

University of Luxembourg

Fourth Four-Year Plan

2018 to 2021

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UNIVERSITÉ DU
LUXEMBOURG

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List of Abbreviations

Abbreviation	Definition
4YP	Four Year Plan
ATP	Adenosine triphosphate
BT2	Building Biotech 2
BT3	Building Biotech 3
CAGR	Compiled Annual Growth Rate
CDD	Non-permanent Employee
CDI	Permanent Employee
CA	Central Administration
CS	Computer Sciences
CPD	Continuing Professional Development
DC	Doctoral Candidates
DMS	Data Modelling and Simulation
DRI	Digital Research Infrastructure
DS	Digital Sciences
DTU	Doctoral Training Unit (FNR PRIDE funding scheme)
EC	European Commission
EE	External Evaluation
ERP	Enterprise Resource Planning
FEDER	European Funds for regional development
FDEF	Faculty Law, Economy, Finance
FLSHASE	Faculty of Language and Literature, Humanities, Arts and Education
FNR	Luxembourg National Research Fund
FO	Fundraising Office
FSTC	Faculty Science, Technology, and Communication
FXA	Fixed Assets
FY	Fiscal Year
HC	Headcount
HCI	Human-Computer Interaction
HPC	High Performance Computing
HR	Human Resources
IC	Interdisciplinary Center
IFRS	International Financial Reporting Standards
INLL	National Institute of Languages
IPCEI	Important Project of Common European Interest
IP	Intellectual Property
IPR	Intellectual Property Rights
IUIL	Institut Universitaire International Luxembourg
KPI	Key Performance Indicator
LC	Learning Center
LCSB	Luxembourg Center for Systems Biomedicine
LIH	Luxembourg institute of Health
LIs	Luxembourg Research Institutes (LIST, LIH, LISER)
LISER	Luxembourg Institute of Socio-Economic Research
LIST	Luxembourg Institute for Science and Technology
LSRU	Life Sciences Research Unit
LTAM	Lycée Technique des Arts & Métiers

Abbreviation	Definition
LUCER	Luxembourg Centre for Educational Research
LUCET	Luxembourg Centre for Educational Testing
LuCS	Luxembourg Centre for School Development
MDDC	Media and Digital Design Centre
MM-SAP	Materials Management System in SAP
MPI	Max Planck Institute
MRT	LIST Department of Materials Research and Technology
MSA	Maison du Savoir
NCER-PD	National Centre of Excellence in Parkinson's disease
ODET	Office of Doctoral Education and Training
OPEX	Operational Expenses
OTP	Budget Code
PHYMS	Physics and Materials Science
PI	Principal Investigator
PO	Purchase Order
QA	Quality Assurance
RE	Research Theme Education
RFP	Request for Proposal
RU	Research Unit
SAP	Software for organising finances at the University
SDS	Service for Site Development
SFC	Service finances and accounting
SIU	Service Informatique de l'Université
SIL	Service Logistique de l'Université
SnT	Security and Trust
UL	University of Luxembourg
ULUS	University of Luxembourg Unified Services

Executive Summary

This Four-Year Plan (4YP) represents the next step toward honing the research, teaching and learning, and outreach strategy of the University of Luxembourg. This plan will contribute to refining the long-term character of the UL.

In 2016, the UL underwent a thorough external evaluation of its Research Units and Interdisciplinary Centres with extremely positive results overall that confirmed the validity of UL's top positions in the international University rankings. The evaluation was taken into consideration for the identification of those areas of research excellence that we propose to focus on in this 4YP:

- **Materials science**
- **Computer science & ICT security**
- **European and international law**
- **Finance and financial innovation**
- **Education**
- **Digital and contemporary history**
- **Health and Systems biomedicine**
- **Data modelling and simulation**

To achieve international excellence in other areas, we will use our existing internal research resources ('structural posts') more efficiently by moving to a performance-based system for distributing these positions.

Advancing learning and teaching is another focus of this plan. Our strategy in this area includes taking full advantage of the infrastructure on the Belval campus, incorporating new learning methods and technology, fostering transversal skills at all levels to improve graduate employability, further investing in lifelong learning, and integrating UL learning and teaching activities with the greater education sector in Luxembourg. Accreditation, increasing the engagement of our students, enhancing skills training for doctoral candidates, and a plan for medical education are all included and discussed under the theme of learning and teaching.

We have also set ourselves the goal of developing an **efficient and transparent administration**. In addition to the research evaluation, the UL also underwent an institutional evaluation. While noting that the UL has achieved a number of accomplishments to date, the evaluation also recommended that we review our internal regulations and procedures to improve the efficiency and effectiveness of our academic and administrative decision-making.

The UL, in collaboration with the National Research Fund of Luxembourg (FNR) and the Luxembourg public research institutes (Lis) will develop a national platform for **Gender** which will include the development of more family friendly policies. By working together, we can share resources to make faster progress in these areas. Optimising resource use in research where the UL and the Luxembourg public research institutes intersect is another component of this plan.

As addressed by the external evaluators, we will work on **empowering students** to play their role within the University.

For our **staff**, we will initiate continuing professional development programmes to enhance their skills and allow them to move upward through the university and to improve the quality of service they provide to the UL.

The UL will develop a unit aimed at fostering **entrepreneurship** and at stimulating the development of innovative ideas by both staff and students. A programme will be put in place to enable mentoring of start-up companies and to train a new generation of entrepreneurs in Luxembourg.

Quality assurance is another overarching theme of this 4YP. To date, Quality assurance has been handled in the Faculties and the ICs. Making QA a university-wide value will promote a deeply rooted quality culture where each member of the university will be guided in its actions through a commitment to professionalism and continuous improvement. Creating these conditions requires a strategy for the long term that takes into account teaching and learning, research, administration and outreach. We see continuing professional development of our staff as crucial for developing this culture.

We recognise that this is a highly ambitious 4YP, but only by being ambitious can we reach our goals 1) to be internationally recognised for our research, 2) to have quality teaching and learning using the most up-to-date pedagogy and technology, and 3) to have a significant positive impact on Luxembourg's society and economy.

Section I. Introduction

A major goal of public research in Luxembourg is to position the country as a knowledge-based society. The national strategy is to foster innovation that will drive sustainable socio-economic development and further diversify the economy by developing new and strengthening existing high added-value economic and social activities.

The University of Luxembourg supports this strategy through its commitment 1) to be an international leader in selected areas of research; 2) to provide high quality interdisciplinary teaching and learning programmes; and 3) to positively contribute to shaping Luxembourg's society and strengthening its economy.

As the only state-supported university in Luxembourg, we acknowledge this privilege, but we also take our responsibility very seriously. We strive to contribute to the improvement of the society and economy of Luxembourg. In addition to our scientific research in collaboration with industry, we also engage in research on the social, cultural, political and economic issues that are shaping Luxembourgish society. Of our student population, 45% are Luxembourgish, indicating that the UL contributes to educating a large number of Luxembourg's young adults.

What has the University Achieved to Date?

Now in its fourteenth year of existence, the University has achieved recognition for a broad range of internationally competitive and locally relevant academic activities. It has established three Faculties with eleven Research Units (RUs) as well as three Interdisciplinary Centres (IC), and has attracted highly talented researchers, students, and staff from over 110 different countries.

The results of the 2016 Interface External Research Evaluation (EE)¹ highlighted the UL's characteristics that have contributed to our success: 1) favourable working conditions; 2) our highly skilled and motivated researchers; 3) our sensible and limited number of research priorities; and 4) our flourishing cooperation with industry, the government, non-Luxembourgish universities and Luxembourgish research institutes. Nine of our eleven RUs and all ICs² were shown to have output of high to excellent quantity and quality.

Table 1: UL competitive hires and ERC awards (2011 to date)

ATTRACT	PEARL	ERC
Cardoso-Leite (FLSHASE, 2016)	Verissimo (SnT, 2014)	Thiele (LCSB, 2017)
Redinger (FSTC, 2016)	Krüger (LCSB, 2013)	Ottersten (SnT, 2017)
Grünwald (LCSB, 2015)	Briand (SnT, 2011)	Glaurdic (FLSHASE, 2016)
Schmidt (FSTC, 2014)	D'Ambrosio (FLSHASE, 2011)	Tkatchenko (FSTC, 2016)
Greiff (FLSHASE, 2012)	Chauvel (FLSHASE, 2011)	Briand (SnT, 2015)
Thiele (LCSB, 2012)		Esposito (FSTC, 2015)
Esposito (FSTC, 2011)		Lagerwall (FSTC, 2014)
		Bordas (FSTC, 2013)

The UL has excelled in acquiring competitive funding to hire excellent researchers (Table 1). We are successful at securing competitive funding from European-wide programmes such as Horizon 2020 and

¹ 2016 – The Research External Evaluation was carried out by Interface; the institutional external evaluation was carried out by IEP - full reports available here: https://www.eni.lu/university/official_documents.

² C2DH was created in 2016 and was not part of the 2016 external evaluation exercise.

the European Research Council, while also consistently securing a substantial portion of national funding from Luxembourg's National Research Fund. The University has established attractive teaching programmes at the bachelor and master levels, developed cutting edge doctoral education training programmes, and created lifelong learning programmes covering a variety of different fields of study. In terms of internationality, the UL has established worldwide partnerships with globally leading institutions in research and teaching.

In terms of national outreach, the UL maintains close collaborations with Luxembourg's economic stakeholders, governmental agencies and non-governmental organisations, as well as with public research institutions, schools, and hospitals. We provide substantial public outreach through conventions and cooperation with the Ministry of Culture, the Ministry of Education, Children and Youth, the Ministry of Sustainable Development and Infrastructures, etc.

In 2017, The University of Luxembourg was ranked 179 (up from 193 in 2015) of the best Universities in the World in the "Times Higher Education World University Rankings". The UL reached 11th place in the "Times Higher Education Young University Rankings". In almost all performance indicators related to research quality and output, the UL is improving year on year.

The Luxembourg Research Landscape

But the UL is only one part of Luxembourg's dynamic research landscape. Public research is also performed at LIST, LIH, LISER, and the Max-Planck Institute for International, European and Regulatory Procedural Law.

The "*Common Strategy Paper 2016-2025: LIH, LISER; LIST and the University of Luxembourg*"³ highlights the common themes and strategic initiatives needed to maintain and improve collaboration between these Luxembourg Research Institutions with the goal of stimulating world-class research. This strategy paper serves as a roadmap for the implementation of a coherent national research and research strategy. One implication of this strategy for this 4YP is that some research areas will build on existing collaborations between the Lis and the UL. Budgets for this initiative will be negotiated separately, assuming these plans are supported by the Government.

Research by, with, and for industry is also fundamental for Luxembourg. In addition to direct funding from industry, Luxembourg's FNR offers a number of funding instruments to foster cooperation between companies and public research institutions. The number of industrial research projects has grown steadily over the UL's history so that in 2016, the external funding from industry equalled approximately 4.5 million EUR.

Alignment with National and International Initiatives

Research and pedagogy at the UL is already well positioned to contribute to a number of national and international strategies, e.g. space resources, digitalisation, High Performance Computing (HPC) and cancer research. The UL will contribute to the Smart Specialisation Strategy⁴, particularly the goals of

³ <http://geophy.uni.lu/users/tonie.vandam/p4/>

⁴ <https://rio.jrc.ec.europa.eu/en/library/luxembourg-strategy-smart-specialisation>

"Digital Lëtzebuerg"⁵ initiative and "The Third Industrial Revolution in Luxembourg"⁶ where a key focus is digital technology and where the UL will contribute to innovation for society as well as the economic and industrial sectors, allowing them to smoothly adapt to the digital age. Another relevant strategy feeding into UL's research is the project of common European Interest in HPC and big data, where Luxembourg has recently joined forces with France, Italy, Spain and Germany. This project intends to develop a number of real-time integrative HPC applications towards a "Smart Nation, appropriate to the Luxembourg and European context and environment"⁷. The project will complement the European supercomputing network to the benefit of Industry 4.0⁸, i.e. the digitisation of business and production processes, and research to allow Europe to catch up in the field of HPC (currently, the list of top 10 supercomputers in the world is dominated by the US and China). Along these same lines, the UL is a member of the partnership for advanced computing in Europe, the mission of which is to enable internationally competitive research by providing world-class computing and data management⁹.

Initiative	UL Faculties and/or IC that will be involved in the initiative
Digital Lëtzebuerg and The Third Industrial Revolution in Luxembourg	FLSHASE, FSTC, C ² DH, SNT
IPCEI on HPC and Big Data Enabled Applications	FSTC, LCSB
Space Resources	SnT, FSTC, FDEF
National Strategy on Cancer Research	LCSB, FSTC

Advances in space technology, the rapidly expanding exploration of outer space, and the inevitable scarcity of certain resources on Earth have all catalysed research in the exploration of space objects. Luxembourg will build on its long history at the forefront of the commercial satellite communications industry, and the UL will contribute to the exploration and utilisation of these resources. In the Luxembourgish government's space activity, space mining and observation (see spaceresources.lu) will be accompanied by a dynamic growth of further research and development activities. Existing UL research in communications, robotics, observational analysis in space, materials science, and law will ensure Luxembourg is an internationally-leading player in these areas. The UL will continue to partner with other Luxembourgish Institutes and industry to further develop synergies in these areas.

In terms of health-related national initiatives, the "*Stratégie nationale de recherche en cancérologie*" is a broad enterprise to understand how to better control, manage, and treat cancer. "Plan Cancer" will engage the ministries responsible for health and research, hospitals, IBBL, Laboratoire National de Santé, funding organisations, LIH, and the UL. This important initiative not only brings together the stakeholders in cancer research in Luxembourg, but more importantly it creates new momentum for establishing unique and controlled cancer cohorts and studies, providing new data and ethical

⁵ <http://www.digital-luxembourg.public.lu/en/index.html>

⁶ http://imslux.lu/eng/nos-activites/pole-de-specialites/8_the-third-industrial-revolution-in-luxembourg

⁷ https://ec.europa.eu/commission/commissioners/2014-2019/oettinger/blog/luxembourg-launches-supercomputing-project_en

⁸ <https://www.forbes.com/sites/bernardmarr/2016/06/20/what-everyone-must-know-about-industry-4-0/-46e075be795f>

⁹ <http://www.prace-ri.eu/prace-in-a-few-words/>

guidelines of relevance to other European countries. Fundamental and applied research at the UL together with future training of medical students and specialists (oncologists) will provide key resources to the *Plan Cancer* and further strengthen links with the above mentioned national partners. Over the course of this 4YP, we will firmly establish the UL as a key research partner in *Plan Cancer* initiatives and also train scientists, medical students, and specialists in tumour biology/oncology.

Table 2 shows which Faculties and ICs will contribute to these national priorities.

The Fourth Four-Year Plan

With this Fourth Four-Year Plan, the University is entering a new stage in its evolution. The rapid growth of resources and change that characterised the early years of the UL are now levelling off. Thus, this four-year phase will be characterised by a refinement of our research foci and a consolidation of resources.

The results of the external evaluation¹⁰ have played a significant role in defining the research areas where resources should be invested over this 4YP. We are excelling in research and want to further develop following core areas:

- **Materials science**
- **Computer science & ICT security**
- **European and international law**

The University has a responsibility to the country with regard to **Education**, which will remain a focus. In addition, the UL will develop **Financial and Financial Innovation**, which are essential for the growth of the Luxembourg economy.

In 2016, the **Centre for Contemporary and Digital History (C²DH)** was added as a third Interdisciplinary Centre (IC). Its creation was too recent for it be evaluated. Over the next four years, the new IC will be the beneficiary of resources to permit its growth and excellence.

RUs that were evaluated less favourably are beginning to address their perceived weaknesses.

