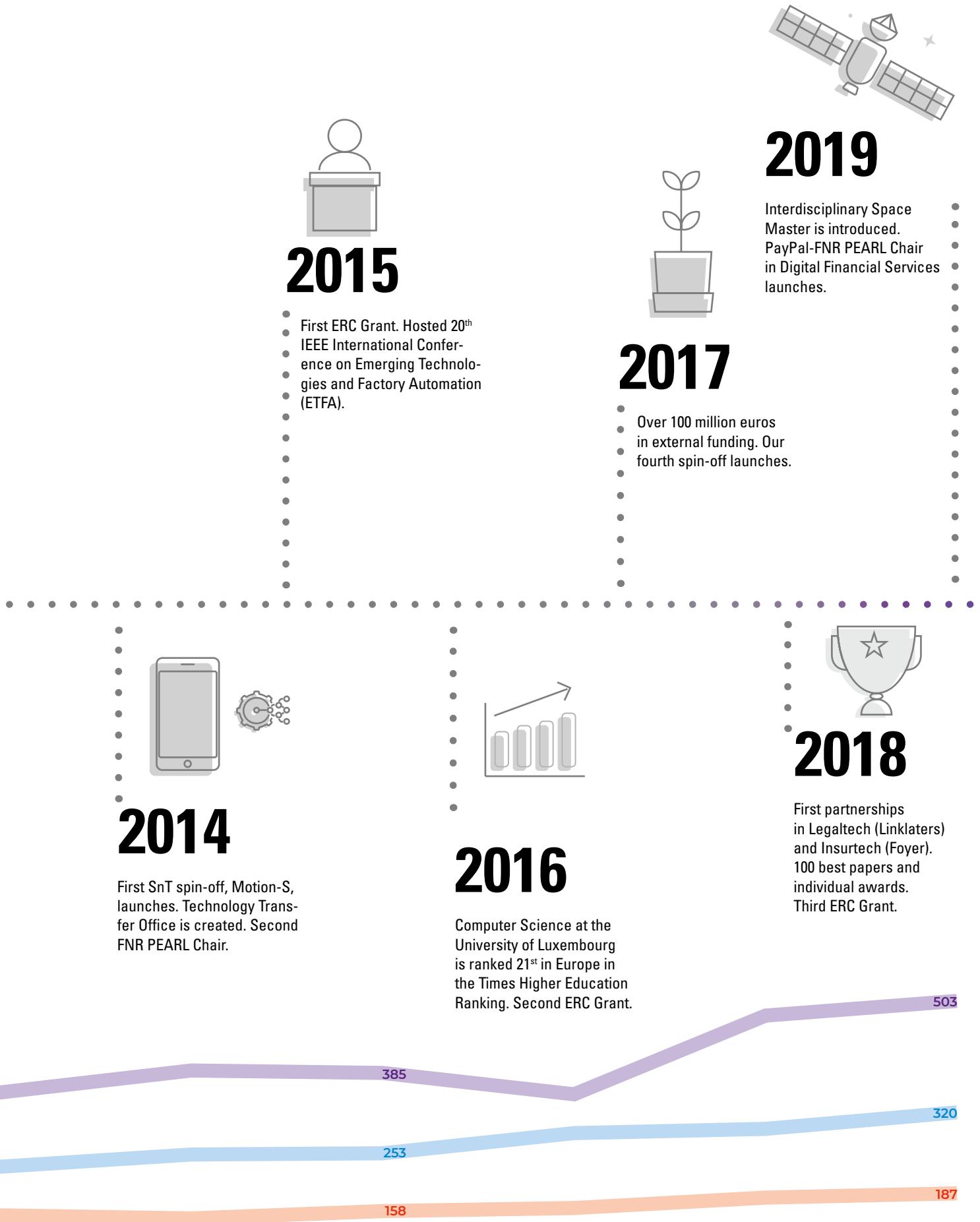


2010

First European Summit on the Future Internet & first European Project.

■ Publications
■ Staff
■ Research projects





Reflections on SnT

Every year the SnT community grows, with each new person bringing unique talent and perspective to our research and making our team stronger. As they join us, many find our culture and way of working distinctive. They have many stories to tell and reflecting on SnT means something different to everyone.

GROWTH



Bhavani Shankar

RESEARCH SCIENTIST, JOINED IN 2009

"Towards the end of my PostDoc at KTH under Prof Ottersten, I was informed about his plans to launch SnT. This looked like an exciting opportunity: we were basically going to build a center from scratch! That's why I joined SnT."



Paulo Esteves-Veríssimo

RESEARCH GROUP HEAD, JOINED IN 2014

"SnT has been experiencing phenomenal growth, both qualitatively and quantitatively, but it hasn't been a case of abrupt changes – there is continuity in our growth strategy."



Cécile Petit

PROJECT COORDINATOR, JOINED IN 2011

"Researchers understandably focus on publications, but it's important to remember that acquiring funding is also a big part of the job. SnT is very demand-driven and project-based, so this is even more the case here. Every year we grow, and that's always been driven from the bottom up, with lots of successful project applications, whether from the EU, FNR or industry partnerships."



**Serket Quintanar
Guzmán**

DOCTORAL RESEARCHER, JOINED IN 2015

"The thing that I like the most about SnT, or Luxembourg in general, is multiculturalism. It's amazing how this impacts creativity and productivity at work, and how interesting the office atmosphere becomes."



Jorge Augusto Meira

RESEARCH ASSOCIATE, JOINED IN 2016

"My most memorable moment at SnT was my first Partnership Day. We get to talk to the other researchers at SnT and meet all of our private and public partners. We still get to talk about science, but in a different, more relaxed environment."

CULTURE

RESEARCH

**Jacek Plucinski**

TECHNOLOGY TRANSFER OFFICER, JOINED IN 2018

"There are many opportunities to transform research accomplishments into licenses, products, or entire businesses. At SnT, I always tell researchers to come and see me, even if the idea sounds crazy. Let's brainstorm first and decide on crazy later."

**Arianna Rossi**

RESEARCH ASSOCIATE, JOINED IN 2019

"One of the most fascinating aspects of SnT is the spirit of collaboration between different disciplines and sectors. This allows us to discover the potential for established research methods and innovative technologies to be used in a wide range of applications: the key question is how we create and transfer this knowledge."

**Mehrdad Sabetzadeh**

SENIOR RESEARCH SCIENTIST, JOINED IN 2012

"I hope more research centres will start to put as much emphasis as SnT does on addressing complex industrial problems."

**Tegawendé Bissyande**

SENIOR RESEARCH SCIENTIST, JOINED IN 2013

"What's special is when the needs of industry and your needs as a researcher feed into one another."

**Marharyta Aleksandrova**

POSTDOCTORAL RESEARCHER, JOINED IN 2017

"For me the very important thing about working here is the diversity of the people. This allows you to get a very different perspective in both your research and life in general."

**Gabriele Lenzini**

RESEARCH GROUP HEAD, JOINED IN 2010

"At the beginning, interacting and sharing ideas was as casual as walking down the corridor or to the kitchen. Today, with SnT being so large and located on two campuses the dynamic is different, more structured; but ideas have never stopped flowing and everyone collaborates with the same enthusiasm!"

Meet SES



“People all over the world are about to have their connectivity experience improved because of the work we did together.”

SES was one of SnT's first industry partners. They deliver amazing experiences everywhere on earth by distributing the highest quality video content and providing seamless connectivity. As the leader in global content connectivity solutions, SES is the only provider that operates both Geostationary (GEO) and Medium Earth Orbit (MEO) satellites providing a unique combination of global coverage and high performance, including the commercially-proven, low-latency O3b constellation. Ruy Pinto, the Chief Technology Officer of SES, reflects on the partnership and how such initiatives enable the company to make a difference on a global scale.

What attracted SES to set up a partnership with SnT ten years ago?

Our business relies on the technology we use to meet the market needs, so we're always looking into innovations that can be turned into better services for our customers, as well as new solutions and business models. This made a partnership with SnT a natural fit, as it provides access to cutting-edge academic research. Signing a partnership agreement was only the formalisation of a long-standing relationship that existed since 2004 with some of SnT's founding researchers.

Ten years later, how have you applied the partnership's research results?

We have successfully launched all 20 O3b MEO satellites and have been commercialising it since 2014. We are now on the cusp of launching our next generation system, O3b mPOWER, which leveraged the technologies we studied in system contexts with SnT.

