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1. Executive Summary

As with other small countries, Luxembourg has limited public resources devoted to research and has a small (and young) public research base. However, it is also rather unique in that it has enacted sizeable increases in spending on R&D over the last decade and is set to double the budget again over the next three years.

The FNR (Fonds National de la Recherche) foresight project was established with the objective of identifying important future research domains for Luxembourg society, and using this information to feed into governmental research policy and to shape new FNR funding programmes.

It was launched on the 20th of January 2006 and based around a comprehensive process of research and discussion with more than 300 stakeholders across Luxembourg society. The FNR foresight exercise has been designed in two phases. This document provides a summary of the initial results from the first six months (phase 1) of this process and outlines the next steps in prioritising the research areas. The document is based on the work and conclusions of the consultancy company CM International, who assisted the FNR in the conduct of the exercise.

The 1st phase of the exercise has devoted a considerable time to generating a baseline based on the collection of background data and first definitions of research domains. In addition, the FNR has sought active interactions with the stakeholders in Luxembourg through interviews, questionnaires and workshops in order to shape a common understanding and discussion of research domains.

This analysis of domains has led to an initial assessment of potential future research domains within 6 scientific fields:

1. Economy, Law and Finance
2. Environmental sciences
3. ICT
4. Life Sciences
5. Physical Sciences and Engineering
6. Social Sciences and Humanities

The consultation process has also enabled the stakeholders in Luxembourg research to express their views on the research strategy that Luxembourg should pursue. The general opinion was that a balance between existing and new research competencies needs to be found, however they also recognise the need to prioritise. Some felt that curiosity driven research has an important role still to play in such a context, and that both fundamental and applied research are relevant. The need for strategic coordination and networking of research actors as well as the strategic public investment in research infrastructure and people was highlighted.

Further steps to be taken on the basis of the initial analysis are outlined in section 6 of the present report.

2. Background and Introduction

The Luxembourg research environment is characterised by a very young and partially under-developed public research infrastructure where the key laws and regulations were put in place only in 1987 and the University of Luxembourg was founded as late as 2003.

In response to the growing strategic importance attached to research and innovation, the Luxembourg Government has enacted sizeable increases in spending on R&D over the last decade and is set to double the budget again over the next three years. The government's commitment to research as a driver of social and economic development in Luxembourg has also been reflected in its commissioning of an OECD study of Luxembourg innovation policy (published in 2006¹). The particular challenge for Luxembourg lies not in distributing limited funds among its existing science community. Rather, it is looking to identify new areas in which to invest much of the spending increases with a view to developing future national champions.

In this context, Luxembourg began to embark in 2005 upon a national technology foresight exercise, primarily with the aim of identifying new research domains for the National Research Fund (FNR) to support from 2007 onwards. In dialogue with the Ministry, two seemingly compatible objectives were fixed to increase the synergy between Ministerial policy and FNR strategic funding support. On the one hand, research domains and priority axes for the public sector, with short-term and/or long-term socio-economic interest for Luxembourg society had to be identified. On the other hand, the administrative board of the FNR has sought strategic intelligence to help it in the narrower task of shaping the future thematic research programmes of the FNR.

Within this evolving context FNR has been proactive in seeking to work closely with stakeholders in identifying research priorities that will make a significant socio-economic contribution to Luxembourg.

¹ OECD, *OECD Review of Luxembourg's Innovation Policy* - Draft Final Report, 24 May 2006

3. FNR foresight approach - 1st phase

3.1 Rationale and scope

The FNR Foresight was born out of the necessity for the FNR to define new research programmes. The first generation of research programmes (7 programmes were launched in the period 2000-2003) are still currently ongoing but their funds are largely committed already to running research projects. In order to develop the 2nd generation of FNR programmes, a bottom-up approach seeking programme proposals from the research community and other stakeholders was employed in 2005 by the FNR.² It was noted that some of the proposals were very well developed, mostly on account of the fact that public researchers were well attuned to the workings of the FNR. However the FNR was critical of the seeming lack of vision in the proposals and felt that the topics proposed were 'more of the same'. In addition, the FNR lamented the fact that few responses were submitted by the private sector or societal actors in general. Hence there was a feeling that economic and societal needs were not sufficiently reflected in the proposals.

The general conclusion was, therefore, that the approach followed for identifying new programmes was too passive on the part of the FNR. Only actors with a direct stake in the FNR programmes (i.e. those who can receive funding) took active part in the exercise. Methods to survey public needs would need to be expanded upon and included further upstream in the development of the programmes. Furthermore, current thinking would need to be challenged by new ideas that would account for future trends in research. In addition to the forward looking aspects, the decision makers at the FNR demanded a thorough assessment of the performance of the ongoing programmes in terms of their impact on the research community, the visibility and renown of Luxembourg research, and their positioning vis-à-vis socio-economic factors.