In addition, many RUs and ICs are collaborating.

- **Health and Systems Biomedicine**
- **Data Modelling and Simulation**

are areas where collaborations already exist, but which would benefit from additional resources. We therefore propose to expand these cross-disciplinary areas.

We will continue to *develop our teaching skills and methods* making research-based teaching a priority. We will institute a merit-based distribution of research funds within and among Faculties and ICs. We will tie the block grants allocated to the Faculties to external funding and other quantifiable research targets. Our funding goal will be to grow our external funding at a rate that is of equal or greater magnitude (in percent) to the budget increases provided by the government. Moreover, we support the proposal of an evaluation after two years, so that we might be able to reallocate funds.

Another very important component of this 4YP will be the creation of a more efficient and *transparent administration*. In addition to the research evaluation, the UL also underwent an external institutional

¹⁰ 2016, full report available here: https://www.uni.lu/university/official_documents

evaluation¹¹ to answer the questions 1) what is the UL trying to do? 2) How is the UL trying to do this? 3) What proves that it works? and 4) how does the UL change in order to improve? The evaluation noted that we have accomplished a number of “very impressive achievements so far” but that we need to “transition from the dynamic start-up phase to stability” and that a “consolidation phase is now needed”. With respect to this 4YP, the evaluation recommended that we 1) “set out timelines and prioritised steps for implementation of the 4YP”; 2) perform a review of our internal regulations and procedures to improve the efficiency and effectiveness of our academic and administrative decision-making; 3) make full use of available data for evidence based decision making; 4) increase the transparency of the budget allocation process; and 5) create an over-arching quality assurance system for the university.

The University has already begun implementing a number of strategic projects to enhance its administrative efficiency. These projects include 1) establishing a cost accounting system 2) establishing a risk assessment system; 3) digitising key administrative processes, 4) developing a new procurement management system, 5) developing a university-wide dashboard for customised access to pertinent indicators, and 6) instituting a framework for systematic staff development and training. Quality assurance is required to make sure these initiatives are implemented in line with the needs of the University’s community and external stakeholders. All of these recommendations have been taken on board and will be discussed in later sections of this document.

Gender, staff development, and students are also important for the UL success and therefore are components of this 4YP. The institutional evaluation indicated that we must develop a gender action plan, with resources to implement the plan.

We will also work to address student issues outlined by the evaluation 1) that “UL students are represented in a more structured and permanent way”; 2) an effective system for electing student representatives needs to be put in place (achieved 2017); 3) students should be supported and incentivised to organise clubs and societies. Efforts toward achieving these goals will be addressed later in this 4YP.

For our staff, we will initiate continuing professional development programmes to enhance their skills and allow them to move upward through the university and to improve the quality of service they provide to the UL.

Development of this 4YP

We have included the input of as many stakeholders as possible when developing this document. It has involved the vice-rectors, the acting Director of administration, the Directors of the Interdisciplinary Centres and the Deans of Faculties. The Deans and Directors have included input from their entities. As a result, we are confident that this 4YP represent a consensus of UL stakeholders. We have further engaged national stakeholders, e.g. FNR, LIs, industry, and government representatives, and solicited their opinions where appropriate.

With regard to timing, Rector Rainer Klump resigned on May 2nd 2017. This 4YP was developed between May 2nd and the Board of Governors’ session of July 8th 2017.

¹¹ The evaluation can be found here https://www.unil.lu/university/official_documents

We will often use the term “impact” in this 4YP. For us, research impact is the effect research has beyond papers and doctoral theses. Impact is when our research can influence and benefit society, industry, and the economy.

As to the format, we follow that of the previous 4YP.

The first sections lay out research, teaching and learning as well as administrative strategies.

In this 4YP, we describe the areas of existing research excellence that have been defined based on a RU’s ability to acquire external funding and on research excellence (quantity and quality) as noted by the external evaluation. (See **Section II.**) We put our newest Interdisciplinary Centre, Contemporary History and Digital Learning, into this category. These focus areas will require further resources to continue growing.

Over this 4YP, research will also focus on enhancing our research impact by bringing together our pillars of research excellence into larger themes that have a strong potential for interdisciplinarity. These interdisciplinary themes include Health and Systems Biomedicine and a broad theme related to Data Modelling and Simulation. These cross-disciplinary research areas are described in **Section III.** To adequately fund these activities means that a restructuring of the resources within the Faculties and ICs are needed.

Section IV provides an overview of the further development of teaching and learning. In **Section V**, we describe an initiative to develop a National Platform for Gender in collaboration with the FNR and the IIs. **Section VI** describes our plans for enhancing technology transfer. In **Section VII**, we briefly describe the most important changes in Administration that will ensure the UL’s continued development.

To continue growing in a positive direction every individual at the UL needs to embrace quality. Quality assurance for research, teaching and learning, administration, and staff development is described in **Section VIII.**

We recognise that this is a highly ambitious 4YP, but only by being ambitious can we reach our longer-term vision. In **Section IX**, we discuss how our initiatives in the 4YP contribute to a longer-term vision (ten to twenty years) for the UL and its role in the development of the country.

Over this 4YP, we will become a leaner and more efficient organisation, changes that will help us reach the goals described here and put us on the path to achieving our longer-term vision. Our energy and our dedication to change increase our chances to accomplish these goals. By the end of this 4YP the UL will have succeeded in further consolidating our core areas of research, scholarship, and teaching and learning. We will have engaged in new areas of research with great funding potential. We will have developed closer collaborations with the other public research centres in Luxembourg. And we will have a highly efficient and transparent administration.

Section II. Supporting Existing Pillars of Excellence

In this Section, we discuss our existing research pillars where excellence has been established. These research areas are defined as excellent because of 1) the quantity and quality of research output and 2) their ability to acquire highly competitive external research funding. As in the past, the UL will focus on a limited number of research fields where excellence, critical mass and a high potential for international leadership already exist or can be obtained. These research areas were also identified as being excellent by the EE.¹²

The areas of excellence include **Materials Science; Computer science & ICT security; European and international law; Finance and Financial innovation**. Although **Education** was not deemed excellent in the EE, the RU is important for Luxembourg so that it is included here. (The RU is also undergoing structural changes to improve its performance.). **Contemporary and Digital History**, as a new Interdisciplinary Centre will need a strong support to gain international visibility.

Additionally, as Luxembourg offers an ideal environment for in-depth research into important cultural, socio-economic, and/or political phenomena that are also of increasing international interest, the research field **Luxembourg Studies** will receive continued support from the University in 2018-2021.

In the next section, we present the themes that we will develop over this 4YP.

Materials Science

Materials research concerns the synthesis of materials, their physical and chemical characterisation, their performance in actual devices, and their theoretical understanding. As a consequence, materials research is generally considered as “enabling”, meaning that foundational knowledge in one of the above activities can diffuse into different fields of research. As an example, the very same nanomaterials, only slightly tuned to each purpose, can be used for various applications, e.g. in sensors, actuators, coatings, or nanocomposites.

Materials science is a national research priority and a funding theme of the FNR. Materials science at UL support this national priority through excellent research results (see the EE), and significant external funding (including three ongoing ERC projects). Research focuses on four axes:

- **Soft and living matter:** research here investigates the properties of soft- and bio-materials, such as highly responsive polymers and liquid crystals and long-range macromolecular interactions, as well as complex phenomena in soft- and living-systems, such as self-organisation and critical phenomena;
- **Photovoltaics and semiconductors:** research spans the range from the fundamental properties of advanced semiconductors, through novel growth methods, to building efficient photovoltaic devices that convert light to electrical energy;
- **Magnetic and multiferroic materials:** research investigates novel functional materials with a focus on the study of the underlying fundamental principles and how functionalities can be translated into technology are part of this topic; examples include state-of-the-art permanent magnets or piezoelectric and caloric compounds;
- **Theory and materials modelling:** research entails developing theories and numerical methodologies to predict and design macroscopic properties of materials based on their

¹² Note: as mentioned above, the C²DH was not included in the 2016 research evaluation.

underlying microscopic structure. These tools are essential for the other three research axes and beyond.

Activities within these four areas will grow over the 4YP. The UL maintains strong interactions nationally and internationally, and we plan to further strengthen the local interactions within the 4YP:

Collaboration with the MRT Department at LIST

A common strategic plan between the UL and LIST's Materials Research and Technology (MRT) department entitled "Belval Future Forge" has been established, where several mutually interesting fields of collaboration are defined, supported by joint professorships. It comprises a joint technology and characterisation platform in the "house of materials" on the Belval campus. The Belval Future Forge will cover fundamental, use-inspired basic and applied research, as well as technology transfer on various novel functional and intelligent materials. In 2016, the MRT and the UL jointly acquired 24 Million EUR from competitive and industrial projects. Areas of collaboration include 1) materials and technology for sensors and energy harvesting to acquire and use broad knowledge of coupling/sensing and energy conversion phenomena with the aim of discovering new general concepts, materials and devices; 2) soft matter, namely innovative polymer-based composites, including an improved durability and the use of alternative materials such as bio-derived polymers and natural fibres; and 3) future collaborations on the topic of nano-additive manufacturing.

Physics and Biology

New innovations in biology can be achieved through a more fundamental understanding driven by physics. The UL has built up research excellence in both physics and biomedicine. It is therefore very promising to reinforce activities at the boundary between the two disciplines. Particularly promising directions concern the characterisation of stochasticity and critical behaviors at the single cell level, a rigorous understanding of the thermodynamics of metabolism and mitochondria, the statistical characterisations of the microbiome, and the design of new materials for biomedicine. Establishing a new sub-discipline of physics to understand complex biological phenomena will develop new approaches to biology.

Materials and Modelling

Computational materials science deploys complex methods and computing algorithms implemented in software code, which generate large amounts of information on novel functional materials that can then be explored with the methods of machine learning and big data analytics. The UL contributes to the development of those methods and is connected to the leading European research networks in the field (see, e.g., Novel Materials Discovery (NOMAD) Laboratory: <https://nomad-coe.eu/>). This activity will contribute to the development of the materials modelling testbed within the aforementioned IPCEI on "HPC and Big Data Enabled Application".

Computer Sciences & ICT security

For the theme **Computer Sciences & ICT Security**, the UL can build on existing excellence that has already started to infiltrate various research domains. Digital technologies are transforming the way progressive research, teaching, and knowledge transfer are undertaken. The ubiquitous presence of digital tools in public, professional and private life combined with artificial intelligence, high computing power and data storage have redefined the type of questions that can and need to be addressed. The UL will actively engage in this process in order to take an internationally leading role in digital research, knowledge creation, and knowledge transfer with the goal of positively impacting Luxembourg's society and economy.

Research in computer science has undergone a rapid and successful development. Initially UL research in this domain was located in only a few RUs. Today computer science, digital science, and/or Data Modelling and Simulation are research foci in all of our ICs and Faculties.

Computer sciences & ICT security is highly successful in attracting competitive external funding from industry, European, and national sources. Hand in hand with relevance and impact, achieving scientific excellence increases the UL's appeal as a national and international research partner and attracts talent to Luxembourg. The university set highly ambitious, long-term goals for this focus area in the Strategic Plan 2009, and a solid foundation for continued development towards these targets has now been laid.

As the country's principal ICT knowledge institution, the University will achieve sustainable integration into Luxembourg by supporting collaborative research programmes in strategic areas, by developing a TTO (Technology Transfer Office) embedded in the innovation ecosystem of Luxembourg, and by attracting and training highly talented and skilled professionals to meet the increasing HR demands of the country's expanding ICT intensive industry. The following areas will require specific investments and are aligned to the Digital Lëtzebuerg strategy and Rifkin report: financial and regulatory technologies, space resources, compliant data management, machine learning, and artificial Intelligence.

UL researchers have forged close links with research groups at leading research universities in Europe, Asia, and the US. We will continue to develop our strategic research areas in digitalisation creating a European hub for international research cooperation by partnering with the best research teams in Europe to enter the highly competitive H2020 and the European Space Agency research programmes. The evaluation review confirmed the importance of computer science for the digital strategy of the university and for Luxembourgish and global society.

Digital Sciences are significantly influencing the Luxembourg research landscape as evidenced by the fact that the country's digital economy has grown significantly over the last decade.¹³ As a central pillar of the UL research and learning strategy, Digital Sciences strongly complements Luxembourg' digital strategy. The UL is well-positioned to support and participate in societal and economic transformations, driven by Digital Sciences and will continue to develop this strategic research area.

Finance and Financial Innovation

Financial Technology (also known as FinTech) is a broad concept that combines innovative new technology with available resources in order to compete in the marketplace of traditional financial institutions and intermediaries in the delivery of financial services.

The UL has initiated its investment in financial innovation with several researchers in the different Faculties and ICs. As the complexity of the regulatory environment increases, ICT tools are necessary to provide scalable and cost-effective, secure, and compliant solutions for the financial and banking sector. Also, the emergence of technologies such as block chain-based systems, smart contracts, crowd-based funding/lending where security and trust aspects are central may have a disruptive impact on the sector.

¹³ Europe's Digital Progress Report (EDPR) 2017 Country Profile Luxembourg, <https://ec.europa.eu/digital-single-market/en/news/europes-digital-progress-report-2017>

In finance, relevant research addresses how the increase in computing power as well as amounts of data leads to new research methods and, moreover, how the increased availability of data impacts the functioning and efficiency of financial markets and the financial industry.

New legal frameworks will be needed to address the challenges (regulation, compliance, and criminal law enforcement) posed by the collaboration between intermediaries inherent to finance-related technology. Research in this domain has the potential to provide growth, prosperity and social welfare but may also become a source of new risks that are at present poorly understood by supervisory authorities and regulators. To react to these risks, research in law is key, particularly in the newly emerging field of regulatory compliance that includes research expertise in management.

The UL has entered into eight long-term strategic partnerships to establish collaborative research in financial innovation including an endowed chair in Digital Financial Service sponsored by PayPal and the FNR that demonstrate industry's strong commitment and endorsement of the UL's strategy in this area of research.

European and International Law

Research in European law necessarily includes various forms of regulation of modern social systems, such as capital markets, media and communication, or health and is therefore interdisciplinary. Research in European law at the UL has achieved an excellent international reputation and research output.

Over this 4YP, further competencies will be developed in the areas of compliance and law enforcement, data management and privacy, as well as intellectual property law. These research fields will attract external support from both private and public stakeholders (compliance, data management) and will be embedded into University-wide research topics (data management/digitalisation; intellectual property/biomedicine/health).

European Union Law

With the aim of actively contributing to current debates and furthering knowledge of EU law in profoundly shifting areas, research in EU law focusses on the following central topics: (1) European economic law and governance, where questions regarding the future of the Economic and Monetary Union as well as regulatory matters are addressed. Linked to these issues and central to the development of the internal market are questions of European civil law, especially contract law, European company law, European social and labour law, as well as applied European consumer law; (2) systemic issues in European legal thought and procedural law, with the latter cutting across all branches of power, the executive, the legislative, and the judiciary as well as their relations in horizontal and in multi-level terms. In that regard, research in European criminal law and comparative public law are growing areas capable of providing the backbone for important normative developments; (3) the external and international dimensions of European law and policies with respect to trade and immigration, both areas that pose important political and legal challenges to European integration.

Data Management and Privacy

With the ongoing digitalisation and growing technological ability to capture, aggregate, and process an ever-greater volume and diversity of data, data management (in particular with regard to big data) will become increasingly important and will have an impact on governments, businesses, and the everyday life of citizens. The analysis of large amounts of data can be used for varied purposes ranging from fraud detection to the enhancement of cybersecurity. While the potential uses of "Big Data" seem

endless, this large-scale processing and data management in general raise numerous and substantial legal questions of data protection and privacy. Research in the field of data management will therefore address these challenges and opportunities from a legal perspective including the new Europeanised regulatory framework for data use. This research area will significantly build on interdisciplinary approaches such as fundamental ethical, social, economic, and technological issues that are connected with the applicable law.