Built on the success of SES's current O3b system, the O3b mPOWER communications system comprises an initial constellation of seven high-throughput and low-latency satellites and extensive ground infrastructure. The global terabit-level scalable constellation will enable the delivery of high-bandwidth, low latency data connectivity services for markets including telecom and cloud, communications-on-the-move and government.

The O3b mPOWER system is built on satellite beamforming technology, which we previously studied in a systems context with SnT. The work we have done in cooperation with SnT laid the foundation to accurately study the system benefits of flexible payloads such as those found in O3b mPOWER. The academic research is used to prioritise technical roadmaps, benchmark key technologies and inform the way we designed next-generation constellations. Now people all over the world are about to have their connectivity experience improved because of the work we did together.

How has the partnership evolved over the past ten years?

The growth of SnT over the past decade has been nothing but impressive, as they went from a small group of people to an internationally recognised expert in satellite communications. If you go to the European Space Agency, or even to the US, people in the satellite industry know SnT's research. The work we have jointly developed has led to an impact for our business, and we look forward to another ten years of pushing satellite technology forward.

Meet LuxAI



“It has been wonderful to have the support of the academic team as we bring research out of the laboratory and into the real world.”

Aida Nazarikhoram and
Pouyan Ziafati (LuxAI)

LuxAI is a Luxembourg-based start-up that builds expressive, humanoid social robots used as a training tool for children with autism. Dr Pouyan Ziafati and Dr Aida Nazarikhoram founded the company after Pouyan finished his PhD at SnT.

How did LuxAI get started?

Dr Pouyan Ziafati: In 2011, I began my PhD here at SnT. I was working on a project called ‘Programming Cognitive Robots’, and every day I would come home and talk with Aida, my wife, about my day.

Dr Aida Nazarikhoram: Originally I am a medical doctor, but at the time I was working as a product manager at a local start-up. Thanks to this exposure, when talking with Pouyan I realised that we had huge potential for interdisciplinary innovation. After some market research we realised that a robot to support interventions for autistic children would be very valuable.

What role has SnT played in your success?

Dr Pouyan Ziafati: SnT was crucial when we got started, as their support made it possible for us to win an FNR Proof-of-Concept Grant. This allowed us to begin conducting studies to test our product in a therapy setting. We worked with

social scientists at the University of Luxembourg, as well as AI experts at SnT to conduct essential validation studies that really helped us hit the ground running.

Dr Aida Nazarikhoram: We continue to flourish as one of the first SnT spin-offs because of the continued confidence the centre has in our work. It has been wonderful to have the support of the academic team as we bring research out of the laboratory and into the real world.

What are your plans for the future?

Dr Pouyan Ziafati: 2019 was a very good year for us as we completed all the required product certifications we needed to go into mass production and international product shipment. We now have customers from all around the world, from the US to China, and to meet the growing global demand for our robots we need to begin producing them in larger quantities.

Dr Aida Nazarikhoram: Now that hundreds of centres across the world are using our QTrobot on a daily basis we want to develop our system’s ability to give therapists and caregivers actionable data. It is important for the person working with a child to know how that child is progressing to determine a personalised training plan •

Meet Sheila Becker



“ I cannot imagine a better way to have prepared for my career than through my doctoral studies. ”

Sheila Becker
(Institut Luxembourgeois de Régulation)

Dr Sheila Becker was one of the first students to receive a PhD from SnT, starting her doctoral work just as the research centre was created. After graduating in 2012 she began working at the Institut Luxembourgeois de Régulation (ILR), before joining the cyber defence team of the Luxembourg Army. She has since made her way back to ILR, now leading their new cybersecurity team.

Why did you choose to study at SnT?

It came about very naturally. I was doing a master's at the University of Nancy, and the work was so interesting that I couldn't stop there, and decided to continue with a PhD. At the same time SnT was just getting started and one of my professors presented the option to do a combined PhD with SnT and the University of Nancy. It was a happy coincidence that I was able to continue working with Radu State, who I had met during my master's.

What did your PhD research at SnT focus on?

The research project that I was part of looked at theoretical concepts to make peer-to-peer (P2P) networks more efficient and secure. The project looked at how machine learning and game theory could be applied in this virtual environment to

expose malicious actors. Within this project I learned how different interactions produce different results in the context of a P2P network.

How has your SnT education helped you in your career?

My PhD taught me how to develop a methodical overview of a long-term problem. That's what a doctoral research project really teaches you to do; to organise yourself and your projects differently. You assess the whole project and its challenges as part of a bigger picture. You learn another way of working – and of thinking. I cannot imagine a better way to have prepared for my career than through my doctoral studies.

What did you enjoy most about doing your PhD at SnT?

Two things really stand out to me as being unique to SnT looking back now. First was the small size of the research teams. I really enjoyed working in a team where we all knew each other, as it made for a very warm working environment. Second was the opportunities for international collaboration. Beyond my collaboration with the University of Nancy, I worked closely with a research group at Purdue University in the US. And the environment of SnT itself is so international, it is exciting to be a part of. I'd say SnT was more like a family than a big university •

A Global Network

Every stage of an SnT experience is international. Researchers join us from all around the world, making the centre a rich environment full of cross-cultural connections. At the end of their time with us many of our alumni find success in Luxembourg, and even more travel on to new positions at universities and companies around the world.

LUXEMBOURG

Our alumni who choose to stay in Luxembourg tend to pursue careers in both public and private organisations, or sometimes create a startup. For example:

- CIRCL (the Computer Incident Response Center Luxembourg)
- FNR
- Amazon
- Talkwalker
- DataThings

EUROPE

Branching out into the EU the public/private split continues, with some going on to research institutions as well.

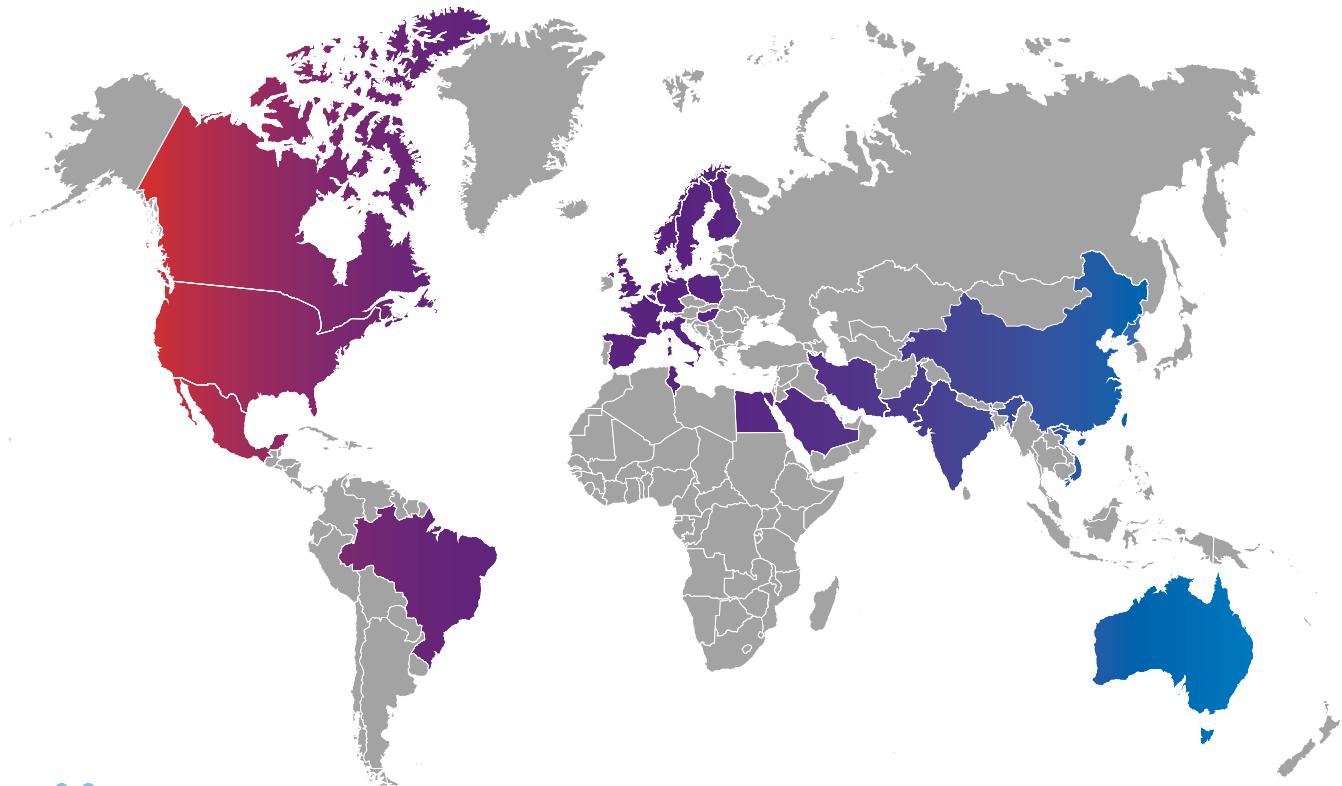
For example:

- ESA
- Munich RE
- Google
- The Fraunhofer Society
- Aalto University

WORLD

When a member of our community leaves us to go even further afield, they take the SnT ethos with them to new organisations around the globe. For example:

- Beijing Jiaotong University, China
- McMaster University, Canada
- The University of Queensland, Australia
- Facebook, US
- Huawei, Middle East



DID YOU KNOW?