To address the participative and future oriented requirements of FNR programme planning, a Foresight approach was proposed. These intentions were communicated to the Ministry of Culture, Higher Education and Research, which was supportive of the approach and requested the Fund to broaden the scope of the analysis from the mere definition of new FNR programmes to the identification of nationwide research priorities i.e. 'research domains in the public sector with short-term and/or long-term socio-economic interest for Luxembourg society'.

With the extended remit given to the foresight exercise, the results are intended to help shape the basis for a coordinated approach in determining the implementation of public research in Luxembourg in a limited number of areas and will lead to financing on the basis of clearly stated strategic and operational objectives. As a consequence it should help to ensure the specialization of public research centre

² Similar to the approach in 2000 and 2002

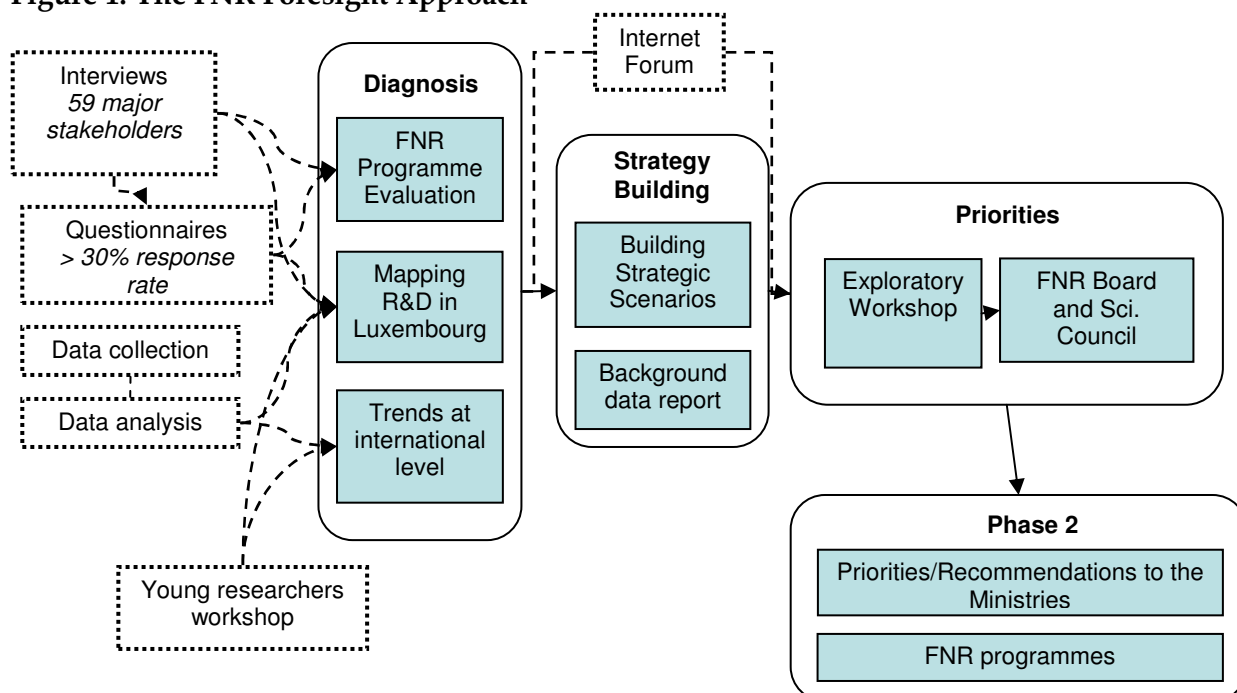
(PRC) facilities into centres with specific skill sets in a limited number of activities, with the government providing appropriate investment levels.

The FNR foresight exercise has been designed as a two phase process where the first phase consisted largely in defining the current position of the Luxembourg research landscape, analysing international trends in research priorities, and identifying possible priority tracks for research. Based on these results, the second phase of the foresight, which is currently underway, focuses upon a set of broad fields with the aim of identifying national priorities for research funding.

3.2 Generating a Baseline

Key features of the FNR foresight exercise³ are the building of a discussion basis and a focus on mobilising a wide range of stakeholders to define and assess the most relevant research priorities to Luxembourg in the medium and long term. To this end the exercise focused in part on collecting background information on the Luxembourg environment and engaged with researchers (senior and junior), private sector actors and public administrators in a range of activities and events. The external consultancy firm CM International helped the FNR to carry out this first phase of the foresight exercise. A summary of the foresight approach is set out in the diagram below:

Figure 1: The FNR Foresight Approach



³ and foresight methods generally

3.2.1 Background data collection and first definitions of research domains

The background data collection resulted in the production of a preliminary baseline report which was the basis for discussion during an exploratory workshop in May 2006. Background material collection was based on the elements detailed below.