Intellectual Property Law

In knowledge-based economies, effective protection and enforcement of intellectual property rights are crucial to stimulate innovation and compete in a globalised economy. This has been the case in the past but is becoming ever more relevant in a rapidly changing technological environment which foresees digitalisation of all areas of life. The EU is a crucial player and promotes within the “Innovation Union” a comprehensive IPR strategy under its Digital Single Market Strategy. This flagship initiative will not only modernise the legal framework for IPR enforcement, but also further develop a balanced approach between use of protected property by society and rights holders’ interests. Research in this area with a focus on the cross-border dimension of enforcement in an online context is essential to contribute to the discussion of how to prevent infringing activities from undermining growth and sustainable employment in the EU. UL research already covers different models of enforcement, but further areas for development include industrial property protection, an area that will be of growing significance in Luxembourg with the arrival of the Unified Patent Court.

Compliance and Law Enforcement

In the field of business law, the aim is to establish an interdisciplinary research field around corporate crime and compliance. In this context, compliance refers to the process of ensuring that a company and its employees follow the applicable laws, regulations, standards, and ethical practices. In addition to the legal issues relating to law enforcement, effective methods of identifying and deterring corporate misconduct will be examined. Research into compliance and law enforcement will facilitate and deepen the understanding of the causes of corporate misconduct, and seek to identify policies and practices to enhance corporate compliance while preserving business innovation and creativity.

Education

The Luxembourg education system is unique because of the country’s multilingualism and its associated societal heterogeneities. Luxembourg’s education-related challenges for education worldwide of today are future challenges, making Luxembourg and its education system a “living laboratory” of international relevance.

In **Education**, the current 4YP will combine the considerations of local needs with the challenges and quality requirements of the international research community. Being a research priority in all previous 4YPs, the Research Theme Education has been able to achieve impact at national and international levels. The UL has been successful in implementing fundamental and internationally visible research (e.g. in the fields of cognitive science, technology-rich assessment and sociology of education). The research in this 4YP will continue to focus on nationally relevant research questions. The UL is committed to helping every single child reach their maximum potential, and thus shares the focus of Luxembourg’s educational policy (“Offrir les meilleures perspectives d’avenir à chaque enfant et chaque jeune”). The national context of education developed considerably over the past few years, with newly implemented educational guidelines, institutions and actors (e.g. multilingual early childhood education, creation of competence centres). The UL will complement, and in some cases, define these efforts in two concrete ways.

First, the research group in education will implement a cluster dedicated to special educational needs. Based on existing capacities in the Research Unit and Centre(s), this new project will allow for the cluster to design reliable valid (digital) diagnostic and intervention instruments (for large-scale and/or individual use) for children with special educational needs in highly-diverse and multilingual learning contexts.

Secondly, the group will monitor the impact of selected national educational reforms, interventions, and projects that have a specific focus on multilingualism and diversity in formal and non-formal education. In this vein, the UL will (1) actively participate in establishing and coordinating the model school “Kannercampus Suessem”, an innovative institution offering research-guided school and extra-curricular activities from day-care to fundamental education, thus providing a unique setting and opportunity (e.g. proof of concept studies) for pupils, teachers, and UL researchers alike; (2) further develop the national report on education (Bildungsbericht) by focussing more systematically on key questions of the Luxembourg education system; (3) extend the language-test portfolio (in early grade levels) of the national school monitoring programme, which will allow for a better understanding of multilingual education efforts deployed during early childcare.

In order to emphasise Education’s national relevance, enhance visibility, maximise synergies, counteract fragmentation of the field, reduce bureaucracy, and facilitate communication with internal and external partners/stakeholders, the UL intends to merge the Luxembourg Centre for Educational Testing (LUCET), the Luxembourg Centre for School Development (LuCS), and the aforementioned novel special education needs cluster into a single research and transfer structure the Luxembourg Centre for Educational Research (LUCER; Zentrum fir lëtzebuergesch Bildungsfuerschung).

Based on the UL’s pioneering work in digital approaches to education (e.g. digital assessment using user-centred methods) all these endeavours will be firmly grounded in the RE’s developments in digitalisation. In this 4YP, the UL will build on the strengths already present, as acknowledged by the external evaluation, and further extend these assets. This will contribute to the role of the UL as a university *for* Luxembourg, while at the same time achieving international recognition and visibility in target domains. Work in the research unit of education will contribute to the three core missions of the UL: research, teaching, and knowledge transfer. The unit will explicitly connect to two other UL priorities, **Health and Systems Biomedicine** (e.g. assessment of children with special educational needs) and **data simulation and modelling** (e.g. big data handling in digital assessment). Naturally, the RE activities will also continue to foster the research-based teaching approach in several core study programmes in education.

Contemporary and Digital History

The Luxembourg Centre for Contemporary and Digital History is the third Interdisciplinary Centre of the University and focuses on the study, analysis, public dissemination and engagement with regards to contemporary history of Luxembourg and Europe. In order to realise its ambition to become a world leading Centre in developing and applying digital tools and methodologies for contemporary history, a sustainable investment in the Centre, especially in its digital research infrastructure and academic staff that have both scholarly and digital expertise, is key for developing and establishing the Centre.

Based on recent discussions with the C²DH Advisory Board and the Scientific Committee, over the time frame of this 4YP, UL researchers working in this focus area will concentrate their activities on four thematic axes that have a double strategic function: first, to concentrate on timely topics that are of high relevance for Luxembourg society and fill important gaps in contemporary historiography; secondly, to apply new digital tools and methods in studying these topics and thereby produce

internationally competitive outputs that demonstrate the uniqueness of the C²DH approach. These themes are

- **Global Histories of Finance:** focussing on the Luxembourg financial industry in a globalised financial network and studying the impact of this sector for the Luxembourgish society and economy;
- **Digitising Industrial Heritage:** developing new forms of digital documentation and representation of the industrial past (especially the steel industry) with the aim to produce innovative public history tools /applications;
- **Legacies of War, Collaboration, and Resistance:** questioning national myths and re-evaluating socio-political phenomena like occupation, resistance, collaboration, forced recruitment and labour, persecution, and their legacies for the two post-war societies; and
- **Digital History and Hermeneutics:** engaging with the urgent epistemological questions of digitisation for the practice of doing history in the 21st century and offering new pedagogical tools (e.g. online tutorial) for digital source critique and transmedia storytelling.

Next to these thematic axes, which concentrate existing scholarly capacities of the four research areas, the Centre will concentrate on acquiring external funding for realising projects that will help to strengthen its position as national expertise Centre and international hub in digital history

In digital or e-learning, the UL researchers working in this priority will develop a strong collaboration with the Media and Digital Design Centre (MDDC) and a partnership with the Learning Centre of the University. In addition, it offers an important contribution to the BA and MA programmes in history as well as to the Doctoral education.

A major challenge for this research theme is the development of a sustainable digital research infrastructure (DRI) that will enable and foster the process of productive “*thinking*” with data as well as in disseminating and preserving the outputs of the Centre. A recent White Paper outlined the necessary strategic investments for the DRI and will serve as a roadmap for the next 4YP. Yet without a critical investment in new research tools, life-cycle management and the creation and enhancement of digital corpora and resource collection and – most importantly – professional and sustainable support from SIU (Service Informatique de l’Université), the researchers working in this field will not be able to realise their ambitions.

Proposed Hires Using Competitive Funding Mechanisms

The Research Service has solicited plans from its researchers on their intentions to apply for funds for PEARL, ATTRACT, and ERC positions for 2018. The requests are shown in **Table 3**. The table contains about 30 demands. However, before the PIs begin writing the full proposal, the Management Team will decide which projects should be submitted in 2018, which should be submitted later, and which should be declined (not a priority or the likelihood of success is low). Decisions will consider the research priorities described in this 4YP and the potential of the Research Unit or Interdisciplinary Centre to attract external funding to support the positions after the initial funding has ended. Of the proposals that are submitted for review, usually only 20% are retained. Finally, the proposal (hiring and funding) must also fit the plans and budgets of the Faculty.

Table 3: Tentative list of positions *requested* for the period 2018-2021 with competitive funding provided that grants will be retained (average success rate 20%). Firm applications will be decided upon in the Management Team and Rectorate. Except for PEARL, ERC Advanced Grant Chairs and ATTRACT, ERC tenure track (for Starting and Consolidators) funding for all competitive hires **will** become the responsibility of the UL after the initial 5 years of the project (Abbreviations: PD = Post Doc; AProf = Ass. Prof.; RU = Research Unit; CS=Computer Science; LSF = Luxembourg School of Finance; DMS = data modelling and simulation. Currently the Research Unit DMS does not exist. The unit will be created later

These figures are preliminary and an approval of the Plan does not imply their approval in detail, but only as a frame of action that will have to be adapted to the yearly budget of the University.

Attract									
RU	Priority	UL funding required <i>at the start</i> of the project				UL funding required <i>after the original 5 years</i> of the project			
		Prof	AProf	PD	PhD	Prof	AProf	PD	PhD
LSRU	Biomedicine/Health					1			1
PHYMS	Materials/Semiconductor						2	1	1
DMS	DMS					1	1	2	2
Law	Europ. & intern. law					1	1		2
LSF	N/A					1			1
INSIDE	Health						1		2
IPSE	N/A					1		1	1
C ² DH	C ² DH						1	1	1
LCSB	Biomedicine/Health					1			1
Pearl									
RU	Priority	UL funding required <i>at the start</i> of the project				UL funding required <i>after the original 5 years</i> of the project			
		Prof	AProf	PD	PhD	Prof	AProf	PD	PhD
PHYMS	Materials/Semiconductor	2			2				
DMS	DMS	2			1				
LCSB	Biomedicine/Health	1			1				
SnT	Computer Science	1			1				
SnT	Computer Science/Mach. Learning	1			1				
C ² DH	C ² DH	1		2	2				
ERC Starting									
RU	Priority	UL funding required <i>at the start</i> of the project				UL funding required <i>after the original 5 years</i> of the project			
		Prof	AProf	PD	PhD	Prof	AProf	PD	PhD
DMS	DMS/Materials	1			1		3	1	2
CS	Computer Science						1		
Law	Europ. & intern. law						1	1	1
IPSE	N/A						1	1	1
LCSB	Biomedicine/Health/CS						3	1	1
ERC Consolidator									
RU	Priority	UL funding required <i>at the start</i> of the project				UL funding required <i>after the original 5 years</i> of the project			
		Prof	AProf	PD	PhD	Prof	AProf	PD	PhD
PHYMS	Theory and materials modelling	1				1		1	1
Law	Europ. & intern. law		1			1		1	1
LCSB	Biomedicine/Health/CS	1	1			1	1	2	2

ERC Advanced									
RU	Priority	UL funding required <i>at the start</i> of the project				UL funding required <i>after the original 5 years</i> of the project			
		Prof	AProf	PD	PhD	Prof	AProf	PD	PhD
DMS	Data model. and sim	1		1	1	1		1	1
Law	Europ. & intern. law	1			1	1		1	1
C ² DH	C ² DH	1		2	1	1		1	1
SnT	Computer Science			1				1	
INSIDE	Health	1			1	1			1
LCSB	Biomedicine/Health/CS							1	1
ERC Chair									
RUL	Priority	UL funding required <i>at the start</i> of the project				UL funding required <i>after the original 5 years</i> of the project			
		Prof	AProf	PD	PhD	Prof	AProf	PD	PhD
DMS	Data model. and sim.	1		1	1	1		1	1

Resource Summary for Existing Pillars of Excellence

Table 4 provides a summary of resources requested by each faculty and IC in this 4YP to support the existing pillars of excellence described in this section.

Table 4: Resources to be distributed to the existing pillars of excellence described in this section. Values in kEuro.					
<i>These figures are preliminary and an approval of the Plan does not imply their approval in detail, but only as a frame of action that will have to be adapted to the yearly budget of the University.</i>					
FSTC	2017	2018	2019	2020	2021
Material sciences	2,401	2,270	3,258	3,619	4,031
Finance and fin. innovation	0	0	572	634	681
FLSHASE	2017	2018	2019	2020	2021
Education	6,637	7,424	8,042	8,310	8,747
FDEF	2017	2018	2019	2020	2021
Finance and fin. innovation	300	1,317	1,691	1,915	1,972
Europ. and intern. law	100	1,148	1,183	1,218	1,255
LCSB	2017	2018	2019	2020	2021
Material sciences	0	33	74	104	107
SNT	2017	2018	2019	2020	2021
Finance and fin. innovation	200	500	800	1,100	1,400
Europ. and intern. law	60	74	82	90	98
C²DH	2017	2018	2019	2020	2021
C ² DH	3,591	4,762	4,915	5,030	5,246

Section III. Growing Cross-Disciplinary Themes

Building on the successes of the last thirteen years and the areas of research excellence discussed in Section II, over this 4YP, the University will promote interdisciplinary research in two areas: 1) **Health and Systems Biomedicine**, and 2) a broad theme including **Data Modelling and Simulation**. The UL will build on our existing achievements and will extend the research in these fields to strengthen collaborations between RUs and ICs in these areas. Collaborating across different disciplines can create critical mass around a research subject and the cross-fertilisation of different ways of thinking can sometimes result in innovation in a field.

The **Health and Systems Biomedicine** is a future-oriented research subject that has the potential to create links across many activities at the university and collaborations with existing expertise at the public research centres and healthcare institutions in the country. At the same time, it is of high socio-economic relevance, as it will improve public health and contribute to the creation of a biomedicine driven economy. The collaboration across traditional disciplinary boundaries between biomedicine, the social and behavioural sciences, environmental research, and computational sciences will create a unique profile of Luxembourgish research. Based on a common IT infrastructure, mechanistic computational models can be derived from real life data on health, environment, nutrition and socio-economic circumstances as well as from suitable experimental models. With a strong link to law and finance, the UL will be in an excellent position to tackle future health challenges. These include topics such as health-economics as well as legal and ethical aspects in the changing society of an information age and rapidly advancing technical progress.

The **Health and Systems Biomedicine** research theme and the Medical Education programme (see Section IV Advancing Learning and Teaching) will be closely linked. The **Health and Systems Biomedicine** research focus federates UL actors in the fields of biomedicine, clinical sciences, behavioural sciences, and social sciences as well as reaching out towards the researchers in the environmental sciences. The aim is a highly, integrated approach to some key pathologies (e.g. neurodegenerative diseases and cancer). The medical training to be offered in the future will obviously be part of this UL strategy as it will integrate interdisciplinary approaches and will involve quantitative and analytical methods that rely on biostatistics and bioinformatics, training the medical doctors and clinician scientists of the future with personalised medicine as a target. With both the research and the education components relying largely on big data usage, computational modelling, and machine learning techniques, the actions in the biomedicine field are linked themselves again to the other cross-sectional theme in digital sciences and modelling.

As the two interdisciplinary themes in this section cut across traditional Faculty and IC boundaries, it will be important to consider different kinds of tools for supporting collaborations.

- **Bridging Groups:** Groups that will build a link to other Research Units or Luxembourgish institutions, they comprise research members and budgets from two or several partners;
- **Attendant (or linked) PIs/Group leaders:** Professors or group leaders that have a temporary co-affiliation with another Research Unit / Interdisciplinary Centre based on projects. They can

attend PI/RU meetings of that RU/IC, have a (flex) desk and may even have funds managed within that RU/IC;

- **Affiliated scientists:** Scientists that have a full working contract in a different (external) institution but have also full working rights in the UL. Professeur Affilié fall into this category; and
- **Clinician scientists:** Medical scientific personnel that work both in research and in healthcare.