The diversity in career paths that our alumni choose to pursue epitomises our culture, and feeds back into the research at the centre. Our global network brings depth to our academic connections and has even been known to ignite new industry partnerships •



SnT is located on Kirchberg
(pictured here) and in Belval.



29

Organisation

Overview

Governance

SnT has two leadership bodies, an Advisory Board that provides oversight and counsel to the University President, and a Management Board executing the day-to-day business of the centre, led by the Director of SnT.

ADVISORY BOARD

Stéphane Pallage, Chairman
President, University of Luxembourg

Erica Monfardini
Director of Administration and Finance,
University of Luxembourg

Anne-Catherine Ries
Premier Conseiller de direction, Ministère des
Communications et des Médias, Le Gouvernement
du Grand-Duché du Luxembourg

Mario Grotz
Premier Conseiller de Gouvernement, Ministère
de l'Économie, Le Gouvernement du Grand-
Duché du Luxembourg*

Pierre Zimmer
CIO, POST Luxembourg

Ruy Pinto
CTO, SES

MANAGEMENT BOARD

Prof Dr Björn Ottersten
Director

Prof Dr Yves Le Traon
Vice Director

16 Heads of Research Groups**
See pages 62-63

Isabelle Chesnay
Head of Office

Dr Carlo Duprel
Head of Technology Transfer Office

* Joined December 2019

** Reflects changes to research groups in January 2020

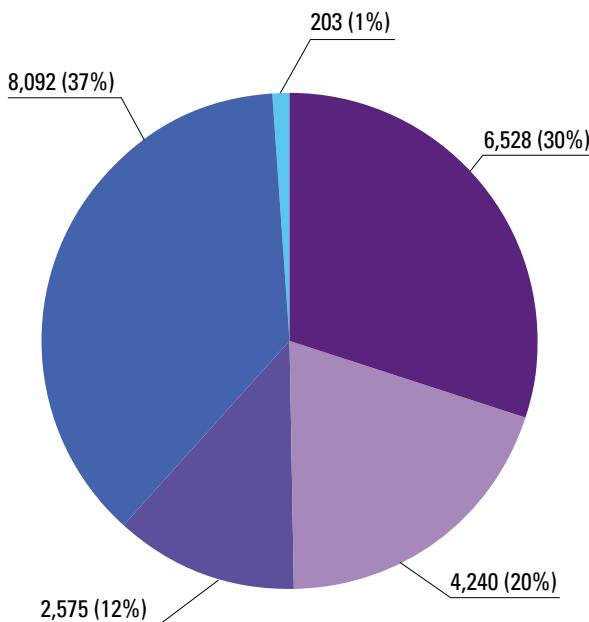
Facilities

SnT is strategically located on two sites – one in the centre of Luxembourg's Kirchberg financial district and one on the University's vibrant Belval Campus. Both locations host state of the art equipment for both hardware and software testing. There are more than ten labs that researchers can use to validate their ideas. Each of them offers a unique environment for work related to SnT's research in computer vision, satellite communications, autonomous driving, aerial robotics, server networks, cybersecurity and safety, as well as Artificial Intelligence.



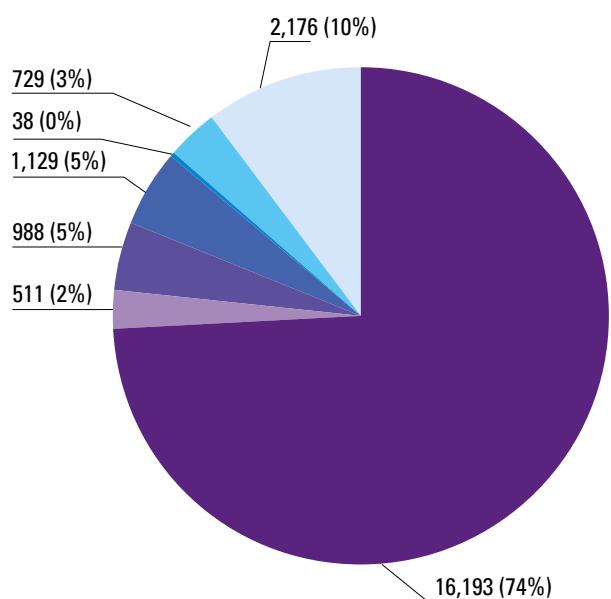
Facts and figures

SnT consumed income 2019 (in kEUR)



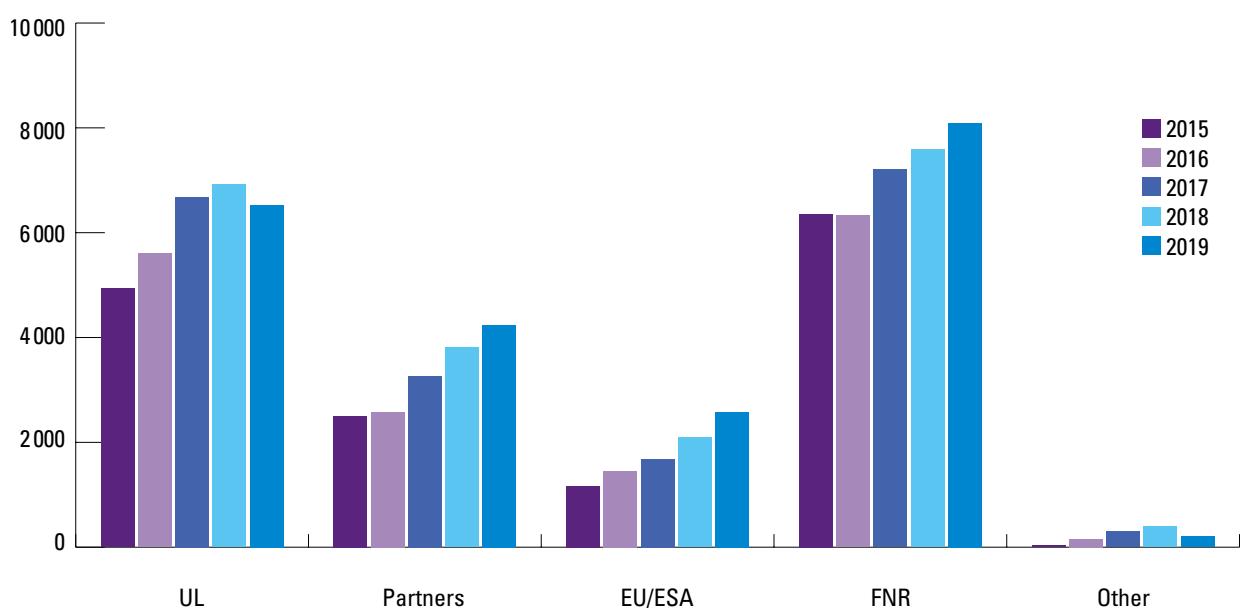
- UL
- Partners
- EU/ESA
- FNR
- Other

SnT expenses 2019 (in kEUR)



- Manpower
- Sub-contracting
- Investments
- Travel
- Operating expenses
- Representation & registration
- In-kind contributions

SnT 2015-2019 consumed income per source (kEUR)



Photos:

1 LunaLab, 2 Belval Campus, 3 Relax & Thinking Room, 4 Kirchberg Campus

Leadership

SnT's research groups are led by internationally renowned experts from across the ICT landscape. Each group has a specialty, with the common thread of security, reliability, and trust, connecting their work. Here they are able to execute research with impact •



**Prof Dr Björn Ottersten,
SnT Director**
SIGNAL PROCESSING AND COMMUNICATIONS (SIGCOM)



**Prof Dr Symeon
Chatzinotas**
CO-HEAD OF SIGCOM

SIGCOM focuses on signal processing in wireless communications, radar and computer vision. Applications range from satellite systems to vehicular sensors and 3D body modelling.