The data collection has made use of existing reports (OECD report, the MECO report 'les activités d'innovation et de recherche au Grand-Duché de Luxembourg', etc), collection of new data (e.g. bibliometrics), as well as targeted interviews with key stakeholders supplemented by questionnaires.

3.2.1.1 FNR programme evaluation

An evaluation of the progress made by FNR since its establishment has been conducted. The analysis assesses FNR's operational and management effectiveness against initial objectives, focusing on questions such as programme selection and project evaluation. It also considers both quantitative and qualitative programme outputs and outcomes, and provides recommendations for future FNR programmes.

3.2.1.2 Mapping of Luxembourg research landscape

The consultants reviewed the main socio-economic trends facing Luxembourg, including a description of the public research actors, R&D indicators, policy instruments for public and private sector.

3.2.1.3 Trends at the international level

In order to understand the potential degree of competition that Luxembourg might face when supporting particular research domains, the consultants carried out an analysis of research priority trends at an international level. A total of 13 countries were reviewed including: Finland, France, Germany, Ireland, Netherlands, United Kingdom, Denmark, Switzerland, Austria, Belgium, Japan, Malta, and United States. The resulting analysis identified the key features of the public research system in each country, as well as thematic research priorities and associated accompanying measures. In order to avoid discussion on research topics from scratch, these foreign thematic research priorities were then put together in a "long-list" which set a well structured basis for the discussion with the researchers in the next steps of the exercise. Careful attention was taken to explain to researchers at all stages of the exercise that this list was by no means extensive or fixed and that domains could be modified and added. The assembly of this long-list was preceded by a discussion on the level of "granularity" of research topics with which to confront the researchers. Finally a four-level granularity was applied (see Table 1).

Table 1: Levels of ‘granularity’ for mapping research topics (examples)

Thematic field Level 1	Research area Level 2	Research domain Level 3	Research axis Level 4
Environmental sciences	Global change and ecosystem	Water management	Drinking water
Bio-medical sciences	Diseases	Cardiovascular diseases	Metabolism and the Cardio-Vasc. system
ICT	Infrastructure	Telecoms	VoIP
Physical sciences and engineering	Knowledge based multifunctional materials	Housing and civil engineering	Energy efficient buildings

3.2.1.4 Interviews

A detailed documentary analysis of FNR’s programmes and management activities was complemented by a series of face-to-face stakeholder interviews with senior researchers, private sector actors and public administrators during the months of January and February 2006. The table below shows the distribution of the interviews among stakeholders:

Minister & Secretary of State, Members of Parliament (Lux. and EU), Ministries, Agencies	13
CRPs, CEPS, University of Luxembourg, other public inst.:	23
Private sector	17
Universities abroad, Institutions abroad	6

A key output from this activity was a series of possible research domains for Luxembourg.

3.2.1.5 Junior researcher workshops

It was felt that the input of the future generation of project leaders and research directors is needed when shaping the directions of future research activities.

In order to test and develop the emerging list (see section 2.2.1) of research domains further, five thematic workshops for junior researcher were held in March 2006. These workshops covered the following broad research fields:

- 1) Environmental sciences
- 2) Bio-medical sciences
- 3) Information communication technologies
- 4) Physical sciences and engineering
- 5) Social sciences and humanities (including economy, law and finance)

During these sessions the consultants presented an initial version of the long list and asked junior researchers to update and assess the domain list.

3.3 Definition of broad research fields

3.3.1 Draft definition of broad research fields and domains

An initial long list of research domains was constructed on the basis of the background research analysing the priority domains identified in the report of the High Level Expert Group (HLEG) set up by Unit K2 “Science and Technology Foresight” of DG research of the European Commission in 2005, presenting Key Technologies for Europe and the domains identified during the country analysis with a group of 13 comparator countries (see section 3.2.1.3).

The sources and cross referencing used in the construction of the long list was based on the following additional elements (see annexe 8.1 for further detail):

- Suggestions from FNR call for programme proposals
- European Commission 7th Framework Programme
- Key Technology for Europe
- Country Analysis
- Interviews
- Exploratory Workshop
- Junior Workshop
- Strategies /annual reports of key Luxembourg research institutions (UL, CRPs, CEPS/INSTEAD).