Health and systems biomedicine

The following subject areas have been identified as research themes that will bring together researchers from the different RUs and ICs to establish cross-sectional activities. We foresee additional collaborations between the UL and other national and international institutions. (See **Table 4.**)

Biomedicine and IT

Biomedicine has become a major player in the big data field and the heterogeneity of information from the clinical to the molecular level requires advanced machine learning approaches and artificial intelligence to identify underlying correlations and networks. IT-supported implementations of personalised medicine have reached healthcare and the related medical informatics includes challenges such as data standardisation and privacy. The activity “Biomedicine and IT” is directly linked to the other cross-sectional theme of the UL “Digital Science, data modelling, and simulation”.

The large amounts of data in biomedicine require a computing that cannot be solved by traditional fast high-performance computing but relies on dedicated hardware that allows fast input/output operations such as field-programmable gate array technologies. LCSB and FSTC plan to engage in this field through the Luxembourg coordinated IPCEI on High Performance Computing and Big Data enabled Applications.

Specific "use cases" will take centre stage to not only further establish Luxembourg as a data hub for biomedical data (through the ELIXIR node), but also to develop and apply advanced machine learning and artificial intelligence approaches to these data. Time series data, e.g. from longitudinal patient cohorts, will be used to integrate data from different sources, including molecular, clinical, and population level data. The aim is to bring together leading UL researchers in experimental and clinical neurology and tumour biology, machine learning, data base and information science, and systems control theory to improve prediction tools for the prediction of disease trajectories and in the long term run to co-develop innovative and comprehensive decision-making support tools for clinicians and healthcare professionals.

Additional research in in this domain will include integration of data sets derived from various technological platforms, modelling of molecular networks based on wet-lab data, and multiscale modelling.

Biomedicine, Socioeconomics, the Environment, and Behaviour

Diseases are not only a result of genetic predisposition but health and diseases are also heavily influenced by environment, life style, and socioeconomic factors. It will be important to investigate the role of these environmental factors and their complex interactions with genetic and epigenetic processes. Research in this domain will focus on understanding the influence of the environment on health and disease by investigating different stressors, including the role of the microbiome, food, toxins and socio-economic influences such as poverty or chronic stress. New competences in epigenetics in particular will need to be developed. The cross-sectional theme "Biomedicine, Socioeconomics and Environment" will be developed as a bridging theme and will include the analysis

of stressors like migration, income inequality and social status on individual and population health. Research in this domain will also focus on cancer and neurodegenerative diseases, the influence of exogenous factors (nutrition, environmental stressors like toxins, etc.) on signalling networks including the regulation of gene expression and of the metabolism.

This activity will also link to many Faculties and ICs.

Research and Healthcare

Integrating research into healthcare will enable information flow between the needs of the patients and the innovation in the lab. Such exchanges will drive more focused research according to the requirements in the clinic and will allow for a faster transfer of the latest research findings into clinical practice in Luxembourg. The National Centre of Excellence in Parkinson's disease (NCER -PD) which is building up a cohort of Parkinson patients and healthy controls has pioneered medical translational research at the UL by bridging biomedical research to the clinics in Luxembourg.

Together with healthcare providers in Luxembourg, we aim to establish a translational medicine network in neurology that integrates both research and healthcare to pursue cutting-edge medical research and provide excellent care. A particularly important element for the creation of innovation is the proximity of biomedical research to the clinic. The envisaged medical training, e.g. the specialisation programmes in neurology and oncology will help to catalyse an efficient knowledge transfer of modern biomedicine into clinical practice. The recruitment of more senior clinician scientists within the Medical Education Programme will be essential in this context. In addition, the UL has to enable the creation of the organisational and legal framework to integrate clinician researchers located in the healthcare institutions. It is planned to use the EU programme WIDESPREAD to build the necessary critical mass in clinical research in Luxembourg. The focus will be on oncology and neurology with immunology as a transversal subject and medical informatics as a central component.

Cutting-edge behavioural-experimental research and interventions in the investigation of health- and disease-related processes are also necessary. Establishing an out-patient clinic (Luxembourg Centre of Mental Health) is a crucial element to the provision of this clinical research and training on the development, maintenance, and treatment of mental health problems. Clinical research will contribute to developing evidence-based behavioural treatments for mental health problems, and prevention interventions to increase mental and physical health and well-being in individuals across the whole life-span. Similar to the longitudinal cohort studies of Parkinson's disease patients, use cases will be developed that are centred around patients and patient cohorts with socio-psychological stress.

Biomedicine and Law and Ethics

Considerations in law and ethics are essential for future-oriented medicine in education, research and societal debate. Questions of ethical, legal and intellectual property issues in biotechnology and health are constantly developing and provide an interdisciplinary link between research in health and research throughout the Faculties and ICs. As a result of the rapid changes in global information flow, the concept of privacy needs to be revisited. A cooperation between the FLSHASE, the LCSB and the FDEF on this topic is foreseen and a joint Chair in Bioethics is envisaged. The issue of privacy will also be of key interest in the context of attempts to develop an appropriate legal framework for data protection, data privacy and security.

In **Table 5**, we show which Faculties and ICs that will contribute to the interdisciplinary theme of health.

Theme	Contributors
Biomedicine and IT	FSTC, SnT, LCSB
Biomedicine and Socioeconomics and Behaviour	FLSHASE, FSTC, FDEF, LCSB ¹
Research and Healthcare	FSTC, FLSHASE, LCSB
Biomedicine and Law and Ethics	FDEF, FSTC, LCSB, FLSHASE
¹ with the LIH, LISER and LIST	

Data modelling and simulation

This area of research refers to the practice of using models (physical, mathematical, or other logical representations of a system, entity, phenomenon, or process) as a basis for simulations. This theme supports analysis, experimentation, and training. Data modelling and simulation can help us to understand a system's behaviour without actually testing the system in the real world.

Data modelling and simulation research is being developed in research disciplines as diverse as climate modelling and drug delivery in the brain. Data modelling and simulation is a cross-cutting UL research theme that addresses technological, scientific, and societal challenges.

The Data modelling and simulation (DMS) initiative is a bottom-up effort from various Research Units. The cross-cutting DMS (formerly known as 'Computational Sciences') has created a positive and symbiotic research environment that relies on a strong scientific, computational, and mathematical research core. Through this cross-cutting theme, researchers from social sciences are, for example, working with theoretical physicists to understand social inequalities through machine learning algorithms.

This cross-sectional research theme will make Luxembourg a model for Europe to test innovative research, teaching, learning and training paradigms in scientific computing which will become the backbone of "Digital Lëtzebuerg". This will be achieved by building on Luxembourg's unique IT infrastructure (HPC, near-total internet access).

Modelling and Material Sciences

(Please see the text in **Section II**. Consolidating Existing Pillars of Excellence, Subsection Modelling and Materials Science)

Modelling and Mathematics

Probability theory, analysis, and partial differential equations (for numerical analysis and modelling), geometry and topology (e.g. computational geometry or topological data analysis), or algorithmic number theory (for cryptography and data security) are a large component of DMS. A focus toward applied mathematics will also be fundamental to build up this research theme.

Modelling and Socioeconomics and the Environment

Modelling tools can be used to predict economy-wide performance and analyse its path toward achieving the United Nations Sustainable Development Goals by 2030. A tax-benefit microsimulation model for Luxembourg to better advise policy makers (and public bodies such as the "Chambre des Salariés") on the redistributive effects of public policies is being developed in a joint collaboration between researchers at the UL and LISER.

Machine learning algorithms, apps, and other computational methods are being developed at the UL to make predictions on the determinants of a successful individual life, to monitor and change health risk behaviours, to understand healthy ageing, epidemiology and public health or to optimise neurofeedback in the rehabilitation of cognitive function in stroke patients. DMS can also be employed to pursue research on the different forms of human learning and its determining factors. Tests and trainings used to enhance cognitive processes that rely on computational models and machine-learning techniques need to be developed.

Like the economy and the human body, Earth is also a complex system where water and air are in constant motion to balance the incoming energy from the Sun. Monitoring these constantly evolving patterns is fundamental for understanding the physical processes as well as for predicting short, medium, and long-term changes as global warming continues. Earth observation data are growing at an exceptionally fast rate due to existing and new satellite, airborne, and ground-based remote sensing systems. This component of DMS will steer the applications of data science to address new questions related to climate change.

Modelling and Digital Humanities

The fast-growing field of digital humanities does engage in many ways with the modelling of datasets for doing both empirical and theory-driven qualitative research. The mass digitisation of corpora (newspapers, manuscripts, audio- and video collections) and the flood of “digital born” sources ask for new methods of mining, analysing, modelling, and visualising digital data in the humanities and social sciences. The Doctoral Training Unit on “Digital History and Hermeneutics” and interdisciplinary collaborations between C²DH and Computer Sciences at UL prepare the ground for a more systematic investigation of the “trading zone” between sciences and humanities in the digital age.

Modelling and Finance and Law

Digital finance and FinTech are concerned with the implications of significant and abrupt changes brought about by digital revolution. Digitalisation has led to an unprecedented level of archived data, i.e. big data. The technological innovations in financial services are forcing commercial banks and other financial intermediaries to adapt. Hence, the UL sees the high potential to connect these fields to a new research focus in data modelling. The same applies to law, as modern legislative procedures are increasingly based on algorithms which can be particularly demonstrated by legislation within the legal framework of the European Union.

Table 6: Cross-disciplinary digital science, computer science, and data modelling and simulation themes and Faculties and ICs foreseen to be engaged in the theme

Theme	Contributors
Computer Science	FSTC, SnT
Digital Science	FLSHASE, FSTC, C ² DH, LCSB
Modelling and Materials Science	FSTC, LCSB
Modelling and Mathematics	FSTC
Modelling and Socioeconomics and the Environment	FSTC, FLSHASE, LCSB, FDEF
Modelling and Digital Humanities	FLSHASE, C ² DH
Modelling and Finance and Law	SnT, FDEF

Summary

In **Table 7**, we show how the resources from the 4YP will be distributed to the interdisciplinary topics by the Faculties and ICs.

Table 7: Resources requested by entity to be distributed to the cross-disciplinary topics discussed in this section. Values are in kEuro. (C²DH is in the excellence category in the previous section and is missing here.) CS = Computer science and digital sciences; DMS = Data Modelling and Simulation; LME Luxembourg Medical Education.

These figures are preliminary and an approval of the Plan does not imply their approval in detail, but only as a frame of action that will have to be adapted to the yearly budget of the University,

	2017	2018	2019	2020	2021
FSTC					
Health	381	3,071	3,286	3,501	3,710
CS	4,350	3,824	4,239	4,545	5,021
DMS	926	1,754	2,093	2,461	2,829
LME	0	1,775	1,866	1,960	2,042
FLSHASE					
Health	4,755	5,138	5,917	6,222	6,481
DMS	261	678	938	1,098	1,139
LCSB					
Health	10,355	10,810	11,324	12,006	12,733
SnT					
CS	5,130	5,313	5,354	5,354	5,404

Section IV. Advancing Learning and Teaching

Learning services promoting skills for the future

The UL strives to offer excellent learning and teaching environments to all its students. To this end, we will start a new initiative to further enhance our educational activities. The education initiative rests on five pillars:

Learning Centre

As a modern research university with a specific focus on digitalisation, the UL has the ambition to become an international leader for digitally enhanced innovative learning environments in the upcoming years. Having moved to a new campus with international visibility and with a new learning centre opening in 2018, the UL currently has a unique chance to benefit from this state of the art infrastructure in order to increase its international reputation. Additionally, the UL wants to become a lighthouse for digital learning in Luxembourg, coordinating its efforts with other national actors, especially in the field of secondary education. The Digital Lëtzebuerg initiative provides a very good platform for the coordination of these activities. The resolute and consistent use of the possibilities offered by digital technology benefits not only the experience of teaching, learning and working at the UL. It will also create opportunities for advancing administrative excellence or a smarter management of the UL infrastructure. The tools needed for this digital experience have to be developed in a professional manner and in alignment with the needs of the UL's complex user community. That is the purpose of the new Media and Digital Design Centre outlined below.

A close collaboration will exist with the usability laboratory of the FLSHASE and its Human-Computer Interaction (HCI) research group who will provide a large part of the scientific expertise needed for these systematic scientific inquiries. Furthermore, close links will be established with the existing e-learning activities in the Computer Science and Communications Research Unit. Among the research questions that will be addressed are the optimal design of learning environments, the added-value of digital collaboration tools, the optimisation of the environment for specific learning tasks, the potential added-value of game-based learning, of immersive technologies, augmented reality, and of location-based services. These questions will not only be studied with regard to learning environments for higher education. Experiments will also involve high school students and primary school pupils. The Learning Centre will thus become a national infrastructure to showcase the added-value of modern technology-enhanced learning environments.

As these activities are potentially of high interest and value for commercial developers of digital tools for educational environments, the UL seeks a privileged partnership with an international technology company. This partner would contribute to the funding of research activities and the Centre in the context of a public-private partnership. Furthermore, the Learning Centre will provide training for UL academic staff and for Luxembourgish teachers in the field of designing and efficiently using digitally enhanced learning environments. The funding of the Learning Centre is currently being discussed with different national stakeholders.

Media and Digital Design Centre (MDDC)

In order to achieve its ambitions, the UL needs a specific infrastructure that pools and develops the expertise that is needed for designing digital media in line with state-of-the-art learning models, be it in the form of blended learning, distance learning or collaborative digitally enhanced learning

environments. The UL will also use this infrastructure to design and partly develop digital tools for improving administrative efficiency and user-friendliness.

With the MDDC, the UL will therefore implement a technology incubation and service hub for the creation and support of teaching, learning, research, and administrative activities, contributing to the realisation of the University's digital strategy. The MDDC will:

- Serve the purposes of all UL actors;
- Leverage expertise in the field of educational media creation and design beyond the boundaries separating research, teaching and administration; and
- Address essential digital needs in the UL so as to augment capabilities for teaching & learning, for research, for managing the UL and its community, and for outreach activities.

The Centre will develop new and adapt existing tools and services to meet these needs.

The MDDC serves the whole university. At the same time, it emphasises research-based teaching and has therefore strong links to research on digital learning and user experience within FLSHASE and the C²DH) There are also links with other structures and facilities focused on the use or development of digital tools at the UL, such as the Service Informatique de l'Université (SIU), the web relaunch project of the communication department, the Luxembourg Centre of Educational Testing (optical mark and character reading lab, development of an online testing platform), the Media and Experimental Laboratory, the CS Research Unit, etc. The MDDC will be managed by a head of operations specialised in media creation and design for educational and administrative purposes. This head of operations will report to a Steering Committee in order to make sure that its university-wide mission be fulfilled.

The MDDC will closely cooperate with the Learning Centre as the main infrastructure to implement and showcase the digital learning environment of the UL, with the FLSHASE usability lab as the main research infrastructure for the study of user experience, and with the digital infrastructure and outreach groups of the C²DH.

The MDDC will also reach out to secondary schools in Luxembourg, in order to coordinate the digital learning strategy of the UL with the digital learning strategy of secondary schools in Luxembourg as part of the Digital Lëtzebuerg initiative. To this end, the MDDC will externally coordinate with the SCRIPT and the Lycée Technique des Arts et Métiers (LTAM) as privileged partners for Media and Digital Design with whom the UL runs a common bachelor programme in this area, which also opens possibilities for the use of shared infrastructures. The funding of this initiative is currently under discussion.