**Prof Dr Yves Le Traon,
SnT Vice-Director**
**SECURITY, REASONING
AND VALIDATION (SERVAL)**

SerVal focuses on three areas: testing, debugging and repair techniques; mobile security and reliability using static code analysis and machine learning; and model-driven engineering with a focus on analytics and artificial intelligence. They work on applications ranging from automated Android app debugging to IoT data analytics with decision making capabilities.



Dr Djamila Aouada
**COMPUTER VISION, IMAGING
& MACHINE INTELLIGENCE (CVI²)***

CVI² carries out research on computer vision, image processing, image analysis, visual data understanding, and machine learning. All research activities are driven by real-world applications with a focus on domains such as: computer-aided design (CAD), healthcare, and satellite systems, among others.



Prof Dr Alex Biryukov
CRYPTOLUX

CryptoLux strives for a greater understanding of how cryptosystems get broken in the real world, how they can be designed and implemented to better resist attacks, and how they should be used to build secure systems and networks.



Prof Dr Lionel Briand
SOFTWARE VERIFICATION AND VALIDATION (SVV)

SVV develops novel and effective techniques to ensure that software systems are reliable, safe, secure, and compliant. Their work heavily relies on artificial intelligence and is done in collaboration with partners in domains such as satellite, automotive, finance, public service, and legal.



Prof Dr Tonie van Dam
REMOTE SENSING APPLICATIONS*

The team uses various types of "remote sensing" data for detecting and monitoring the physical characteristics of the Earth. To-date the research focuses on modelling, analysing, and interpreting data in terms of geodynamic processes, global warming and its associated effects on the water cycle, and changes in ice mass.



Prof Dr Thomas Engel
NETLAB**

NetLab works on privacy by distribution, network and system security, Supervisory Control and Data Acquisition and cybersecurity, IoT, vehicular communication and multimodal traffic management, and wireless networks and mobile security.



**Prof Dr Paulo
Esteves-Veríssimo**
**CRITICAL AND EXTREME SECURITY
AND DEPENDABILITY (CRITIX)**

CritiX investigates methods and architectures to ensure systems resilience in an automated way, keeping them safe, secure and operational even in face of unexpected threats, like when compromised by highly skilled and well-equipped hacker attacks. Such systems include autonomous driving, e-health, blockchains, or power grids.



Prof Dr Gilbert Fridgen
**DIGITAL FINANCIAL SERVICES AND
 CROSS-ORGANISATION DIGITAL
 TRANSFORMATIONS (FINATRAX)***

The main objectives of the FINATRAX research group are understanding the digital transformation in various industries, designing transformative solutions in the areas of Fintech, RegTech and LegalTech, as well as deriving generalisable principles about "what makes a good design".



Prof Dr Pascal Bouvry
PARALLEL COMPUTING & OPTIMISATION GROUP (PCOG)

PCOG conducts research on parallel computing, search, and optimisation techniques. The team is specialised in large-scale discrete/combinatorial problems. Some application domains include cryptology, unmanned autonomous vehicles (UAV), smart cities, sustainable development, and systems biomedicine.



Prof Dr Jacques Klein
TRUSTWORTHY SOFTWARE ENGINEERING (TRUX)*

TruX is a software engineering and software security research group. It develops innovative approaches and tools towards helping the research and practice communities build trustworthy software.



Prof Dr Peter Y.A. Ryan
APPLIED SECURITY AND INFORMATION ASSURANCE (APSIA)

APSIA specialises in the mathematical foundations of cybersecurity and the design and modelling of security protocols (classical and quantum). Applications range from electronic voting systems to privacy enhancing technologies. The group also performs interdisciplinary research in cybersecurity, with close collaborations with social sciences, physics and law.



Prof Dr Gabriele Lenzini
SOCIO-TECHNICAL CYBERSECURITY (IRISC)*

The IRiSC group positions its research in the area of socio-technical cybersecurity. Today, securing a system requires understanding not only digital communications and protocols, but also the human and legal reality where the system is deployed.



Prof Dr Radu State
SERVICES AND DATA MANAGEMENT (SEDAN)

SEDAN works on blockchain, cloud computing, and data analytics, developing new architectures, algorithms, and approaches for dealing with ever-increasing volumes of data. Applications range from blockchain infrastructures for KYC and digital trading to analysis and visualisation of big data for public utilities.



Prof Dr Miguel Angel Olivares Mendez
SPACE ROBOTICS (SPACER)*

SpaceR is focused on developing approaches to increase the autonomy of planetary and orbital robotics for space exploration, operations, and resource utilisation. This covers planetary robotics (orbiters, landers, rovers, and other mobile systems) and orbital robotics (servicing, operations, and maintenance activities).



Prof Dr Holger Voos
AUTOMATION AND ROBOTICS

Automation and Robotics investigates approaches to perception, control, adaptation, and learning for networked autonomous cars, service robots, drones, and space robots. In large-scale distributed systems it works on novel distributed estimation, control, and optimisation algorithms.

*New research group launched in January 2020

** Research group moved into the Faculty of Science, Technology, and Medicine as of January 2020

Events

1 Yves Elsen (HITEC), Claude Meisch (Luxembourg

Ministry of Education), Fabrice Croiseaux (INTECH) – SnT Gala Dinner

2 Alexander Stubb (European Investment Bank) – SnT Gala Dinner

3 Jacek Plucinski and Ida lenna (both SnT) – Partnership Day

4 Standing: Borce Stojkovski (SnT), Philippe Ludivig (iSpace), Jean-Richard Riccardi (Clearstream), Franck-Alexandre Sallebant-Bessone (Cebi), Aurel Machalek (SnT), Chetan Arora (SES), German Castignani (Motion-S), Ivana Vukotic (SnT), Enjie Ghorbel (SnT), Beltran Fiz Pontiveros (SnT) Lower: Christine Homolko (SnT), Raphael Frank (SnT) – Partnership Day

5 Björn Ottersten (SnT) – Partnership Day

6 Marc Hamilton (Nvidia) and Raphael Frank (SnT) – Partnership Day

7-8 Partnership Day at Casino 2000



DISTINGUISHED LECTURES

Mind the Gap: Promises, Pitfalls, and Opportunities of Hardware-Assisted Security, by Prof Ahmad-Reza Sadegh from TU Darmstadt, Germany, March 2019

SCIENTIFIC EVENTS

NVIDIA Session 1 DLI Fundamentals of Deep Learning for Multiple Data Types, by Dr Georgios Varistea, April 2019

NVIDIA Session 2 DLI Fundamentals of Deep Learning for Computer Vision, by Dr Georgios Varistea, June 2019

UniGR Summer School VTSA 2019, by Dr Jun Pang & Prof Sjouke Mauw in collaboration with Inria Nancy, the Max-Planck-Institut für Informatik in Saarbrücken, and the University of Liège, July 2019.