The outcome is a first draft of a long list of research domains and a subdivision of the research domains and axes into 5 broad research fields⁴

3.3.2 Online questionnaire survey

Assessment of the resulting research domains was then undertaken through an online questionnaire survey according to the criteria of attractiveness and feasibility for Luxembourg in the medium to long term. Attractiveness, in this respect, was based on assessments of a number of sub-criteria:

Attractiveness

- societal need - Does the research domain have the potential to contribute positively to the needs of Luxembourg society?
- economic need - Does the research domain have the potential to contribute positively to the needs of Luxembourg’s economy?
- emerging trend - Does the research domain represent an emerging area for research that is likely to be important for the future?
- sustainable development need - Does the research domain have the potential to provide an attractive contribution to sustainable development in Luxembourg

⁴ The subdivisions of the list were revised at several instances of the exercise

– i.e. development that meets the needs and aspirations of the current generation without compromising the ability to meet those of future generations?

Feasibility

- scientific base - Is the research domain potentially relevant to existing research competencies in Luxembourg?
- economic need - Is the research domain potentially relevant to existing companies in Luxembourg?
- regional partners - Are there potential research partners in the surrounding Grande Region?

This online survey was publicised widely, and received responses from some 283 researchers, private sector actors and administrators in Luxembourg⁵ giving a respectable response rate of more than 30% of around 800 representatives from stakeholders contacted to participate in the questionnaire. Hence a sizeable proportion of the 400-500 FTE⁶ researchers active in public research are believed to have participated in the exercise.

Respondents were asked to identify and assess up to ten research domains of 'short-and/or medium term socio-economic benefit to Luxembourg society' according to the criteria of attractiveness and feasibility mentioned above. In total the respondents prioritised 1694 research domains which equates to an average of 6 domains assessed per respondent.

Respondents were also asked to add to the list of research domain axes of research that were included in the questionnaire, and indicate whether they agreed with their inclusion⁷.

Online questionnaire response

Respondents : 283 questionnaires validated (800 people contacted)	%
CRPs, CEPS, University of Luxembourg, CHL	46
Universities abroad, Institutions abroad	22
Private sector	14
Other public inst.: Museums, Hospitals, Associations, Small institutes, Central bank	11
Ministries, Agencies, Chamber of commerce etc	7
Male respondents	78
Female respondents	22

⁵ Including Luxembourgers abroad.

⁶ Full-time equivalent

⁷ Note, respondents were not asked to complete an assessment of axes against the criteria of feasibility or attractiveness.

The outcome is a first assessment of the research domains according to several criteria of feasibility and attractiveness.

3.4 Validation of the research fields

3.4.1 Exploratory workshop (EWS)

This first ranking issuing from the questionnaire was presented to participants of an Exploratory Workshop (EWS), where researchers and research users were brought together for the first time to discuss and validate the emerging analysis and ranking of the research domains. The output of the EWS serves as a discussion basis for the subsequent workshops in the second phase (see section 6).

This workshop, held in May 2006, was designed to bring together experts from Luxembourg, discuss strategy options, and rank the domains within each thematic area.

The workshop yielded good consensus in the workshops for 'Environmental sciences, Information communication technologies, and Physical sciences and engineering'. The ranking of some domains in the 'Life sciences' and 'Social sciences and humanities' workshops remain contested and need to be analysed further in the second phase.

In addition, it became clear during the EWS discussion that "*Economy, law and finance*" and "*Social sciences and humanities*" should be separated and therefore the number of research fields for the second phase of the foresight exercise has been augmented to 6.

The outcome served in the preparation of Phase 2 and initial prioritisation of the research domains (and some axes), which have been integrated into 6 broad research fields.

4. Stakeholder views on Luxembourg public research strategy / FNR programmes

As mentioned before, stakeholder views on the future development of Luxembourg research priorities were collected through different means during the foresight exercise including: some 50 face to face interviews with senior researchers / stakeholders (and additional phone interviews), an online questionnaire (283 responses), five thematic junior workshops and the final exploratory workshop.

Regarding public research strategy, the findings from the above mentioned activities suggest, broadly, that there is a need for a more strategic approach to public R&D, including support for prioritisation of research funding and stronger interaction between research actors. That is, stakeholders recognise that Luxembourg cannot hope to achieve a leading international position in all research domains, but will need to target its resources on the basis of a nationally agreed strategy. A related finding is the widely held belief amongst stakeholders that this strategy should focus on multiple objectives for public research, including physical and social sciences.

In addition to these views on future public research strategy stakeholders also made important comments on the future direction of FNR programmes:

- Balancing existing and new research competencies. New research domains have the potential to allow Luxembourg to gain a head start over other countries - but are more risky. Supporting (exclusively) existing competencies contributes to building critical mass but may impose rigidity to the research system and fail to provide the flexibility to respond to new developments in other domains.
- No consensus on how tightly to focus programmes: researchers recognise the need to prioritise, but feel that curiosity driven research, and interdisciplinary research should also be supported.
- Public investment in research infrastructure and people is necessary. This double pronged strategy only was felt to give synergistic effects.
- Prioritise fundamental and applied research relevant to the Luxembourg economy and society. The former serves as an essential basis to the latter. Even though researchers argued on balance, they also think that fundamental research should be given a higher priority in Luxembourg.
- Need for strategic coordination and networking of research actors, both at the policy level, but also amongst researchers (thematic and interdisciplinary).