Fostering Transferable Skills as a Key Aspect of Tertiary Education Curricula

No curriculum can prepare students for the complete range of challenges they will encounter in the manifold and rapidly changing work environments of today. It is therefore more and more important, and by now widely recognised, that tertiary education must include the systematic development of transferable skills, i.e. the development of a set of generic skills that enables graduates (from bachelor to doctorate level) to adapt to rapidly changing social and economic environments, to assess their needs for acquiring new skills, to successfully solve complex problems in today's technology-rich, collaborative work environments. The UL will therefore create specific programmes that will complement its existing curricula in order to foster transversal skills in the complete student population and at all levels. These transversal programmes will focus on three domains: (1) Language skills as a transversal skill for communication in line with the multilingual character of the UL. To exploit this area, the UL's Language Centre will seek a close cooperation with the National Institute of Languages and extend its offer of linguistic learning opportunities for both students and staff. (2)

Digital literacy, from dedicated skills and competences such as coding abilities to mastery of data security challenges and the management of one's digital identity to leveraging technology-rich learning environments. (3) Entrepreneurial skills as a means to develop a large set of social and cognitive transferable skills, such as proactivity, presentation and collaboration skills, creativity, problem solving, time management, and leadership. The UL's entrepreneurial initiative involves local partners already active in the area of entrepreneurial skills training and/or the Luxembourgish entrepreneurship ecosystem. It features practice-focused workshops, the setting up of a venture mentoring programme addressing all students as well as a student-centred incubator.

Attentiveness to contemporary challenges and readiness to apply acquired skills to complex problems requires an open mind accustomed to coping with diverse perspectives and able to integrate expertise from a variety of disciplinary and interdisciplinary origins. This is why the UL, as part of its transferable skills initiative, works towards opening its curricula to content from other disciplines, and encourages inter- and transdisciplinary courses. The aim is to offer a learning environment that exposes students to alternative perspectives, that facilitates encounters with other disciplinary backgrounds and with the outside world, and that hones students' judgment on how best to bring their knowledge and skills to collaborative problem solving.

Fostering Lifelong Learning Activities

In today's rapidly changing work environments, a good part of the knowledge and skills acquired during initial training will quickly be outdated. For this reason, it is eminently important that institutions of higher education provide continuous training and lifelong learning opportunities. Such a perspective on lifelong learning necessarily focuses on the professional context and thus asks for a closer collaboration with corporate actors in Luxembourg. The UL will therefore create a lifelong learning institute that will be attached to the UL, but in a legally separate structure. Lifelong learning opportunities that are tailored to the needs of the Luxembourgish economy, while at the same time responding to rigorous quality standards will be developed.

Integrating and Coordinating the Learning and Teaching Activities of the UL with the Education Sector in Luxembourg

The new LC and MDDC are designed to provide a national infrastructure that offers technology-rich learning environments and showcases their potential added-value for learning at different levels. Both Centres are scaled such that they can serve not only the University, but a range of educational actors in the country. The UL will leverage its position as a research university in Luxembourg to develop research activities addressing the question of the optimal design of new learning environments. With the MDDC, the UL will create a service hub that uses educational insight and design expertise to bring learning environments alive while filling them with content. One important aspect is the provision of learning platforms that allow the whole UL and other educational actors in the country to share content, tools, and courses, and make them accessible to a broad range of learners on-site and off campus. Being a small country, Luxembourg cannot afford educational compartmentalisation. Capitalising on technological advances to pool resources not only expands the reach of individual educational providers. It also makes learning more effective, as it gives learners access to learning opportunities that fit their needs, thus allowing them to acquire the skills that matter to them. As facilitators for learning, educational research and design, the two new Centres will act as living laboratories for the benefit of learners and the educational sector of the Grand Duchy. By concentrating important infrastructural and material investments, and connecting them to available expertise, this strategy optimally exploits economies of scale for the benefit of a variety of stakeholders from the field of education in Luxembourg.

Quality assurance in teaching and learning is presented in **Section VIII** Quality Assurance.

Accreditation Strategy

The UL is committed to offering high-quality education to serve its students, the Grand Duchy, and the Greater Region. Quality assurance at the UL motivates, supports, and gives credit to the efforts of UL's academic community to live up to this commitment. In order to document and certify the quality of its education to its stakeholders, the UL has set itself the objective of obtaining international accreditation as part of quality assurance in teaching and learning. During the next 4YP, the UL will seek external accreditation of at least eight study programmes.

Parallel to these programme accreditations, the UL will invest in the preparation for system accreditation, by building up a university wide system for the periodic review and systematic monitoring of study programmes and the academic administration that meets European and international standards for quality assurance in higher education. As quality assurance is a joint responsibility of the Faculties and the central administration, accreditation costs will be shared, with Faculties leading programme accreditations, and the Office of the Vice President for Academic Affairs being in charge of coordinating the system accreditation process.

Table 8: Estimated costs for accreditation (kEuro). (QM = Quality management required in Central Administration (CA) to support this effort)

These figures are preliminary and an approval of the Plan does not imply their approval in detail, but only as a frame of action that will have to be adapted to the yearly budget of the University.

	HR			Other OPEX	Total
	CA	Per Faculty	QM staff		
Programme accreditations¹	65	82	157	150	454
Preparation system accreditation²	541	267	731	518	2,057

¹ Estimated costs for the accreditation of 8 study programmes over the next 4YP, 2 per Faculty and 2 vocational training/lifelong learning programmes.

² Includes costs for setting up an internal evaluation and monitoring procedure, for data management, information systems, and documentation, and for improvements of the academic administration and support services.

UL Students

For the academic year 2016/17, 6,153 students enrolled at the UL. Of those, 50% belonged to one of 11 Bachelor programmes, 25% to one of 45 Master's programmes and 10% were doctoral students. The remaining 15 per cent of our students have taken up training as part of the UL's 16 vocational and lifelong learning programmes.

The UL has sustained a steady expansion of its student population at the Master and PhD levels, where it now attracts well-qualified, national and international graduates. Over this 4YP, the UL seeks to further strengthen its attractiveness to the best-performing students by introducing more targeted and selective admission procedures.

Young Luxembourgers with a secondary school degree have traditionally been highly mobile.¹⁴ The UL aspires to offering quality bachelor degree programmes that represent a serious alternative for the top high school graduates of the country particularly for study programmes that have strategic importance to Luxembourg. To this end, the UL will use the 4YP to push for innovation but also a further consolidation of its Bachelor programmes.

An education at the UL is academically challenging but also personally rewarding. Efficacy in learning, ownership, participation, and a sense of belonging to a vibrant academic community are all part of the study experience the UL aspires to offer. Making this a reality includes a student-centred campus development, creating innovative learning spaces alongside opportunities for student initiatives, academic exchange and social encounters, for cultural activity, sports, and leisure. Empowering our students means systematically including them in university governance, institutional development, and quality enhancement. But it also means providing them with the necessary infrastructure and human resources. The opening of the “Maison des Arts et des Etudiants” combined with the provision of resources for student-driven initiatives will play a central role in this context.

With a new system of student representation that foresees elections of study programme representatives at the beginning of each academic year, the UL guarantees that students take part in decision making and shaping the future of their university at all academic levels – turning the UL into a place of learning *by* and not just for students. Student representation also implies making the individual student, with his/her talents, ambitions, and expectations the touchstone of educational success. Complementing curricular learning with systematic tutoring and advising that supports holistic student development has always been a priority at the UL. This holistic approach to student involvement and development is to become a trademark of the UL curriculum; and with the next 4YP the University will take important steps towards this goal.

A UL education does not end with graduation. The University cares about the professional future of all of our students, and we try to enhance their possibilities for employment from the day of their arrival. For the UL, employability means fostering skills that matter for a lifetime. The transversal skills initiative described above is testimony to this conviction. The creation of an out- and forward-looking study environment that maintains strong links into the world of work and production is another cornerstone of the UL’s employability strategy. That is one reason why the UL equally cares about its alumni. Over the next 4YP, the University’s new Alumni Officer will work closely with our Employability Service and Entrepreneurship initiative to build up an active network of former students, employers, the entrepreneurial ecosystem of the Greater Region as well as cultural and social actors, in an effort to create springboards for successful careers and to energise the UL education with real world perspectives.

The Institutional Evaluation Programme recommended “that students should be supported and incentivised to organise clubs and societies on topics of interest to themselves, and that the university infrastructure be made available for this”. Toward this end, we will provide the students with funding for this purpose. We will provide a budget of 100 kEuro/yr.

¹⁴ cf. for example OECD (2016), Education at a Glance 2016: OECD Indicators, OECD Publishing, Paris, p. 62.

<https://www.oecd.org/education/skills-beyond-school/EAG2016-Annex3.pdf>

Vacataires

For the Winter-Summer semester of 2016, the cost of vacataires was 4.4 million Euro (salary plus travel). This cost in and of itself is high but acceptable under the conditions 1) that there is a real demand/need for those study programmes and 2) that all teaching staff at the UL (who are expected to teach 180 hours/year) actually teach their full load. As part of a larger initiative to evaluate all study programmes in terms of student numbers, graduate numbers, and employability, we will carefully investigate whether it is possible to reduce the cost of our 'vacataires' expenses and determine whether reasonable policies are in place to prevent any abuse of the system.

Doctoral Education

Doctoral education is a fundamental component of the UL research productivity and impact. The objectives of doctoral education are to improve the general quality of the training and support offered as well as enhance doctoral candidate employability. At any one time, the UL hosts about 700 doctoral candidates (DC). The number of DC who have completed and defended their dissertations since 2014 are shown in **Table 9**. The jump in enrolment in 2017 is due to the success of the FNR's PRIDE funding instrument. Note that a new PRIDE call will be released in the Fall, 2017. Please note that the numbers for 2017 represent the numbers up to the end of June, 2017.

Year	Enrolled for the first time	Defended
2014 (End of Year)	119	83
2015 (End of Year)	153	121
2016 (End of Year)	154	120
2017 (End of June)	126	75

A large part of the publicly supported research output in Luxembourg is performed by doctoral candidates. Thus, doctoral education is important to Luxembourg. Among Luxembourgish institutions hosting doctoral candidates, only the University has the right to award PhD degrees. To improve national collaboration in doctoral education, in October 2016 the heads of all the public research institutions signed the Collaborative Agreement on Doctoral Education. In the agreement, the contracting parties determine the way in which research projects required for the doctoral degree are carried out by the non-university institutions together with the university. Still being the sole degree-awarding institution, the University of Luxembourg remains responsible for the verification/validation of academic standards of doctoral training, but the supervisors for PhD projects within the framework of the cooperation can now also come from the other research institutes.

Over this 4YP, the UL will build on existing efforts to further develop and cultivate a common vision of doctoral education and training. We will offer better administrative services (a pilot as part of the University of Luxembourg Unified Services (ULUS) run by the 'ServiceNow' tool) to both candidates and supervisors in the admission and enrolment of candidates and monitoring of the evolution of candidate's progress; we will strengthen the existing quality assurance mechanisms; and we will introduce greater and more systematic personal development planning as part of the services available to doctoral candidates.

The next steps in this strategy include

- Ensuring that all doctoral candidates are enrolled in and benefit from the opportunities (in the form of training and exchange) afforded through doctoral schools and programmes;
- Continually updating regulations and key procedures in line with “best practices”;
- Streamlining and automating administrative and candidate progress monitoring;
- Building a data set of robust information on candidate satisfaction, graduation/attrition rates, graduate employability, and career tracking, as well as other indicators;
- Expanding transferable skills course offerings and further tailoring career readiness planning and activities; and
- Building links to our alumni.

Centrally, the Office of Doctoral Education (ODET) receives about 65kEuro (value in 2016; 2017 value is caused by accounting issues) to organise skills training for all DCs. The current staff in the ODET equal 1.5 CDD; both are working on developing the training offerings and administration. In 2018, we ask that both positions be converted to CDIs and that the 0.5 FTE be increased to 1.0 FTE. The ODET’s Office of Administration, responsible for admission and progression tracking of the DCs, currently has 1.8 FTE. We have asked for 1 FTE in 2017 (staff mobility) to handle the increase in DC. The required new resources are shown in **Table 10**. Increasing the human resources to the group will insure sustainability of the team. Additional funding is required to cover the cost of new skills courses that will improve the employability of our graduates.

The biggest effort in Doctoral Education over this 4YP will be consolidating the governance of doctoral programmes under one single doctoral school. The justifications for a consolidation are to insure 1) that all doctoral students are enrolled in a doctoral school; 2) that all students receive the same benefits for professional travel (meetings or stays with collaborators) and training (e.g. summer schools); and 3) the ODET would be able to negotiate directly with the FNR for travel and training support. Currently, each FNR AFR funded DC already receives 2000 EUR for travel and 6000 EUR for training and mobility. For the PRIDE DCs, a lump sum of 8500 EUR/per student of salary costs is paid to the DTU in order to pay for training and other DTU direct costs. Only 30-40% of our DCs are not funded by the FNR.

A concrete plan for this consolidation will be developed in 2018 in close cooperation with the Deans to ensure that the Faculty interests are respected.

Table 10: Annual Costs of Doctoral Education (kEuro) (Current and needs over the P4); Only new positions are listed. To be clear, we are asking that the 1.5 CDD become CDI.

These figures are preliminary and an approval of the Plan does not imply their approval in detail, but only as a frame of action that will have to be adapted to the yearly budget of the University.

Initiative	Annual Cost		FTE	
	2017	2018-2021	2017	2018-2021
Transferable skills courses ²	260 ¹	130		
National DC welcome day	15	15		
Vitae researcher development framework/toolbox - subscription (cost shared) and RDF Planner	0	10		
Coordinator			1 CDD	CDD => CDI
Admin. Support			0.5 CDD	1 CDD => CDI

¹Originally allocated 65 kEuro for 2017; Unspent budget for Gender in 2016 moved to DE for 2017.
²All training, ULLA, Gender Leadership, Doctoral education to be optimised to avoid duplication

Luxembourg Plan for Medical Education (LME)

The provision of sufficient numbers of medical doctors (general practitioners and specialists) for the rapidly growing and diversifying population of Luxembourg will be a challenge, especially in view of the ever increasing average lifespan.

For Luxembourg and its public decision makers, it is of utmost importance to provide sustainable solutions to the new needs in the field of healthcare that would necessitate the involvement of many actors. The UL is ready to play its part and contribute to the success of this national endeavour by considering to include medical education in its academic curricula. Medical education fits into the UL's scientific profile and long-term strategy. The development plan will follow the document "Medical Education in Luxembourg" approved by the Board of Governors on 10-12-2016.

The initiative for medical education at the University of Luxembourg has been translated into a sequential implementation plan by the government to start medical education in 2018. In March 2017, Ministers Marc Hansen (Higher Education and Research) and Lydia Mutsch (Health) presented the degree in medicine and two specialisations to the members of the relevant two parliamentary committees. This bachelor's degree in medicine will be taught in close cooperation with other universities, for the time being an agreement already exists with the University of Strasbourg and the University of Lorraine, but provisions for other agreements, e.g. with universities in Germany and Belgium, have been made.

In addition to the three-year university curriculum, the initiative foresees the creation of two new specialisations (expected to begin in 2019 once the legal framework required for the teaching is finalised) one in neurology, which will also include neurosurgery and psychiatry, and the other in oncology. For the moment, Luxembourg offers only a specialisation in general medicine. With a greater specialisation offering, it is hoped that medical students who have completed their studies, will choose to return to the Grand Duchy to do their specialisation.

Launch of the Specialisation Programme

Specialist training will be coordinated by UL and will include both courses at UL as well as hands-on training in hospitals and at general practitioners' private practices. An educational programme will be implemented that explicitly requires dedicated time for integrating research training up to 18 months, offering an advanced career track that combines the specialisation with a PhD. IT competency is

another important component to train doctors familiar with biomedical IT, including electronic patient records, device-based assessments and decision support systems guiding diagnosis and therapy.