NVIDIA Session 3 Fundamentals of Accelerated Computing with CUDA Python, by Dr Georgios Varistea, August 2019

ISM Module on Satcoms, by Symeon Chatzinotas in collaboration with SES, September 2019

1st CONCORDIA-h2020 Open Door by Dr Antonio Ken Iannillo & Prof Radu State, October 2019

SnT hosted 16 research seminars and 18 PhD defences during 2019

BUSINESS

How to leave academic research, create your own start-up and survive in a competitive environment? By Dr Raphaël Frank in collaboration with Dr German Castignani (Motion S), May 2019

Partnership Day - for SnT's 10-year anniversary celebration, June 2019



9 Thibaut Britz (Talkwalker) – Talk: How to go from a 2-person start-up to market leader?

10 Stéphane Ambrosini (Marks&Clerk) – Talk: How do I patent my software?

11 Adi Shamir (Weizmann Institute) – ESORICS

12 First Global Team Luxembourg mentored by SnT's Jose Luis Sanchez-Lopez (far right)

13 Fernando Kaway Carvalho Ota (SnT), Stéphane Pallage (University of Luxembourg) and Jorge Meira (SnT) – University Open Day

14 Antonio Iannillo (SnT) – Concordia H2020 Open Door

How do I patent software? By Jacek Plucinski in collaboration with Stéphane Ambrosini (Marks&Clerk), Mathis Bruck (Pronovem), and Jean-Paul Wagner (Corax IP), October 2019

How to go from a 2-person start-up to market leader? By Dr Raphaël Frank in collaboration with Thibault Britz (Talkwalker), October 2019

10th Anniversary Gala with Partners, featuring Alexander Stubb, Vice President of the European Investment Bank, November 2019

Get to know the Luxembourg start-up ecosystem, by Dr Raphaël Frank in collaboration with Charles-Louis Machuron (Silicon Luxembourg), November 2019

How to create my spin-off at SnT? By Dr Carlo Duprel, Jacek Plucinski, and Dr Raphaël Frank, November 2019

Open source in research, licensing, and business, by Jacek Plucinski in collaboration with Malcolm Bain (Across Legal), December 2019

PUBLIC

Open Day 2019: Get up close and personal with our research activities, March 2019

Czech-Luxembourgish Robotics Day, May 2019

Luxembourg Science Festival, November 2019

First Global, Dubai – an international robotics competition, October 2019

Spotlight on



ESORICS, September 2019

The 24th edition of the European Symposium on Research in Computer Security (ESORICS) was organised in Luxembourg by SnT's Prof Dr Peter YA Ryan. ESORICS is Europe's premiere conference on computer security and this was one of the most successful editions of the event. The five day gathering boasted an impressive number of paper submissions and welcomed 323 attendees.

One of the world's top cryptographers, [Adi Shamir](#), opened the conference. Shamir is a co-winner of the 2002 A.M. Turing Award, with American computer scientists Leonard M. Adleman and Ronald L. Rivest. We also welcomed [Véronique Cortier](#), winner of an ERC starting grant, who gave a keynote address on her work on electronic voting. [Bart Preneel](#), the notable cryptographer from KU Leuven, delivered the third keynote on cryptocurrencies •

1 2019 attendees at ESORICS

2 Peter Ryan (SnT), the organising chair of ESORICS welcomes attendees

3 Steve Schneider (University of Surrey), Kasper Rasmussen (University of Oxford), Ilias Giechaskiel (Independent Researcher), Sokratis Katsikas (University of the Aegean), and Kazue Sako (NEC Security Research Labs) at the best paper award ceremony

4 Véronique Cortier (CNRS) gives a keynote on 24.09.2019

5 Attendees on a guided visit of Luxembourg City

6 Arianna Rossi (SnT) networks during poster sessions

7 Adi Shamir (Weizmann Institute) gives a keynote on 23.09.2019

8 Bart Preneel (Katholieke Universiteit Leuven) gives a keynote on 25.09.2019

Awards

BEST PAPER AWARDS

Optimal Multiuser Transmit Beamforming: A Difficult Problem with a Simple Solution Structure

Prof Dr Emil Björnson, Prof Dr Mats Bengtsson, Prof Dr Björn Ottersten
 2019 Signal Processing Society Award
 IEEE Signal Processing Magazine Best Column Award
 IEEE 45th International Conference on Acoustics, Speech, and Signal Processing
 4-8 May 2020, Barcelona, Spain

Decision Support for Security-Control Identification Using Machine Learning

Seifeddine Bettaieb, Dr Seung Yeob Shin, Dr Mehrdad Sabetzadeh, Prof Dr Lionel Briand
 The 25th International Working Conference on Requirements Engineering (REFSQ 2019)
 18-21 March 2019, Essen, Germany

Generating Automated and Online Test Oracles for Simulink Models with Continuous and Uncertain Behaviors

Dr Claudio Menghi, Dr Shiva Nejati, Khouloud Gaaloul, Prof Dr Lionel Briand
 ACM SIGSOFT Distinguished Paper Award
 27th ACM Joint European Software Engineering Conference and Symposium on the Foundations of Software Engineering (ESEC/FSE)
 26-30 August 2019, Tallinn, Estonia

Sequential Reprogramming of Boolean Networks Made Practical

Cui Su, Dr Jun Pang
 17th International Conference on Computational Methods in Systems Biology (CMSB 2019)
 18-20 September 2019, Trieste, Italy

A Query System for Extracting Requirements-related Information from Legal Texts

Amin Sleimi, Dr Marcello Ceci, Dr Nicolas Sannier, Dr Mehrdad Sabetzadeh, Prof Dr Lionel Briand, John Dann
 27th IEEE International Requirements Engineering Conference (RE 2019)
 Best Industrial Paper Award
 23-27 September 2019, Jeju Island, South Korea

A Machine Learning-Based Approach for Demarcating Requirements in Textual Specifications

Dr Sallam Abualhaija, Dr Chetan Arora, Dr Mehrdad Sabetzadeh, Prof Dr Lionel Briand, Eduardo Vaz
 Best RE'19 Research Paper Award
 27th IEEE International Requirements Engineering Conference (RE 2019)
 23-27 September 2019, Jeju Island, South Korea

Energy Efficient Design for Coded Caching Delivery Phase

Dr Thang X. Vu, Dr Lei Lei, Prof Dr Symeon Chatzinotas, Prof Dr Björn Ottersten
 3rd International Conference on Recent Advances in Signal Processing, Telecommunications & Computing (SigTelCom 2019)
 21-22 March 2019, Hanoi, Vietnam

Accomplishing Transparency within the General Data Protection Regulation

Prof Dr Gabriele Lenzini, Dayana Spagnuelo
 5th International Conference on Information Systems Security and Privacy (ICISSP 2019)
 23-25 February 2019, Prague, Czech Republic

Effects of Multiple Oscillator Phase Noise in Precoding Performance

Liz Martínez Marrero, Dr Juan C Merlano Duncan, Dr Jorge Querol, Prof Dr Symeon Chatzinotas, Prof Dr Adriano J Camps Carmona, Prof Dr Björn Ottersten
 37th International Communications Satellite Systems Conference (ICSSC 2019)
 29 October to 1 November 2019, Okinawa, Japan

An Empirical Study on Vulnerability Prediction of Open-Source Software Releases

Dr Matthieu Jimenez, Renaud Rweomalika, Dr Mike Papadakis, Federica Sarro, Prof Dr Yves Le Traon, Prof Dr Mark Harman
 Distinguished Paper Award (ACM SIGSOFT)
 27th ACM Joint European Software Engineering Conference and Symposium on the Foundations of Software Engineering (ESEC/FSE'19)
 26-30 August 2019, Tallinn, Estonia

Semantic Fuzzing with Zest

Rohan Padhye, Caroline Lemieux, Prof Dr Koushik Sen, Dr Mike Papadakis, Prof Dr Yves Le Traon
 Distinguished Artifact Award (ACM SIGSOFT)
 International Symposium on Software Testing and Analysis (ISSTA 2019)
 15 - 19 July 2019, Beijing, China

Search-based Test and Improvement of Machine Learning-Based Anomaly Detection Systems

Dr Maxime Cordy, Steve Muller, Dr Mike Papadakis, Prof Dr Yves Le Traon
 Distinguished Artifact Award (ACM SIGSOFT)
 International Symposium on Software Testing and Analysis (ISSTA 2019)
 15 - 19 July 2019, Beijing, China

INDIVIDUAL AWARDS

Prof Dr Pascal Bouvry and Dr Matthias R. Brust received the **Information Security Day 2019 Security Project of the Year Award**.

Dr Eva Lagunas, Dr Shree Krishna Sharma, Dr Sina Maleki, Prof Dr Symeon Chatzinotas, Prof Dr Björn Ottersten won the **Outstanding Scientific Publication FNR Award** for the publication 'Resource Allocation for Cognitive Satellite Communications with Incumbent Terrestrial Networks' in IEEE Transactions on Cognitive Communications and Networking.

Jelegenj Krivochiza won the **2018 IEEE Access Best Multimedia and Networking Award Part 2** for the video produced by SnT on: FPGA Acceleration for Computationally Efficient Symbol-Level Precoding in Multi-User Multi-Antenna Communication Systems.

Sean Rivera, Dr Sofiane Lagraa and Prof Dr Radu State won a distinguished paper award at the **IEEE Workshop on the Internet of Safe Things** held at IEEE S&P 40th IEEE Symposium on Security and Privacy. The topic was: ROS-Defender: Dynamic Security Policy Enforcement for Robotic Applications

Renaud Rweomalika, Dr Michail Papadakis and Prof Dr Yves Le Traon won the **Facebook Software Testing Competition**.