5. Strategy options

Alongside the assessment of the priority domains a series of strategy options were also developed. These strategy options illustrate how a particular perspective adopted for the selection of research domains is likely to influence the development of the research landscape and its interactions with the wider socio-economic context in Luxembourg.

Each thematic field answers to very different types of needs and has different key success factors. Therefore the strategy to be developed needs to be differentiated. Some thematic fields need for their scientific development to be close to users whereas others need to rely on scientific excellence in order to bring societal value. Four standard strategy options are outlined hereunder:

- **Strategy option 1: Build critical mass to develop the business base**
A strategy based on clear inter-relations between users and research, identified as being highly attractive in relation to economic or societal value added.
- **Strategy option 2: Scientific excellence strategy**
A strategy based on development of high level research activities which have the greatest potential to firmly establish Luxembourg on the international science map
- **Strategy option 3: Differentiation strategy**
A focused strategy built on developing research in areas where little or no competition exists, and which have either economic or scientific potential
- **Strategy option 4: Sustain diversity in Luxembourg**
A strategy based on supporting, and therefore spreading risks, across a larger number of domains and research teams - with a focus on either economic or scientific potential.

Each strategy option is elaborated in the form of:

1. Key features of the strategy - what are the main objectives?
2. Priority domains profile - which types (according to attractiveness and feasibility criteria) of domain are likely to be most consistent with the objectives of the strategy option?
3. FNR role and resource allocation - what role should FNR adopt? How should funding be split? Which other actors should be involved?

The assessment of these strategy options was initially undertaken by participants of the exploratory workshop through a process of discussions, followed by a voting exercise to determine the favoured option. While Strategy option 2 emerged as the generally favoured option, the main conclusion from the session was that appropriate strategy options need to be taken into consideration for each priority field and domain.

6. Outlook and further Options

This report concludes with recommendations of next steps to develop FNR programmes and other policy instruments. These recommendations issue from a joint meeting of FNR board members and the members of the Scientific Council. The outcomes of the first phase of the exercise were presented, debated and the next steps for the 2nd phase fixed. To this end the report proposes the terms of reference for a phase two of the foresight project. These terms of reference present for each thematic field priority domains as they emerged from phase 1.

6.1 Terms of reference for Economy, Law and Finance field

The “economy, law and finance” research field is most likely to contribute towards strategy option 1 (developing Luxembourg’s business base), and strategy option 3 (differentiation strategy). The rationale for strategy 1 is linked to the fact that this research field is strongly business orientated and connected to Luxembourg’s existing business base in this area. Many smaller companies, however, do not currently have strong links to sources of research expertise. This presents opportunities for better connections and joint research between companies and the expertise held within institutions such as the Luxembourg School of Finance. The rationale for the law/finance research field also draws from the unique position of Luxembourg as host of several European institutions including the European Court of Justice and related law services.

Priority domains identified during EWS (not online questionnaire) include:

- Priority 1: Improving Business Environment
- Priority 2: Regulation, Governance and European Integration

The members of the FNR board and the members of the Scientific Council insisted that given Luxembourg’s strong economic orientation towards banking and finance, there is a need to develop a clear priority in this area. Also research domains of interest to small and medium enterprises need exploration as there may be a strong potential for innovation in SMEs. The labour market issues which are at the intersection with the Foresight group on Social Sciences and Humanities should be considered in the two groups, if possible in common. Overall, they expressed the need to strongly associate the partners from the private sector to explore the potential future research priorities.

In terms of implementation issues for phase 2 mapping of existing research competences both in Luxembourg and in the *Grande Region* will be needed to determine areas on which the strategy can build, plus partnership opportunities. Coordination with the Ministry of Economy, Ministry des *Classes Moyennes*, BCL, ABBL, BEI, Court of Justice, LSF will also be necessary. Similar coordination with private sector (banks, insurances), etc will also be needed.

While further competence building in Luxembourg research in this field should be a key goal, the presence of important building blocks there is potential for rapid implementation into concrete funding mechanisms.

6.2 Terms of reference for Environmental Sciences Field

A strategy based on environmental sciences research is likely to contribute primarily to option 1 (building critical mass in the business and user communities of such research). The rationale, here, is linked to the increasing legislative requirements vis-à-vis EU and Kyoto frameworks facing Luxembourg. Strengthening research in this area would also help to meet societal demands for environmental improvements. This should be addressed with a highly scientific approach from the public sector which in turn should provide a favourable environment for the development of spin-off companies as well as attracting companies to Luxembourg.