The planning and practical implementation of such programmes requires individuals who are responsible for representing the different specialties involved to drive the ambitious profiles and mobilise all relevant stakeholders. Recruitments have to be made for leading these programmes at a professorial level and with excellent competences in state-of-the-art pedagogical training in clinical medicine.

Establish a Bachelor Programme in Medicine

The development of a full curriculum for the Bachelor in Medicine needs to start immediately. The curriculum will place a strong emphasis on interdisciplinary competences in molecular biomedicine, systems approaches, biomedical informatics and other skills that will be required for personalised medicine in the future. Early exposure to clinical applications and training will be provided through modern pedagogical concepts. The aim will be to develop “vertical” training based on 4 key principles: student-orientation, patient-orientation, system-orientation and competence-orientation. This broad interdisciplinary education will allow students to either continue with medical training for a Master in Medicine or to pursue a research track in biomedicine.

Organisational Implementation

The Ministry has earmarked a budget for the specialisation in the above-mentioned priority areas and the preparation of the Bachelor. A roadmap and corresponding budget plan for the specialisation and the bachelor programme will be developed accordingly, as well as the structural implementation. The practical implementation of the medical education will require an immediate roll out of the following activities:

- Adaptation of staff categories and career schemes for physician scientists and corresponding legal implementation on the UL level (Law and internal regulations (ROI));
- Definition of the contractual framework for medical doctors entering the specialisation programme (hybrid-contract; ROI, convention with hospitals in Luxembourg);
- Implementation of a PhD option for physician scientists, allowing achievement of the degree within the contractual framework specialisation programme (ROI);
- Career perspective after accomplished specialisation training in the (academic) hospitals in Luxembourg (assistant professor, associate professor);
- Creating training curricula in the participating clinics and private practices to ensure that rotation principles allow for the mandatory research training for doctors during the specialisation training;
- Development of access criteria and selection mechanisms for medical education;
- Negotiations with other universities to enable seamless continuation of education of students coming from a bachelor degree in Luxembourg and that reassure a modern Master’s programme according to the research priorities of the Luxembourg medical education. Ideally,

the concept would entail that part of the Master's training can also be provided in Luxembourg in the prioritised specialisation areas;

- Change management from existing programmes with a Bachelor in Biology and a first-year medical training towards an integrated programme for a Bachelor in (Bio-)Medicine that allows both further training in Medicine or a research career in biomedical sciences;
- Development of a resources plan reflecting the ambitious training programme and a corresponding recruitment plan; and
- Development of a profile for a future Director should medical education evolve towards a fully-fledged medical school covering a full curriculum including at the master's level.

Section V. Gender

National Platform for Gender: Shared vision of the UL, FNR, and Lis

“Gender equality is at the core of European values and enshrined within the European Union (EU) legal and political framework. The EU and its Member States are at the forefront of the protection, fulfilment and the enjoyment of human rights by women and girls and strongly promote them in all external relations, also beyond development cooperation.”¹⁵

The Luxembourg research community (the FNR, the UL, LIH, LIST, and LISER) is keenly aware of the difficulty of hiring qualified women researchers and promoting them into leadership positions. (There is also an issue around men who are underrepresented in some research areas.)

To increase the competitiveness of Luxembourg’s economy we need to optimise the country’s human resources and make full use of its potential. Clearly, gender equality is indispensable for reaching this goal in science and academia. Thus, the UL will seek to contribute to increasing the participation of women in research and higher education in Luxembourg.

To improve the situation, the UL together with its partners will first look to collect scientifically sound information on female and male researchers who have already left or who are planning to leave academia and research.

In addition, all Luxembourg-based institutes will offer gender and diversity awareness training. At a minimum, this kind of training should be required for anyone reviewing proposals, anyone sitting on search and selection committees interviewing and hiring new academics or researchers, and anyone who has any contact with students.

Strong commitment from institutional leadership at the UL and its partners will promote a culture in which administrations understand that diversity contributes to excellence and will actively communicate this view inside and outside of the institution. UL leadership is also responsible for transforming the institutional structure and culture so that targeted recruitment, retention, and promotion of women are goals that are seriously pursued.

The UL and its partner institutions will collectively offer continuing professional development programmes explicitly designed to prepare female researchers and academics for leadership positions. They will continue to develop family friendly policies, e.g. lab assistants to protect pregnant or lactating researchers from their labs, breast feeding rooms, awareness of temporal gaps in women’s employment history for family reasons, telecommuting, job search assistance for partners, and even working between institutions to accommodate the trailing spouse in a dual-research couple with an acceptable research position.

The FNR and the Luxembourg Government must also demonstrate strong support for gender equality through promotion, and tie institutional funding to gender equality plans. In addition, the FNR could increase the participation of women in science by having opportunities only for women researchers, e.g. ADVANCE NSF.

Our goal is to increase the participation of women in research and higher education in Luxembourg.

¹⁵ [europa.eu/rapid/press-release MEMO-15-5691 en.pdf](https://europa.eu/rapid/press-release_MEMO-15-5691_en.pdf)

For the UL, we will develop a Gender Action Plan and start a programme to provide leadership training to women at the UL. To support administrative activities, we foresee a need of 0.50 FTE.

Table 11 : Annual resources for Gender initiatives over the 4YP (kEuro)		
<i>These figures are preliminary and an approval of the Plan does not imply their approval in detail, but only as a frame of action that will have to be adapted to the yearly budget of the University.</i>		
Initiative	Annual Cost	
	2017	2018-2021
Leadership Course for 10-15 women ²	--	40
“Leaning into Research”	--	10
Other	--	20
Total	0 ¹	70
¹ Unspent budget for Gender in 2016 moved to DE for 2017. Budget in 2017 used to cover other UL commitments ² All training, ULLA, Gender Leadership, Doctoral education to be optimised to avoid duplication in training.		

Section VI. Exploiting Results and Enabling Technology Transfer

Technology transfer (TT) is the process of commercialising ideas or technologies. This transformation can take place through a number of means, in particular through the collaboration between research organisations and industry, the licensing of intellectual property rights, the creation of start-up businesses or university spin-out companies. Hence, the ideal technology transfer value chain actively bridges the “two worlds” of academic to industry-scale research launching of new services and products. In order to achieve this in the most efficient and impactful manner, the following activities and support services are considered as central elements of the value chain and need to be performed in an organised and well-concerted manner:

- Early education and training of staff to raise awareness for intellectual property issues, technology valorisation, innovation, and entrepreneurship;
- Early technology scouting within research groups for new valuable IP and promising technology developments;
- Protection and maintenance of IP including building up of IP portfolios;
- Relationship and contractual management with industrial collaboration partners, clients, and licensees;
- Development and support of proof of concept studies; and
- Spin-off support, investor relations and other fundraising activities.

It is among the UL’s central missions to disseminate knowledge and exploit research results (Art 2 law of the 12th August 2003¹⁶) and four of our key performance indicators (KPIs) refer to the output of Technology transfer and innovation (number of patents, licenses, and spin-offs; amount of revenue created through TT activities). The UL considers potentially exploitable intellectual property (IP) to be a valuable asset that should be protected and valorised in the most effective way, so that it reaches the market place to ensure the highest possible socio-economic return. Any potential financial return enjoyed by the University will be employed to the highest possible extent to further support and nurture innovation and entrepreneurial activities, and to incentivise the UL inventors.

Consequently, the technology transfer offices (TTOs) at the UL were founded to grow the entrepreneurial spirit in our researchers, to organise the protection of IP, to transfer new technological approaches to industry, and to facilitate the early-stage financing of transfer projects. The TTOs develop connections with Luxembourgish and international industry to help take scientific results from concept to commercial exploitation.

TTOs currently exist within the SnT¹⁷ and the LCSB¹⁸. FLSHASE and the FSTC are asking for additional funds in this 4YP to develop their own TTOs. Currently we also have a TTO in the Central

¹⁶ https://www.en.uni.lu/university/official_documents (see Loi du 12 août 2003 portant création de l'Université du Luxembourg)

¹⁷ https://www.fr.uni.lu/snt/technology_transfer_office

¹⁸ <https://www.en.uni.lu/lcsb/innovation>

Administration¹⁹. Due to the increasing demand for technology transfer support at all stages in the Faculties and, even more prominently, in the Interdisciplinary Centres, the overall TTO workforce has substantially increased, (with the help of third-party funding) to approximately seven FTEs in 2017 compared to two FTEs in 2013. Given the variety of tasks ranging from early technology scouting at the research group level over patent management to investor relations, and the diversity of research and development topics pursued at UL, this workforce will have to be further substantially increased in the next years both in the Central Administration as well in the Faculties' and ICs' TTOs in order to be able to match the envisioned quality and efficiency of TT activities at UL.

The UL strives to develop its technology transfer services so that all of the services in the technology transfer value chain (see above) are available for all UL staff members. The educational and training measures will become mandatory for all academic employees to increase the efficiency in awareness building and to build up truly innovative and entrepreneurial environment in and around UL. Close and trustful relationships between researchers and TTO staff are supposed to become a normality at UL and will allow to valorise the as yet unexploited research projects and IP with socio-economic potential and to further nurture innovative and entrepreneurial mind-sets in our researchers by building role model examples and promoting best practices.

Initial entrepreneurship-building activities at SnT and LCSB have proven the high yet untapped potential of an innovative mind-set and interest in socio-economic impact of research within the Centres' staff. The backward-looking, traditional way of conducting research for its own sake and merits has already shifted so that it has become common to ask questions like: "what could be the value of our research for society?" or, "is there a potential practical application of what is done in the lab, which goes beyond publishing the results in an academic journal?" the UL is on its way to helping to shape a new generation of researchers whose ambition to do excellent research is enriched by the desire to have a positive impact on the economy and to give something back to the society, which nurtures them and puts trust in their abilities and research vision. Several projects in the field of entrepreneurship training, mentoring, and start-up support have been recently submitted to the FNR for funding. In case funding will be granted, these projects will strongly enrich and support the still limited on-going activities in these areas and substantially help to achieve our vision.

Technology and IP scouting within research groups is planned to become a streamlined and regular activity of dedicated TTO staff with field expertise residing within the Centres and Faculties. These activities will help to identify and make use of research projects and IP, which are currently not yet valorised.

In case the UL IP or promising projects cannot be out-licensed or attract the strong interest of a potential start-up team (UL staff or beyond), the UL endeavours to become a hub to bring such projects to the next technology readiness levels, with the ultimate goal of reaching the market. The TT offices at the UL are already the main contact points for such activities and aid researchers in developing proof-of-concept projects (either FNR-funded or through other means) as well as attracting investors

¹⁹https://www.en.uni.lu/universite/presentation/organigrammes/organigramme_rectorat_administration_centrale/technology_transfer_office

to facilitate the ultimate spinning-off of the technology into a dedicated start-up business. These activities play a crucial role in developing an innovative environment around the UL, which in turn will create new possibilities for collaboration, career options, and role model success stories. On top of this, the UL's international visibility as a strong contributor to socio-economic growth will be enhanced. In the next years, the UL strives to further strengthen these activities and to build capacities both internally and in collaboration with external partners to provide space, mentoring, and initial funding to nurture promising projects and their teams in the early development stages up to the point of start-up creation. However, the UL will actively seek to keep the closest possible contact to its spin-off companies and offer paid, arms-length services to continue potentially necessary and crucial mentoring and business development support.

Taken together, technology transfer is supposed to become an intrinsic, central, and vital activity at the UL, which will be a major pillar in developing UL's excellence, societal impact and international visibility.

Section VII. Developing an Efficient and Transparent Administration

Central administration's mission is to support all members of the UL community by offering them services that allow them to efficiently carry out their teaching and learning, research, and outreach missions. UL staff members committed to efficient administration share values including excellence, integrity, and focus on end-user satisfaction. Key skills include leadership, transparency, collaboration, project planning, and management. Today, international standards in the best higher education administrations include user-facing administrative services, advanced and uninterrupted IT, and transparent and continuous accountability for all stakeholders.

In the last 4YP, funding priority was given to growing research and teaching staff and study programmes. Due to the rapid growth of these activities, central services had to grow quickly to keep pace with the increasing requests from staff, students, funding bodies, and the ministry. Both recent institutional and research evaluations highlighted the need for increased administrative efficiency by defining processes, developing tools, and improving transparency. The UL administration in its current status must place renewed focus on a service-oriented approach.

Improving the service-oriented approach can be achieved by fostering cooperation, teamwork, and sharing information between the central administration and Faculties and ICs. Over this 4YP, the various services and offices in central administration will undergo a series of transformational programmes.

The recommendations formulated in the institutional evaluation and the analysis performed by the UL's management and transformation team outline the priorities for transforming the UL's administration:

- Increase strategic planning and enhancement of financial management, i.e. increase the transparency in the budget process (allocation, monitoring, and forecasting), regular use of IT tools to plan and respond to user needs and maintain control over spending;
- Make reliable data and expert analysis of such data available as a basis of sound decision-making and reporting;
- Define clear performance indicators that are trackable with archived data;
- Define processes and standard operating procedures and define roles and responsibilities in administration and in administrative processes;
- Improve transparency of decision making;
- Map individual and group competences throughout central administration and subsequently correct inequalities by fairly allocating human resources;
- Develop clearly structured communication flows, both bottom-up and top-down;
- Leverage the SAP (ERP) tool to enable the best use and allocation of resources (now used for manual workarounds); and
- Offer continuing professional development training to improve the skills of current staff.

The overall aim of the above-mentioned actions is to reduce the administrative burden on research and teaching Faculty, students, and administrators.

Below, we detail the areas prioritised for change over this 4YP. These areas are budgetary planning and controlling, information technology and digitalisation, site development, safety and security services, and human resources. We briefly discuss these areas here.

Budgetary Planning and Controlling

The overall aim of budgetary planning and controlling activities is to develop processes, skills, tools, and systems to ensure that accounting is efficient and accurate. At a minimum, the UL will seek to produce a precise overview of the expenditures and commitments on a monthly basis. To accomplish these goals, several actions will be undertaken:

- Assess and redesign the process workflows in the finance and accounting department (SFC), and coordinate these with HR, IT, and purchasing;
- Develop an analytical accounting system that will allow the university to: 1) standardise entries into the ERP system; 2) analyse expenditures; 3) manage contracts efficiently; and 4) perform a reliable and trackable inventory of assets (UL will need to adapt its policies in these areas in order to comply with international standards);
- Develop and implement a reliable reporting system that monitors and controls operations;
- Keep track of all financial commitments (personnel, OPEX, e.g. from agreements, etc.); and
- Define and carry out an annual and strategic budget planning process.

Four key components are necessary to achieve these objectives:

Develop an Office of Controlling

This office is required to continue the detailed work begun in 2017 and required to maintain a coherent and efficient tracking of expenses. The office had been recently established with existing personnel. We will review the requirements to further develop and organise this office with the goal being to guarantee the quality and accuracy of control-related tasks for central administration and the units.

Establish a Procurement Office

A sound procurement policy will guarantee efficient management and use of UL funds. Over this 4YP, a model of mixed centralised and decentralised purchasing system will be put in place under the Director of Administration, with the goal of reducing costs and improving efficiency, while ensuring supplier quality and performance. We will hire a procurement manager in 2017, and the various policies and procedures and processes will be developed. The set-up of these processes will also enable the University to perform an accurate management of the UL's inventory. This initiative will have no impact on the 4YP budget.

Improve contract management

A coherent contract management system will be critical for improving overall financial accounting. The goal over the next four years is to: 1) develop a reliable contract management database; 2) create a 'How To' and best practices manual; and 3) develop an automated warning system (e.g. for contract expiration or changes).

Improve SAP

Please refer to the discussion in the Information Technology and Digitalisation section below.