Aleksei Udovenko and Prof Dr Alex Biryukov from the Cryptolux team have won the **Whitebox cryptography competition WhiBox'19 in both the design and analysis category**. This competition has been organised by an international community of researchers to address the growing interest of the industry towards white-box cryptography (most particularly for mobile payments).

Dr Michail Papadakis won the **Distinguished Reviewer Award** at the 12th IEEE International Conference on Software Testing, Verification, and Validation (ICST 2019) in Xi'an, China.

Dr Van-Dinh Nguyen won **Exemplary Editor of IEEE Communications Letters 2019**.

Dr. Domenico Bianculli received the **Distinguished Reviewer Award** at the 41st International Conference on Software Engineering (ICSE 2019) •

People

Heads of SnT Research Groups

OTTERSTEN, Björn, Prof Dr, Director
 LE TRAON, Yves, Prof Dr, Vice-Director
 AQUADA, Djamilia, Dr*
 BOUVRY, Pascal, Prof Dr
 BRIAND, Lionel, Prof Dr
 BIRYUKOV, Alex, Prof Dr
 CHATZINOTAS, Symeon, Prof Dr
 ENGEL, Thomas, Prof Dr (until 31.12)
 FRIDGEN, Gilbert, Prof Dr*
 KLEIN, Jacques, Prof Dr*
 LENZINI, Gabriele, Prof Dr*
 OLIVARES-MENDEZ, Miguel, Prof Dr*
 RYAN, Peter, Prof Dr
 STATE, Radu, Prof Dr
 VAN DAM, Tonie, Prof Dr*
 VERISSIMO, Paulo, Prof Dr
 VOOS, Holger, Prof Dr

*Research group head as of 01.01.2020

Affiliated Faculty

BORDAS, Stéphane, Prof Dr
 COLE, Mark, Prof Dr
 CORON, Jean-Sebastien, Prof Dr
 HILGER, Jean, Honorary Prof Dr
 HOFMANN, Mahulena, Prof Dr
 MARTIN, Romain, Prof Dr
 MAUW, Sjouke, Prof Dr
 MAX, Charles, Prof Dr
 VAN DER TORRE, Leon, Prof Dr
 VITI, Francesco, Prof Dr

Senior Research Scientists

NEJATI, Shiva, Dr
 SABETZADEH, Mehrdad, Dr
 BISSYANDÉ, Tegawendé F, Dr

Research Scientists

BIANCULLI, Domenico, Dr
 BRORSSON, Mats, Dr
 CORDY Maxime, Dr
 DANOV, Gregoire, Dr
 DECOUCHANT, Jérémie, Dr
 FRANK, Raphael, Dr
 LAGUNAS, Eva, Dr
 MERLANDO DUNCAN, Juan Carlos, Dr
 MYSORE RR, Bhavani Shankar, Dr
 PANG, Jun, Dr
 PAPADAKIS, Michail, Dr
 PASTORE, Fabrizio, Dr
 ROENNE, Peter, Dr
 SHARMA, Shree Krishna, Dr
 THOEMEL, Jan, Dr
 VARRETTE, Sébastien, Dr
 VÖLP, Marcus, Dr

Research Associates

ABUALHAIJA, Sallam, Dr
 AL ISMAEIL, Kassem, Dr
 ALAAEKERAHOODI, Mohammad, Dr
 ALEKSANDROVA Marharyta, Dr
 ALFEREZ Mauricio, Dr
 AL HRAISHAWI, Hayde, Dr
 ALLIX, Kevin, Dr
 ALVES MARTINS, Wallace, Dr
 ANDRENACCI, Stefano, Dr
 ANTONEOLO, Eric, Dr
 ATASHPENDAR Arash, Dr

BANA, Gergely, Dr
 BARRERA, Olga, Dr
 BARTEL, Alexandre, Dr
 BARTOLINI, Cesare, Dr
 BEIERLE, Christof, Dr
 BEN ABDESSALEM, Raja, Dr
 BEZZAOUCHA, Souad, Dr
 BOUALOUACHE, Abdelwahab, Dr
 BOYTSOV, Andrey, Dr
 BRUST, Matthias, Dr
 BHAUMIK, Ritam, Dr
 CASSAGNES, Cyril, Dr
 CAZZATO, Dario, Dr
 CECI, Marcello, Dr
 CHEN, Xihui, Dr
 CHOUGRANI, Houcine, Dr
 DAS, Rig, Dr
 DASHEVSKYI, Stanislav, Dr
 DEGIOVANNI, Renzo, Dr
 DU, Manxing, Dr (as of 01.11)
 ELRAKAIBY, Yehia, Dr
 ESFAHANI, Alireza, Dr
 FALK, Eric, Dr
 FIZ PONTIVEROS, Borja Beltran, Dr (as of 15.01)
 FOTIADIS, Georgios, Dr
 GADYATSKAYA, Olga, Dr
 GHORBEL, Enjie, Dr
 GIURGIU, Andra, Dr
 GRACZYK, Rafal, Dr
 HAJRI, Ines, Dr
 HAMMERSCHMIDT, Christian, Dr
 HAMMES, Christian, Dr (as of 01.02)
 HURIER, Médéric (as of 01.09)
 IANNILLO, Antonio Ken, Dr
 IOVINO, Vincenzo, Dr
 JAMROGA, Wojciech, Dr
 JUKSS, Maris, Dr
 KACEM, Anis, Dr
 KAISER, Daniel, Dr
 KAYHAN, Farbod, Dr
 KIBRIA, Mirza Golam, Dr
 KINTIS, Marinos, Dr
 KISSELEFF, Steven, Dr
 KONG, Long, Dr
 KRISHNASMAY, Ezhilmathi, Dr
 KUMAR, Sumit, Dr
 LAGRAA, Sofiane, Dr
 LADID, Latif, Dr
 LEI, Lei, Dr
 LI, Xiaochen, Dr
 LOPEZ BECERRA, José Miguel, Dr
 MACHALEK, Aurel, Dr
 MATURO, Nicola, Dr
 MEIRA, Jorge, Dr
 MENDOZA MONTOYA, Jesus Fabian, Dr
 MENGHI, Claudio, Dr
 MESTEL, David, Dr
 MOULINE, Ludovic, Dr (as of 15.11)
 MSADEK, Nizar, Dr
 MUELLER, Johannes, Dr
 NGUYEN, Van Dinh, Dr
 OLIVARES, Oscar Cornejo, Dr
 OSTREV, Dimitar Valentinov, Dr
 OSVIK, Dag Arne, Dr
 QUEROL, Jorge, Dr
 QUINTANAR GUZMAN, Serket, Dr
 RAHLI, Vincent, Dr
 RAMIREZ-CRUZ, Yunior, Dr
 RIAL DURAN, Alfredo, Dr
 ROBALDO, Livio, Dr
 ROBERT, Jérémie, Dr
 ROSIE, Razvan, Dr
 ROSSI, Arianna, Dr
 SAHIN GEBIZLI, Ceren, Dr

SAJADI ALAMDARI, Amin, Dr
 SAMIR, Areeg, Dr
 SANCHEZ LOPEZ, Jose Luis, Dr
 SANNIER, Nicolas, Dr
 SASSIOUI, Redouane
 SAYAR, Imen, Dr
 SCHIFFNER, Stefan, Dr
 SHABAYEK, Abd El Rahman, Dr
 SHBAIR, Wazen, Dr
 SHIN, Donghwan, Dr
 SHIN, Seung Yeob, Dr
 SOUA, Ridha, Dr
 SPANO, Danilo, Dr
 STEICHEN, Mathis, Dr
 STOLFI ROSSO, Daniel, Dr
 SYMEONIDIS, Iraklis, Dr
 TITCHEU CHEKAM, Thierry, Dr
 TORRE, Damiano, Dr
 TSINOS, Christos, Dr
 TURCANU, Ion, Dr
 UDOVENKO, Aleksei, Dr
 VARISTEAS, Georgios, Dr
 VU, Xuan Thankg, Dr
 WANG, Jun, Dr
 WANG, Qingju, Dr
 WASIM, Muhammad Umer, Dr
 XIANG, Lin, Dr
 YANG, Yang, Dr