The EWS workshop has developed the assessment from the questionnaire and proposed the following ranked priorities:

- Priority 1 (in order of ranking):
 1. Water management
 2. Natural environment management
 3. Ecotechnologies
 4. Biodiversity and conservation
 5. Climatology, natural environment and catastrophes forecasting
 6. Bio energies
- Priority 2:
 1. Sustainable production and products,
 2. Sustainable transport and logistics,
 3. Photovoltaic solar energy,
 4. Hydrogen as fuel source⁸

To pursue this strategy it will be important to clarify the existing scientific base clusters in most of these domains. Alongside this there are number of environmental issues, specific to Luxembourg that could provide a focus. In this respect it will also be necessary to determine the number of domains that should be supported, given the broad nature of this research theme.

In addition, the participants stated that the granularity of the domains assessed here need to be reviewed. They felt for example that Photovoltaic solar energy was in fact a sub-category of Ecotechnologies.

Other issues to consider in the implementation include effective coordination with the Ministry of Environment, Ministry of Agriculture, Viticulture and Rural Development,

⁸ These particular domains, although deemed interesting, were ranked lower particularly in view of a lack of a strong research basis. Logistics and Sustainable transport were however described as highly attractive for Luxembourg in various stages if the exercise and care should be taken to reinvestigate the potential for these domains in the 2nd phase.

Ministry for the Interior and Regional Planning, suitable collaboration with users, and partners, as well as networking in the *Greater Region*.

6.3 Terms of reference for ICT field

Analysis of the ICT field undertaken at the EWS and internal discussion within FNR/CMI suggest that the ICT research is likely to contribute primarily to strategy option 1. This is linked to the fact that ICT research is closely connected to the needs of important user communities. Common ground therefore exists for projects of relevance to researchers and business, as well as government organisations pursuing e-service developments.

The rationale for selecting ICT for further domain analysis in phase 2 of the foresight exercise is further supported by the presence of an existing resource base in Luxembourg, characterised by a strong IT-driven sector as well as research activity (building, for example, on earlier FNR funding under the SECOM programme). There is also a strong strategic rationale for prioritising ICT domains. Here, ICT has been identified within a national action for e-Luxembourg, as well as the EU's 7th Framework Programme (FP7). Luxembourg has also become a full member of the European Space Agency (ESA). These frameworks provide a supportive rationale for action, as well as the potential for Luxembourg to access funding and links to partners / expertise. One area in which support could be focused is that of the SME sector, where many companies could benefit from the advances made in this area.

The domain priorities identified as having the greatest coherence with this domain, and associated priority ranking include:

- Priority 1:
 - Security and trust,
 - e-services
- Priority 2:
 - Telecommunications,
 - Multimedia
- Priority 3:
 - Business and IT,
 - Interactive computing technologies,
 - Adaptivity,
 - Modelling and simulation technologies

It should be noted that Adaptivity is not seen as an interesting niche for Luxembourg by some members and that Modeling & simulation technologies should be treated in the thematic field „Physical Sciences & Engineering“.

In progressing the foresight process in relation to ICT a number of implementation issues stand out. As a strategy built around developing the business base it will be important that there is close collaboration with the industry/private sector, with an important coordinator role for Luxinnovation. Similar close collaboration will also be

necessary with the Ministry of Economy, Ministry of Communication (in view of e-services/'e-Luxembourg').

Within the Luxembourg ICT research community opportunities may also exist for stimulating closer collaboration between the activities of the CRPs and the University.

6.4 Terms of reference for Life Sciences field

A strategy build around the Life Science research field is most likely to contribute towards a differentiation strategy (option 3). The rationale for this derives from the highly competitive nature of research in this area – with many countries prioritising life sciences research. Luxembourg, however, appears to possess some comparative strengths in areas such as cancer tissue bank, epidemiology resource base, population structure and diversity and so on. Partnerships are also evident between the CRPs and other actors such as the CHL, along with strong potential for spill over into multidisciplinary domains.

Life sciences research has clear potential to contribute towards societal and health issues. Economic benefits from such research have also been recognised by the Ministry of Economy's desire to create favourable environment for biotechnology companies.⁹

The domain priorities identified as having the greatest coherence with this domain, and associated priority ranking include:

- Priority 1 :
 - 21st century challenges and life-style diseases
- Priority 2:
 - Cardio-Vascular disease,
 - Oncology,
 - Infectious diseases and immunity,
 - Biochemistry and cell biology,
 - Food and human nutrition, Agriculture

The above prioritisation was not supported by all participants of the workshop and will need to be revised in the phase 2 of this exercise.