Information Technology and Digitalisation

The IT infrastructure and related services are fundamental to enable all people at the University to work more efficiently. The UL aims to become an internationally-leading university in digital sciences, and sees the digitalisation of all processes and workflows across administrative offices and services as fundamental for reaching this objective. Specific plans tailored to every department involved in digitalisation are currently being drafted.

The major activities over this 4YP will focus on the following:

- Extension of the IT infrastructure to adapt to the growing needs of the UL;
- Regular revision of IT budget management consisting of: set up of mechanisms for cost controlling, clear business cases for investments, and formal reviews with approval gates;
- Completion of the implementation of the SAP ERP system: Since 2013, the University has been working on the design and implementation of the SAP ERP to streamline its processes. To date, SAP has been used for some HR and Finance tasks, with a sub-optimal result. An SAP audit performed by an external consultant has shed light on what actions are needed in the near future regarding ERP developments to enhance the system. A precise cost analysis will be undertaken in 2017. This additional investment will require funds on top of the projected 4YP as currently reported in the relevant budget tables;
- Implementation of a unified system for managing service requests and execution, along with the restructuring and redesigning of all associated processes. This concept, the ULUS (University of Luxembourg Unified Services) run by the 'ServiceNow' tool, will make UL services more efficient and transparent;

Table 12: Resources to support SAP and ULUS in the 4YP (kEuro)

These figures are preliminary and an approval of the Plan does not imply their approval in detail, but only as a frame of action that will have to be adapted to the yearly budget of the University.

SAP Run	7,760
SAP additional module	1,690
ServiceNow	4,000

- Compliance with the new data protection requirements: the European General Data Protection Regulation went into force in May 2017 and defines the need for much higher control and documentation of data access and processing.

The UL IT systems urgently need a back-up storage system and a disaster recovery system. These needs are under revision at the moment and therefore not covered in this 4YP; they represent an estimated total investment of 5.7 Million Euro.

Site Development

Management and maintenance of the UL's premises are crucial to facilitate the smooth functioning of the UL's principal missions, teaching, research, and outreach.

Given the current budget constraints, some projects are under review. However, there is a clear commitment to keep up with the UL's development needs in terms of space and infrastructure. The sustainable and efficient use of UL space and infrastructure requires clear communication and clear decision making by all stakeholders: Government, University management, and the users of the space.

Implicit in this effort is a good working collaboration with the Fonds Belval and a formalisation of the terms and conditions. Several contractual arrangements still need to be negotiated with the Fonds Belval to develop synergies with the UL. These negotiations cover many aspects of the Belval site (maintenance, landscaping, cleaning, security, etc.) where collaborations would optimise the allocation of resources and activities. The aim is to finalise such arrangements by the start of 2018. In order to do so, the rights and responsibilities of all partners will be analysed and agreed upon. Namely, a specific analysis will be undertaken to assess the cost of tasks covered by the UL under the frame of the project "Autonomy Belval" in 2016.

Health and safety for people working and studying on the UL campuses need to be guaranteed, including research safety. Over the course of this 4YP, the UL will review its safety policy and ensure that safety standards at the highest international levels are rigorously applied and communicated across the University.

Human Resources

People are the University's most valuable and most strategic resource. The UL will work to further improve staff working conditions and motivation by delivering innovative HR programmes and strategies to continue growing the UL into a world-class university.

Personnel costs represent a significant portion of the University's budget; the 4YP priorities will focus on using funds dedicated to personnel in an efficient and predictable way, by monitoring headcount evolution.

The UL is in the process of finalising an analysis of the impact of shifting from an age-based remuneration system to a job seniority-based remuneration system. This approach has already been implemented in other public research institutes in Luxembourg. During the first year of the 4YP plan this approach will be evaluated also for the UL personnel, with the aim of signing a collective bargaining agreement with the staff delegation. We are also developing plans to provide additional pension schemes to our researchers (RESAVER).

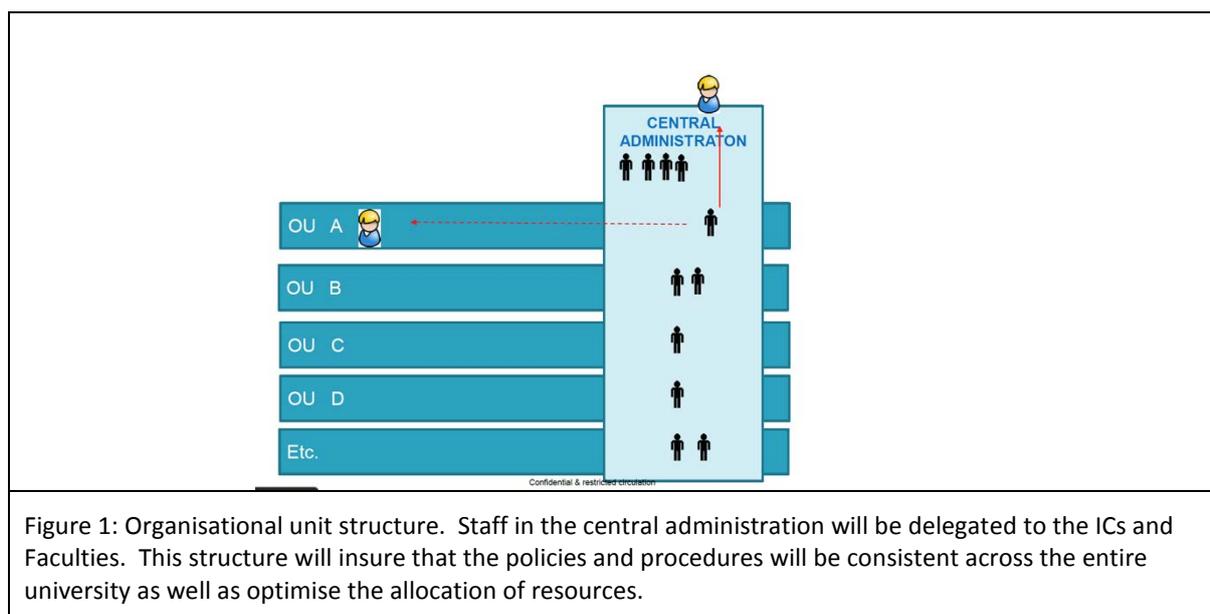
The UL will further improve: (a) the workplace environment, focusing on the level of flexibility given to employees, (b) feedback, centering on measurable standards (such as written evaluations and other resources provided to employees); (c) management relationships, focusing on managers' influence on the performance of employees; (d) barriers in the workplace, examining internal and external sources that impede performance; and (e) recruitment/promotion strategies, focussing on the organisation's compensation incentives.

The UL will enhance strategies (health promotion, training) that provide a positive assortment of motivational tools and opportunities.

An initiative to offer Continuing Professional Development courses to all Staff CPD is discussed in **Section VIII**, Quality Assurance.

Organisational Units

The concept of organisational units was discussed at the 2017 strategic retreat of the Board and the Rectorate as a way to optimise resources while also guaranteeing compliance with UL policy, branding, and procedures (Figure 1). There are job profiles within the Faculties and ICs that duplicate the efforts of staff in Central Administration. In some cases, it may be justified to have a duplication of profiles if the work load is such that more than one individual is needed to handle the work. In all cases, there must be a tie to central administration to ensure that the UL brand, procedures, and policies are consistent throughout the UL.



The Service for Human Resources was the first to create the concept of ‘HR Partner’. This concept works extremely well, and it consists in ‘dispatching’ professionals into the Faculties and ICs to closely work with them in matters such as recruitment and talent management matters, and in aligning them and the Central Administration on new procedures. The Research Service also has a central and satellite presence so that procedures are consistent, and the assistance to researchers is where it is most needed, i.e. Faculties and ICs. But there are other administrative functions that have a central and a decentralised representation that could benefit from an organisational structure that ensures compliance and reduces duplication of effort.

The areas that we will attempt to restructure in this way include communications, finance, controlling, doctoral education, quality assurance, technology transfer, and procurement. We will further prioritise to which tasks we will invest our internal expertise and manpower and those which could be sub-contracted to realise savings.

Communication

The marketing and communication teams within the University have evolved over the last thirteen years from a small central team of three people in 2004, to a central team of six and a decentralised team of sixteen (across the Faculties, Centres, and central services in 2017). There are two issues concerning communication in the 4YP: 1) how do we optimise resources so that our communication team is responsive to the university’s needs and 2) how do we define our communication strategy.

Strategy

Communications Offices have, until recently focused, on raising credibility with a strong emphasis on media relationships (e.g. print journalists and technical writers). To date the UL has a traditional, print oriented approach covering activities such as press, PR, events, advertising, corporate and student marketing, fundraising, international relations and outreach. Web and social media are secondary channels.

In the immediate future, the UL must migrate to a digital strategy. The UL’s goals are 1) outreach and 2) attracting the best researchers and students who are digital natives accustomed to smart devices as

their primary channel for communication. To achieve these aims, the UL must invest in digital communication experts and embrace technologies based on robust user experiences.

The digital strategy should also include a new dynamic website for the UL. In this 4YP, we have budgeted for a “face lift” (see **Table 13**). However, to support our image as a modern digital university, the web site would need to be entirely recreated.

Developing strategic and credible multimedia content (web, video, infographics and photography) and storytelling tools will become key to ensuring its positioning and reputation, as well as and delivering communication objectives of awareness raising, promoting, and building credibility for:

- Outreach to create deeper understanding of how we contribute to solutions for society’s needs
- Research and teaching
- Student ambassadors to attract, build and maintain relationships through the student life cycle phases from recruitment to alumni.

A marketing strategy that includes the development of social media channels and the creation of engaging and meaningful multimedia content (web, video, infographics and photo content) that facilitates outreach and attracts the best researchers and students means that the UL must invest in new technologies. These technologies will enable communications while ensuring General Data Protection Regulation (GDPR) compliancy, search engines and social media capability, email marketing, and high rankings in internet search engine result lists. At the heart of this digital strategy is a website linking numerous digital systems and transactions.

Communication and Marketing Organisational Units

A critical factor for success of a communication strategy is a shared vision across all of the university together with common practices and toolkits to facilitate consistent messaging and branding in all channels, cost effective production and ability to leverage best practices and develop synergies. We will also need to invest in digital experts to sustain these channels and ensure we continue to keep abreast of developments and evolve as technology and target audiences’ needs evolve. A more coherent strategy is being developed, around increased presence in social media, a new website, and a more efficient use of resources throughout the university.

Table 13: Website budget (kEuro)

These figures are preliminary and an approval of the Plan does not imply their approval in detail, but only as a frame of action that will have to be adapted to the yearly budget of the University

	2018	2019	2020	2021
New web site (face lift)	150	100	50	50

Student Services

The current Student Department (Service des études et de la vie étudiante, SEVE) has served UL’s students and academic staff in a broad variety of areas. While the UL holds on to the principle of a one-stop-shop for student matters with a single – increasingly digital – face to the student, the assembly of all student-related services under one roof has reached our organisational limits and no longer supports UL’s dedication to administrative excellence and efficiency. The restructuring of UL’s student services will fix these limitations.

The stewardship of student records, from admission to graduation, is one of the core academic functions any University has to fulfil, and it is increasingly entrusted to a dedicated Office of the Registrar. The UL’s new Registrar’s Office will not only act as keeper of student records. Rather, it

makes a genuinely academic contribution to the educational success of UL's students, by supporting them throughout their time at the UL in all matters concerning academic administration. To do this efficiently, the Office will successively digitalise its services, both vis-à-vis students and staff ('guichet étudiant', 'guichet enseignant'), and with respect to the registry itself.

With the growth of its student population, the UL has invested ever more resources into the provision and management of student accommodation. Affordable housing for UL's students remains a priority. The UL will now re-assess how best to guarantee cost effective, quality accommodation for its students. Facility, occupancy and lease management will be organised as a central service under the responsibility of the Administrative Director. It will operate on the basis of a full cost model that will allow the UL to assess which services are most efficiently rendered in-house and where outsourcing is beneficial. The allocation of flats and the handling of tenant contracts will be part of the new Office of the Registrar.

We have already highlighted that the UL intends to further empower its students to take charge of not only their learning, but also of the institutional conditions under which it takes place. With a new Office for Student Life, the UL creates a single point of contact from students for students that is at the same time well integrated into the academic administration. The Office will handle all matters concerning student life and well-being, and serve UL's student representatives as a resource for daily business and development projects alike.

In order to provide students efficacious support in preparing for professional life, the proposed restructuring the SEVE's existing 'Campus Carrières' activities will join forces with UL's alumni officer and its entrepreneurship initiative in a new Career Development Office.

Mobility is a key feature of the student experience at bachelor, and increasingly at master level at the UL. To further promote a centre of competence in all matters related to international relations, as well as create a one-stop shop for both student and staff incoming and outgoing mobility activities, the former SEVE mobility team members will join the specialists in International Relations Office in a new unit.

The UL will also increase its efforts to make its student services and training offer accessible to all types of students, including students who have special educational needs. An integration office in charge of the optimisation and adaptation of the teaching and learning environment for students with special educational needs will be created.

International Relations

The UL's internationality is recognised as a strength and differentiating factor of the UL, as demonstrated by its strong positioning in internationalisation in worldwide rankings. In the next 4YP, the UL will continue to develop key strategic partnerships with target countries and markets, through amongst other mechanisms, collaborations such as the Confucius Institute that will be established in 2018. Similarly, through international summer schools, the UL will look to attract greater numbers of students to Luxembourg from prestigious partner universities around the world to achieve a greater balance in student exchanges allowing us to maintain the partnerships with those institutions. The University needs to define a real international strategy; in 2018, we will submit this strategy.

To support these activities, the International Relations Office (IRO) will consolidate and reinforce its positioning as a one-stop shop for all matters related to international relations and mobility both for students and staff. In addition, the UL will improve welcome services to international visiting scientists as well as new researchers arriving to the UL. This will allow the UL to continue to attract top researchers from around the world as part of its recruitment strategy. The UL will build on the expertise

of EURAXESS Luxembourg, part of a pan-European Initiative launched by the European Commission to promote research careers and facilitate the mobility of researchers across Europe (see <https://www.euraxess.lu/>) and of which the UL is the national coordinator. Please note that the UL supports EURAXESS activities for all researchers in the country.

EURAXESS activities have steadily increased over the last few years.

Table 14: Resources in the 4YP to support the IRO (annually)	
	Resources
Operating budget: Travel to International fairs, Global Exchange Programme, Participation in rankings, Membership Fees (e.g. UNICA)	170
International Summer School	30
EURAXESS	25
SEVE Mobility	10
Total	235

Research Support

The Research Support Service supports the UL's vision to make UL one of the leading research universities in the world, up from its present ranking of No 178 globally and No 14 of the young universities under the age of 50 in the 'Times Higher' Ranking.

Within this vision, the Vice-president for Research and the Research Support Department have the following mission/roles

- Define the UL research strategy;
- Direct research support, i.e. organising and setting the criteria for the distribution of UL internal research funds based on a thorough international peer review process;
- Support researchers in the acquisition, research management, dissemination and exploitation of external grant money. This includes quality assurance checks and institutional validation of project applications (FNR, EU, International), identifying funding sources and communicating the relevant information as well as developing procedures and guidelines in line with the UL's Research Strategy;
- Establishing and maintaining relationships with funding agencies, research organisations, potential sponsors and external stakeholders such as the Brussels Liaison Officer (LUXCOR), Science Business Network for Horizon 2020 and 9 Framework Programme for Research and Innovation;
- Interfacing with the UL departments and committees;
- Liaising with and support of the Research Facilitation Group members; and
- Leading the mid-term research external evaluation.