PhD Candidates

ABDALLAH, Ibrahim
 ABDU, Tedros Salih
 AHMED, Eman
 AMIN, Sleimi
 ANTONIADIS, Nikolaos
 ARSLAN, Yusuf
 ARORA, Akash
 BADAWY, Haythem Kamel
 BALOGLU, Sevdenur
 BANDI, Ashok
 BAPTISTA, Renato
 BELGACEM, Hichem
 BELLESI, Melissa
 BELTRAO, Gabriel Tedgue
 BENEDICK, Paul-Lou
 BETTAIEB, Seifeddine
 BHADAURIA, Anshuman
 BOMMARAVENI, Shrikanth
 BOONYARIT, Changaival
 BOUFAIED, Chaima
 CAMINO, Ramiro
 CAO, Tong
 CARVALHO OTA, Fernando Kaway
 CASTILLO LOPEZ, Manuel
 CEJAS, Orlando
 CHAOUCH, Karim
 CHARLIER, Jérémie
 CHENG, Hao
 CHIARA, Pier Giorgio
 CHERENKOVA, Kseniya
 CIMARELLI, Claudio
 DAMODARAN, Aditya
 DAOUDI, Nadia
 DE LA CADENA, Vladimir
 DI MAIO, Antonio
 DILMAGHANI, Saharnaz Esmaielzadeh
 DOKHANCHI, Sayed Hossein
 DOMOUCHTSIDIS, Stavros
 DUFOLO, Gabriel
 ESTAJI, Ehsan
 EZZINI, Saad
 FAHMY, Hazem
 FEHÉR, Dániel

FERNANDES, Maria
 FERREIRA TORRES, Christof
 FISCARELLI, Antonio
 FU, Shange
 GAALOUL, Khouloud
 GAO, Jun
 GARG, Aayush
 GAUTAM, Sumit
 GENC, Ziya Alper
 GHAMIZI, Salah
 GINI, Agnese
 GLAUNER, Patrick
 GUBRI, Martin
 HABEN, Guillaume
 HAQIQATNEJAD, Alireza
 HU, Hailong
 JAFARNEJAD, Sasan
 JUBBA HONNAIAH, Puneeth
 KAIAFAS, Georgios
 KHAN, Nida
 KHAN, Zanis
 KHANFIR, Ahmed
 KHRAMTSOVA, Ekaterina
 KIEFFER, Emmanuel
 KISUB, Kim
 KODHELI, Oltjon
 KOLBE, Niklas
 KONG, Pingfun
 KORRAI, Praveenkumar
 KOYUNCU, Anil
 KREMER, Paul
 KREUTZ, Diego
 KRIVOCHEZA, Jevgenij
 KUI, Liu
 LAMBERT, Christoph
 LACOSTE, Clement
 LEE, Jaekwon
 LESAGE, Laurent
 LIU, Chao
 LOTHRITZ, Cedric
 LUDIVIG, Philippe
 MAI, Xuan Phu
 MANUKYAN, Anush
 MARRERO, Liz Martinez
 MAYOUCHE, Abderrahmane
 MEHRIZI RAHMAT ABADI, Sajad
 MESSAOUDI, Salma
 MOSTAANI, Arsham
 NGO, Chanhduc
 NORVILL, Robert
 OJDANIC, Milos
 OYEDOTUN, Oyaebade
 PANDI PERUMAL, Raja
 PAPADOPOULOS, Konstantinos
 PARRY GOWHER, Majeed
 PASCOAL, Tulio
 PEJO, Balazs
 PILGUN, Alexandre
 PINTO GOUVEIA, Ines
 POLGE, Julien
 QADEER, Rizwan
 RAEI DEHAGHI, Ehsan
 RIOM, Timothée
 RIVERA, Sean
 ROBINET, François
 RWEMALIKA, Renaud
 SAINT, Alexandre
 SAMHI, Jordan
 SALIGRAMA CHANDRAKANTHA, Shreyas
 SAMIR LABIB, Nader
 SCHMITT, Xavier
 SEDIGHI, Saeid
 SHAFT, Brian
 SIMOES SILVA, Douglas
 SOROUSH, Najmeh
 SPIGNOLI, Lorenzo
 STOJKOVSKI, Borce
 SU, Cui
 SYED, Hira
 TESSARO LUNARDI, Willian
 TIAN, Haoye

TRAN, Dinh Hieu
 TRESTIOREANU, Lucian Andrey
 TUMAS, Vytautas
 TIKHOMIROV, Sergei
 UI HAQ, Fitash
 VAN WIER, Jeroen
 VÁZQUEZ SANDOVAL, Itzel
 VEIZAGA CAMPERO, Alvaro Mario
 VITTO, Giuseppe
 VUKOTIC, Ivana
 WANG, Anyue
 WANG, Min
 WEI, Ma
 YUAN, Ya Xiong
 ZOLLINGER, Marie-Laure

Research Fellows

ABU HAIJA, Izza
 ARORA, Chetan, Dr
 CARLSON, John
 CASTIGNANI, German
 CHERKAOUI, Omar, Dr
 DUNLOP, Dominic
 GÖKNIL, Arda, Dr
 GOUSSETIS, George, Dr
 KUBLER, Sylvain, Dr
 LI, Li, Dr
 MILELLA, Mario
 MISHRA, Kumar, Dr
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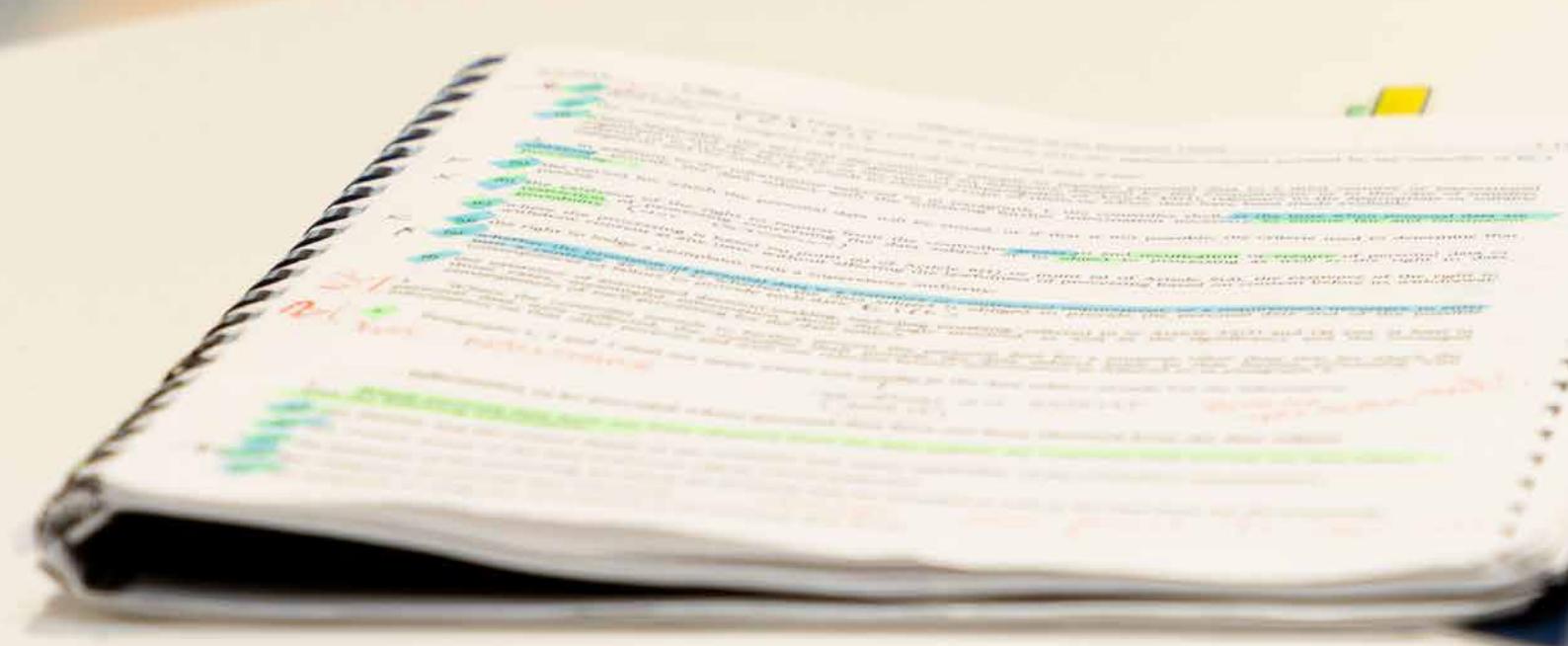
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 WU, Ceasar, University of Melbourne Australia
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 ZHAO, Yanjie, Beijing University of Posts and Telecommunications