Implementation issues for phase 2 relate to identifying comparative advantages underlying above domains (research competence and an economic base), and opportunities for multidisciplinary research. This will require close cooperation with the Ministry of the Economy to ensure synergy with national strategies, as well as detailed research to identify areas in which it is possible to maximise spill over potential. The key challenge, however, will be linking these findings to domains in

⁹ Speech Jeannot Krecké, *Minister of the [Economy and Foreign Trade](#)* , 21 of Feb 2006, Conference: Growth factors for Biotechnology by the Ministry of [Economy and Foreign Trade](#)/CRP-santé at the Chamber of Commerce Luxembourg

which there is little competition from other countries, and identification of existing and potential regional/and international partnerships.

6.5 Terms of reference for Physical Sciences and Engineering field

Analysis of the physical sciences and engineering field suggests that it has the potential to contribute towards a strategy based on developing the business base (option 1) and scientific excellence (option 2). This research field, like ICT, demonstrates close proximity to application areas and the involvement of users in research development. It is able to build on the country's existing business cluster in this area and ongoing collaboration between the public and private sectors. Potential also exists to support new research domains that will help business to prepare for the future applications by building scientific excellence in these domains.

The domain priorities identified as having the greatest coherence with this field, and associated priority ranking include:

- Priority 1 :
 - Nanosciences and nanotechs,
 - Materials with novel properties,
 - Supramolecular functional materials
- Priority 2:
 - Engineering,
 - Business opportunities from space,
 - Industrial design technology (Modelling and simulation; numerical methods, integration of modelling and simulation in the design process)

The FNR decision makers recommended not neglecting engineering aspects in this field - though in the first phase of the foresight exercise a large focus has been set on Materials.

Implementation of this terms of reference is likely to face a number of specific issues. A key challenge, here, will be to determine the most appropriate research axes within "Nanosciences and nanotechs" and "Supramolecular functional materials" domains, where potential exists for building scientific excellence with longer term application, in association with international potential partners. Collaboration will also be important for domains such as "Materials with novel properties", but a key issue here will be partnerships with industry, and ensuring sufficient coordination with the Ministry of Economy and Luxinnovation.

6.6 Terms of reference for Social Sciences and Humanities field

Research in the social sciences and humanities is most likely to contribute towards the strategy option of addressing the needs of the Luxembourg society (option 1), as well as the scientific excellence (option 2) agenda linked to internationally recognised standards for methodology in the social sciences and humanities.

The rationale for this research field is linked to the presence of Luxembourg-specific societal issues in areas that research could contribute to. This includes: labour market problems (rise of unemployment; transborder workers); ageing (demographic challenge); cultural issues (important in the multi-cultural context in view of social cohesion); multilingualism (a niche for Luxembourg). Such issues were identified in phase 1 of the foresight exercise as important areas to consider in the future.

Luxembourg is also the home of a developing scientific base at the UL and CEPS, including a track record in setting standards for data and methodology. Overall, however, research in this area can benefit from improvements in competence.

Two large domains have been identified plus one interdisciplinary domain (from the EWS):

- School, work, qualifications, welfare
- Culture, Language Diversity, History, Identity
- One additional interdisciplinary domain (with Health and medical sciences): Ageing

The FNR board members and the members of the Scientific Council expressed the need to specify the 2 large research domains, 'School, work, qualifications, welfare' and 'culture, language diversity, history, identity' and to highlight relevant research themes. Also, if possible, the labour market issues should be treated in common with the Foresight expert panel on economy, law and finance (Phase 2).

A number of implementation issues stand out for phase 2. Given the societal nature of this research challenges it will be important that effective coordination is established with the Ministry of Culture, Education, Labour, Social Security, Family, Health, Economy (statistics) and other relevant actors and users.

The presence of FNR in a national forum on ageing will also help to provide awareness of partners, plus identify synergies with other project opportunities. Understanding competences in areas such as work/labour markets/social security - at the Grande Region level – will also be important here.

6.7 Phase 2

The launch event for the 2nd phase is held on the 16th of October 2006. The 2nd phase builds on the terms of reference outlined above and will focus on further developing the 6 fields. For each field the methodology for phase 2 will be structured around thematic expert panels composed of national and international researchers from the public sector as well as representatives of the research user community and the private sector.

The aim of these panels will be to consider the results of phase 1, plus new research commissioned in areas such as the Luxembourg / *Grande Region* research competencies. Panels will then debate this material, discuss cross discipline research opportunities and refine the issues for implementation. The outcome of these debates will be a list of a limited number of national research priorities of socio-economic interest to Luxembourg. This list will be discussed within the Board of Administration and Scientific Council of the FNR. Finally it will be submitted to the Ministry of Research which will coordinate the discussion on the proposal with key actors from Luxembourg.