Over the course of this 4YP, the Research Service will implement three new initiatives:

- Set up the ULLA Leadership Academy and training of postdoctoral scientists in essential soft skills such as scientific writing, good scientific practice, initial leadership skills;
- Implement a Research Information System which will provide comprehensive and structured data access and retrieval data for research projects statistics; and
- Develop the post-award EU support service portfolio.

In 2017, the management team decided that we could not put out a call for the PULs (internal research proposals) usually supported by the Research Service. In 2018, the management team will reconsider how to strategically use these funds for research.

Approximately 1.5 Million EUR will be used to establish a large equipment, attraction and retention fund. This fund will be used to support researchers to use state-of-the-art equipment and to fund the equipment of professors who are newly hired or whom the University wishes to retain. The university expects its professors to perform cutting edge research and thus must provide them with state of the art equipment. An equipment fund is fundamental for recruiting the best scientists, including in the experimental sciences, and needs to enable the UL to make competitive offers, also in terms of equipment. Further, to retain excellent researchers we must be able to regularly replace out-of-date equipment.

In other universities in other countries, large equipment is funded by local or national agencies. Because Luxembourg is small, such funding is difficult to establish. Therefore, the research institutions here must provide their own funding for equipment. LIST, for example, uses their end of year reserves to buy new equipment and then charges depreciation to all projects using the equipment, allowing the reserves to remain at a viable level.

Therefore, the university needs resources to initiate an equipment fund. The UL will make sure, that the equipment is properly depreciated (according to European regulations) and covered by any newly funded project using the equipment.

A committee of large equipment users will be established to distribute funds fairly; however, those areas deemed strategically thematic will have priority. The committee will establish regulations for accessing the large equipment fund may include:

- Funding requests require a detailed written proposal, describing the planned use of the equipment and describing the planned refinancing of the equipment fund;
- Projects are selected by an external expert panel, covering all experimental sciences;
- Selection is based on past performance of the PI and on the scientific quality of the proposed project;
- Depreciation will be calculated according to regulated principles;
- Projects are usually externally funded projects. However, the free budget of each professor can also be used to contribute to the equipment fund. The plan for refinancing must be part of the original project proposal; and
- Professors who consistently fail their refinancing obligations will not be eligible to access the equipment fund.

These rules cover equipment for researchers already at the UL. Newly appointed colleagues are expected to negotiate equipment support in the hiring process.

Table 15: Large equipment fund (kEuro).

These figures are preliminary and an approval of the Plan does not imply their approval in detail, but only as a frame of action that will have to be adapted to the yearly budget of the University.

Initial Start-up fund	1,500
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Fundraising

The UL has a goal to increase private donations to an extent that they become a significant part of the University's yearly budget.

Current status of Fundraising at the University of Luxembourg

The UL's fundraising efforts over the last few years, spearheaded in large part by the LCSB, have demonstrated the huge potential for raising financial donations to support UL research projects. Over 4 million EUR have been raised since the inception fund raising activities. The UL has also experienced some major successes in identifying governmental and corporate partners that have committed to support endowed chairs. Six endowed professorships (chairs) currently exist at our university. Since 2012, the UL has also developed student housing with the help from corporate partners, besides having inherited several buildings that have been transformed into student housing. Still, a lot of work is required to create a university-wide culture of philanthropy. We will develop a fundraising office (FO) over to achieve this goal and to increase the funding we receive today.

Fundraisers will be distributed to the Centres and Faculties and central administration to enhance the UL's fundraising efforts. They will develop a portfolio of donors, including private individuals, corporate sponsors, foundations, service clubs and alumni. Initially, activities will consist of hosting visits to the UL's different Faculties and Centres, organising events for specific causes (such as 'Art2Cure' for the LCSB's brain research), and giving presentations all around Luxembourg. Fundraising priorities will be set by defining one or two flagship projects for each Faculty/Centre where donors can be attracted. Later, one annual 'centralised' fundraising event should be organised for all existing and potential new donors. Building on the opening event in March 2017 at Spuerkeess, a yearly donor event will complement major societal interactions. Under these conditions, we project that the UL could make up to 1.8 Million EUR in yearly profit (including the value of inherited real estate, land and legacies) through their fundraising activities by the year 2021.

Impact

The FO will have an impact at many different levels. First, we can expect to raise millions of EUR for UL research. The FO can also have a strong impact on the reputation of the University and help with its integration within the local community. Finally, a strong collaboration between the FO and Alumni office will significantly strengthen the relationship of the UL with its national and international alumni, thereby creating an important network beyond the borders of the Grand-Duchy.

Section VIII. Quality Assurance

Quality assurance (QA) is the systematic assessment of procedures adopted by UL to monitor performance and to ensure achievement of quality outputs or improved quality.²⁰

The UL is committed to QA in the areas of research, teaching and learning, outreach, and administration. This commitment equally applies to the institutional support it provides to students and staff in promoting and advancing quality enhancement. After a period of rapid expansion, the UL is now operating at a scale, which calls for systemic, institution-wide processes and instruments.²¹ A series of measures have already been put in place at the level of Faculties, ICs, Research Units and study programmes. Over this 4YP, the UL will integrate existing measures into a quality assurance system that, while being mindful of the different needs for substructures, sustains the further evolution of the institution and meets international benchmarking standards for QA in higher education.

Teaching and Learning

A key aspect of a QA system is monitoring, evaluating, and enhancing teaching and learning where the University is dedicated to the promotion of pedagogical innovation, the empowerment of its students, high retention and graduation rates, and the success of its graduates in the professional world. To this end, the University has designed a quality assurance system that integrates Faculties and the central level, and that systematically stimulates and supports quality improvement at the local level. Through the consistent implementation of this system over the next 4YP, the UL is preparing its study programmes for the external evaluation in 2020 and paving the ground for the accreditation of the university's quality assurance system. As part of the strategic plan for quality assurance, the university is supporting selected study programmes in obtaining external accreditation. In parallel, and in cooperation with the Institut Universitaire International Luxembourg (IUIL), it is setting up an internal quality audit system for the periodic evaluation and continuous monitoring of all of its study programmes. This system also redefines the criteria and procedures for the creation of new, and the termination of existing, study programmes. The long-term ambition is to successfully gain international system accreditation of this quality audit framework, and to promote it as a blueprint for quality assurance in higher education in Luxembourg.

The University is intent on increasing the transparency of institutional expectations and rewards, in an effort to reinforce intrinsic motivations, vigorous – and complete – scholarship, and sound academic judgment.

Please also see the Subsection Accreditation Strategy in **Section IV** Teaching and Learning.

²⁰ Harman, G. and Meek, V. Lynn (2000). *Repositioning Quality Assurance and Accreditation in Australian Higher Education*. Centre for Higher Education Management and Policy University of New England. Retrieved 24 August 2016.

²¹ Past external evaluations have emphasized the need for a more systematic and integrated development of quality assurance. For the latest, see IEP Evaluation Committee, *University of Luxembourg Evaluation Report*, 2016, p. 18.

Table 16: Teaching and learning budget (kEuro)

These figures are preliminary and an approval of the Plan does not imply their approval in detail, but only as a frame of action that will have to be adapted to the yearly budget of the University.

	2018		2019		2020		2021	
	kEuro €	FTE						
Total	300	1.5	279	2	282	2	249	2
Quality Officers	126	1.5	175	2	181	2	187	2
Operational costs and investment								
Staff costs	5		6		6		6	
Programme accreditations	40		30		45		25	
Internal quality audit	40		42		35		21	
Programme cost analysis	12		0.0		0.0		0.0	
Data quality management	28		0.0		0.0		0.0	
Quality enhancement	49		23		10		9	
External evaluation (over and above main cost, e.g. student auxiliaries , but does not include cost of the actual evaluation)	0.0		0.0		5		1	

Research and Doctoral Education

For doctoral education, the University is in the process of defining a series of benchmarks that will allow the existing doctoral schools and the new University doctoral school to monitor the career progression, educational experience, and graduation success of doctoral candidates. Effective supervision is essential to a high quality doctoral education, and the University will be expanding existing training of PhD supervisors over the next years.

We will further develop our strategy to acquire external funding, in particular EU funding (to date, 7 ERC fellows hired in the past 4 years).

Another important initiative to improve the quality of our research output will be the distribution of research resources based on merit. Distribution of open structural posts will be based on a grant proposal that takes into consideration previous publications and the funding record. But an evaluation of performance must also consider an individual's contributions to teaching and outreach. An uncomplicated version of this mechanism would be e.g. a 10-20% reward on top for an acquired grant ('past performance').

Quality assurance in research has profited from the vertical integration of research facilitation provided by the UL's Research Office. Steps are now being taken to define coherent guidelines and procedures for Faculty staff recruitment, career progression, internal funding allocation, performance measurement and output monitoring. In 2005, the European Commission launched the European Charter for Researchers and Code of Conduct for the Recruitment of Researchers, which set out some principles for good working conditions for researchers.

The UL has received the HR Excellence in Research Award. The Human Resources Strategy for Researchers (also known as HRS4R) is the mechanism through which the European Commission seeks to ensure that concrete steps are put in place by institutions to enhance working conditions for researchers across Europe as set out in the European Charter and Code. The strategy encompasses a

five-step implementation process for gaining EC recognition for commitment to implementation of the European Charter and Code principles. The European Commission recognition is the 'HR Excellence in Research' Award. This process is designed to be 'light touch', respecting institutional autonomy and making public information on institutional action plans and progress in their implementation. In 2012, the UL received the award. Over this 4YP, we will update processes and procedures to renew our application for the award.

Administration

Implementing quality controls in the UL administration will start by defining administrative functions and the levels of performance that need to be achieved.

The administration and central services will implement regular quality controls, to ensure that the required level of performance is achieved. Processes will be defined, in the focus areas HR, financial controlling (budgeting process, monitoring), contract management (see Section VII: Developing an Efficient and Transparent Administration for more details).

Once the processes have been defined, we will monitor the quality of the performance of our administrative staff in an objective and consistent way and adapt goals and skills accordingly. Over time, the UL will focus on maintaining the levels of quality.

Continuing Professional Development

Continuing professional development (CPD) is essential for maintaining the standard and integrity of services offered by all of our staff. The CPD Research project²² found that CPD training is strongly correlated with staff motivation, and that it can improve job performance. Further results supported the idea that CPD can increase staff's willingness to push a little harder, and will improve the UL's reputation as an organisation that supports staff growth.

Professional development is a continuous process. We would like all UL staff to be responsible for managing and undertaking CPD activities and ensuring that they apply what they learn in training to their professional life. In the long-term, we envision that all UL staff would embrace a culture of CPD which would identify that skills are needed for a particular service and determine how to fulfil them. Over this 4YP, the UL will try to catalyse the development of this culture by offering CPD courses to all our staff and demonstrating that this learning/training is an integral part of work rather than an extra optional activity. Additionally, by linking participation in CPD courses and improved performance to bonuses or promotions would further embed the CPD culture in our university community.

We need to be wise about implementing a CPD programme at the UL. Before we invest, we should survey our staff and their line managers to determine what skills they feel that they need. Then we will invest in a number of courses that respond to the identified needs. The courses will be held during working hours. After the first year, we will obtain feedback from line managers and participants and adjust the programme accordingly. The effectiveness of the CPD will be reported on in the mid-term review.

²² <https://www.apm.org.uk/media/1263/the-cpd-research-project.pdf>

Section IX. Long-term Vision

This 4YP represents another step on our path to refining the research, teaching and learning, and administrative strategy that will ultimately define the University of Luxembourg in 20-30 years. Our long-term vision must be shaped by the future needs of society, economy, health, the environment, and industry at global and national levels. Our vision must be sufficiently flexible to anticipate change and to guide future teaching and learning and research initiatives and the allocation of resources.

Most futurists, scholars, decision makers, and business leaders would agree that megatrends such as climate warming, a growing population, dwindling petroleum resources, decreasing ability to access fresh water, health challenges, political conflict, and migration will have a profound and lasting influence on many if not most human activities, processes and perceptions²³. The OECD Science, Technology and Innovation Outlook 2016 provides an excellent summary of the megatrends that are expected to influence the future research and innovation foci of public and private research institutes.

More and more, technology will be demanded to mitigate the effects of these global trends, and these demands will shape the future of research in science, technology, and innovation. The OECD report proposes a set of technologies that are ‘the most promising and potentially most disruptive and carry significant risks.’ The technologies include 1) the Internet of Things; big data analytics; artificial intelligence; neurotechnologies; nano/microsatellites; nanomaterials; additive manufacturing; advanced energy storage technologies; synthetic biology; and blockchain. These megatrends and technologies are challenges that we should be considering as we strive to define the future research agenda for the University of Luxembourg.

The UL must take a leading role in initiating the local, regional, and global debate on megatrends. We are in a comfortable position in that we are still well supported by the government and thus, can focus resources and energy to address these bigger questions. Over this 4YP, we will debate how the UL will place itself to tackle the big socio-economic challenges of the future.

In the meantime, our vision for the UL 2040 includes the following:

Interdisciplinarity as a major driver of Innovation

In a number of selected fields, the UL will become a world-wide leader in research and associated innovations. The UL will be a role model of how in a defined number of disciplines a small country can establish international leadership by systematically combining basic research with its applications. This requires a strong commitment to excellence in basic research and the investments necessary to efficiently translate the outcomes originating from basic research to other domains and disciplines. The priorities identified and described in the current 4YP, **Data modelling and simulation**, and **Health and systems biomedicine**, do have the potential to serve as an anchor point for achieving excellence and to drive innovation in the country in the next decades. Interdisciplinarity will be a fundamental principle for our students’ education. The University of Luxembourg will be highly attractive for students who are keen to being trained in using interdisciplinary approaches to tackle complex adaptive systems, e.g. health, the environment, societal systems, independently.

Positioning as a National Think Tank

The UL will position itself as a centre for intellectual debate and rational, knowledge based argument exchange. The University will proactively contribute to agenda setting in Luxembourgish society in terms of defining the topics and challenges that need to be discussed among the different

²³ OECD Science, Technology and Innovation Outlook 2016

stakeholders. In this role, the University will drive the concept of "citizen science", where outreach to and participation of the public and other political and industrial stakeholders becomes the norm rather than the exception.

Attracting the Testbed Studies

As a result of its compact country size Luxembourg is ideal as a testbed for innovations. The relatively limited number of stakeholders in particular fields of expertise and the proximity between the key academic, industrial, and political players provides conditions for highly efficient testing of innovations and proof of concepts. The Belval Campus will develop into an international well known attractor for testbed studies and become a dynamic learning and research environment.

Transformation of the Luxembourgish Healthcare System

Medical innovation and medical research will cross-fertilise with one another and become the motor of a transformation of the national healthcare system. The UL will become a major player in the forefront of eHealth, with a world class IT-infrastructure. Luxembourg will be one of the premier international medical data hubs integrating data management and analysis. The expertise in medical IT and eHealth will be highly integrated with a unique portfolio in medical education.

University without Borders

The geographic location of Luxembourg will allow for the development of a "Grand Region University" where both research and education across borders are a highly attractive feature of being a student at the UL. Students graduating from the UL will have experienced a unique interdisciplinary and multilingual training and be well prepared as leaders to tackle for the challenges of the future.

In this 4YP, the cross-disciplinary themes of **Health and systems biomedicine** and **computer science** should be established as strong pillars of excellence together with the related fields of **data modelling and simulation**, **materials science**, cognitive sciences, and a unique medical education tied to clinical access and aligning well with the technology, development and health advances that will be required in the future. Focusing resources in these areas will put the UL on the path to being able to positively address the change and technology demands of the future.

Entrepreneurship

The UL will develop a unit aiming at fostering entrepreneurship and at promoting the boost of innovative ideas among students and staff. A specific programme will be put in place to enable mentoring of start-ups and to train a new breed of entrepreneurs in Luxembourg.