Our Output



Projects

New projects initiated in 2019

Partner Projects

Secure and compliant data management

Project	PhD student	Supervisor	Partner
An Artificial Intelligence-assisted Framework for GDPR Compliance Analysis	Orlando Amaral Cejas	Mehrdad Sabetzadeh	Linklaters (BRIDGES)

Fintech

Project	PhD student	Supervisor	Partner
Secure and Decentralised Machine Learning	Ekaterina Khramtsova	Radu State	LOGOS (BRIDGES)
Explainable Machine Learning in Fintech	Yusuf Arslan	Jacques Klein	BGL BNP Paribas (BRIDGES)
Drilling Textual Documents to Support Automation in Fintech	Cedric Lothritz	Jacques Klein	BGL BNP Paribas
Automated Quality Assurance for the Management of Financial Data	Hichem Belgacem	Lionel Briand	BGL BNP Paribas
Robust Machine Learning Systems	Salah Ghamizi	Yves Le Traon	BGL BNP Paribas
TestFast	Ahmed Khanfir	Yves Le Traon	BGL BNP Paribas (BRIDGES)
Improving the Continuous Integration Process	Milos Ojdanic	Yves Le Traon	PayPal
Incident Management and Root Cause Analysis	Guillaume Haben	Yves Le Traon	PayPal

Cybersecurity			
Project	PhD student	Supervisor	Partner
Stream Monitoring for Self-healing Edge Computing Security	Zanis Khan	Domenico Bianculli	HITEC

Space Systems			
Project	PhD student	Supervisor	Partner
Resource Allocation and Interference Mitigation for Demand Based Capacity Adaptability in Satellite Communication Systems	Puneeth Jubba Honnaiah	Symeon Chatzinotas	SES (IF)
Resource Allocation Techniques for the Return Link of a Multibeam Satellites System	Clement Lacoste	Symeon Chatzinotas	SES

Autonomous Vehicles			
Project	PhD student	Supervisor	Partner
Verification of AI-Based Safety Critical Complex Systems for Functional Safety	Fitash Ul Haq	Lionel Briand	IEE
Automated Debugging and Repair of AI-based Automotive Software Systems	Hazem Fahmy	Fabrizio Pastore	IEE
MIMO Distributed Radar for Indoor Applications	Gabriel Tedgue Beltrão	Bhavani Shankar	IEE (IF)

FNR Projects

Project	Principal Investigator	Programme
EnCaVIBS - The EU NIS Directive: Enhancing Cybersecurity across Vital Business Sectors	Mark Cole / Thomas Engel	CORE
Onniva - Automatic Detection and Prevention of Deserialization Vulnerabilities	Alexandre Bartel	CORE
SPRINGER - Signal Processing for Next Generation Radar	Björn Ottersten	CORE
STELLAR - teSTing sElf-LeARning systems	Yves Le Traon	CORE
ThreatAdapt - Adaptive Byzantine Fault and Intrusion Tolerance	Paulo Esteves-Veríssimo	CORE International
STV - Socio-Technical Verification of Information Security and Trust in Voting Systems	Peter Y. A. Ryan	CORE International
SATOCROSS - Support of Advanced Test cOverage Criteria for RObust and Secure Software	Michail Papadakis	INTER (with ANR)
ExLiFT - Explainable machine Learning in FinTech	Jacques Klein	BRIDGES (BGL BNP Paribas)
STABILITY4.0 - Seamless TraceABILITY for I4.0	Yves Le Traon	BRIDGES (Cebi)
IMoReF - Improved Model-based Requirements for Financial applications	Lionel Briand	BRIDGES (Clearstream)
CAFFE PF - Cost-aware Active Feedback & Feature Extraction for Profiling Financial transctions	Radu State	BRIDGES (LOGOS)
TESTFAST - Software testing in a fast, clever and effective way	Yves Le Traon	BRIDGES (BGL BNP Paribas)
EQUACS - Early QUality Assurance of Critical Systems	Mehrdad Sabetzadeh	BRIDGES (QRA)
REGAL - Resource allocation and intErference mitiGation for demand based capAcity adaptabiLity in satellite communication systems	Puneeth Jubba Honnaiah	Industrial Fellowship (SES)
MIDIA - MIMO Distributed Radar for Indoor Applications	Gabriel Tedgue Beltrão	Industrial Fellowship (IEE)
PriML - Privacy attacks and protection in Machine Learning as a service	Hailong Hu	AFR-PhD
FIber - FIber the FILE Blockchain	Eric Falk	Pathfinder
DigitalUs - DigitalUs	Beltran Borja Fiz Pontiveros	Pathfinder
MoNeyBox - "Mobile Money in a Box" - Inclusive, Interoperable & Secure by Design	Tegawendé F. Bissyandé	POC
GenoMask-POC - Early stage read filtering and masking of genomic information	Jérémie Decouchant	POC
SIMMS - Swarm Intelligent Mission systeMS	Grégoire Danoy	POC
PreMaaS - Predictive Maintenance as a Service	Jorge Augusto Meira	POC
Drones, lëtz interact!	Jose Luis Sanchez Lopez	Science Festival 2019
Resource Allocation for Cognitive Satellite Communications with Incumbent Terrestrial Networks	Eva Lagunas	FNR Awards 2019 for Outstanding Scientific Publication
ESORICS 2019 - The 24 th European Symposium on Research in Computer Security	Peter Y. A. Ryan	RESCOM

Project	Principal Investigator	Programme
Smart Schoul 2025 - Smart Schoul 2025: The Future Luxembourg Smart School	Djamila Aouada	PSP Flagship
QOE-WiC - Distributed optimisation and dynamic programming for wireless edge caching to maximise quality of experience	Symeon Chatzinotas	INTER MOBILITY

EU and ESA Projects

Project	Principal Investigator	Programme
FAQAS - Fault-based, Automated Quality Assurance Assessment and Augmentation for Space Software	Fabrizio Pastore	ESA
PRACE-6IP - PRACE 6th Implementation Phase Project	Pascal Bouvry	H2020
GENIAL - GrEen Networking And cLoud computing Resubmission	Yves Le Traon	Erasmus plus
ESTEC visit - Practical implementation of precoding on the gateway side	Symeon Chatzinotas	ESA
TOKEN - Transformative impact Of blocKchain tEchnologies iN public services	Radu State	H2020
MetaBioMec - Biomechanics of menisci: a multiscale experimental, theoretical and modelling approach for biomimetic meniscal replacements	Olga Barrera	MSCA-IF
CONCORDIA - Cyber security cOMPeteNCe fOr Research anD InnovAtion	Radu State	H2020
SPARTA - Special Projects for Advanced Research and Technology in Europe	Paulo Esteves-Veríssimo	H2020
FIN-TECH - A FINancial supervision and TECHnology compliance training programme	Radu State	H2020
CyberSec4Europe - Cyber Security Network of Competence Centres for Europe	Paulo Esteves-Veríssimo	H2020
TERMINAL - Minibus électriques automatisés dans les navetteurs transfrontaliers	Raphaël Frank	Interreg V A
LAST-JD-RIoE - Law, Science and Technology Joint Doctorate: Rights of the Internet of Everything	Leon van der Torre	MCSA-ITN

Other Projects

Project	Principal Investigator	Programme
STIRRING - Satellite-Assisted NB-IoT for Smart Farming	Symeon Chatzinotas	NOKIA

Publications

Doctoral Theses

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15. Quintanar Guzman, S. (2019). Nonlinear Observation and Control of a Lightweight Robotic Manipulator Actuated by Shape Memory Alloy (SMA) Wires. Unpublished doctoral thesis, University of Luxembourg, Luxembourg.
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18. Udovenko, A. N. (2019). Design and Cryptanalysis of Symmetric-Key Algorithms in Black and White-box Models. Unpublished doctoral thesis, University of Luxembourg, Luxembourg.
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9. Barboza da Silva, F., & Alves Martins, W. (2019, July 25). Semi-blind Data-Selective and Multiple Threshold Volterra Adaptive Filtering. Circuits, Systems, and Signal Processing, 1-24.
10. Bartel, A., Klein, J., & Le Traon, Y. (2019). MUSTI: Dynamic Prevention of Invalid Object Initialization Attacks. IEEE Transactions on Information Forensics and Security.
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