It is anticipated that the final output of this process will be the elaboration of governmental programmes supporting the identified national priorities and the development of appropriate funding instruments. The design of the future FNR programmes will be largely dependent on the policy detailed in the governmental programme.

7. Concluding remarks

Although the FNR Foresight exercise is still only about half-way through, it is already apparent that several features of the research system have had an impact on its conduct. Prominent among these is the system's novelty and its associated dearth of statistics and analysis. This was rightly anticipated as a problem, and has necessitated FNR to set aside a significant proportion of the project's time in order to undertake a baseline study. Without such data, it would be difficult to conduct a foresight exercise. Nevertheless, some data remains missing, particularly around the research competences of the PRCs. These are, of course, known in a broad sense, but information on the research activities of individual research groups is not available at the present time.

Other aspects of the system, related mostly to its small size, have also left their mark on the shape and scope of FNR Foresight. For example, the small number of researchers in the country means that the validity of their views is often questioned. Because of this, efforts have been made to include international participants as far as possible, both as a validation of and as a complement to the views of Luxembourg-based researchers. In phase 1, this has meant examining international trends in R&D spending priorities and including international experts into the interview programme. In phase 2, international experts will be invited to meetings to interact with the thematic expert panels and will be asked to prepare reports and make presentations. The aim here is wholly to provoke national experts to adopt a broader perspective on their areas.

Another peculiarity is the large spending increases that are planned over the coming years. These essentially mean that everyone is safe in their current positions, with funding virtually guaranteed, particularly as it would appear to be difficult for the current system to absorb the new budgetary increases. The focus of FNR Foresight is therefore not so much to prioritise among existing research activities, but rather to identify new promising areas for Luxembourg to pursue as part of a strategy to champion in specific scientific domains.

Fortunately, it is recognised that increasing spending on R&D will not, on its own, deliver desirable outcomes. In this regard, both the FNR Foresight and the Luxembourg research system in general face some major challenges for the future. Amongst these are the following sorts of issues:

- How to shift debates on what R&D to perform to a more future-oriented plane?
- How to reduce the influence of existing research agendas on the determination of domain areas?
- How to implement a continuous future-oriented reflection on the research domains?
- How to inform and take into account developments at the University of Luxembourg and the new City of Science?

- How to build capacity in the top priorities, even if some human resources and infrastructures already exist, never mind a situation where little capacity might currently exist?
- How to absorb the significant spending increases proposed?
- How to ensure critical mass whilst maintaining sufficient variety for new opportunities to emerge?

Phase 2 of FNR Foresight and the subsequent decisions processes will need to address these issues if the research system is to follow a fruitful path.

8. Annexes

8.1 Domain origin matrix

The domain origin matrix is an overview of the 8 sources of information utilised or activities undertaken in the construction and finalisation of the long list of research domains. The crosses indicate that that particular source or activity had an impact on the inclusion of a domain into the final list. The sources or activities are divided into two groups:

- Unprompted construction of the original list
- Discussion / prioritisation / finalisation of the list¹⁰

The country analysis column contains 2 pieces of information. The number represents the actual number of countries in the comparative list of 13 that are demonstrating a priority research focus towards that domain. The second piece of information relates to the competition level devised by attributing a weighted score to each domain based on the actual amount of public R&D expenditure (based on Eurostat figures 2001-2004) by the comparator countries.

FNR suggestion for calls for proposals

The domains suggested by the Luxembourg and international research community during the 2005 FNR calls for project proposals exercise.

FP7

The research domain priorities as outlined in the European Union's 7th Framework programme for funding of research and development. The current Framework Programme is FP6, that is due to expire at the end of 2006, with FP7 running thereafter until 2013.

Key Technology for Europe

The priority domains identified in the report of the High Level Expert Group (HLEG) set up by Unit K2 "Science and Technology Foresight" of DG research in 2005 presenting Key Technologies for Europe.

Country Analysis

The domains identified during the country analysis with a group of 13 comparator countries. Weightings were given to each comparator country based on public R&D expenditure (Eurostat R&D statistics 2005).

¹⁰ However during these activities an opportunity was given for the addition or deletion of domains if robust reasoning was demonstrated.

Interviews

The domains identified during the face-to-face interviews held with 50 senior researchers, companies and public administrators both within Luxembourg and overseas, conducted during January and February 2006.

EWS

The domains identified during the Exploratory Workshop conducted in May 2006, with thematic experts from Luxembourg.

Junior Workshop

The domains identified during the thematic workshops held in March 2006 with junior researchers from Luxembourg.

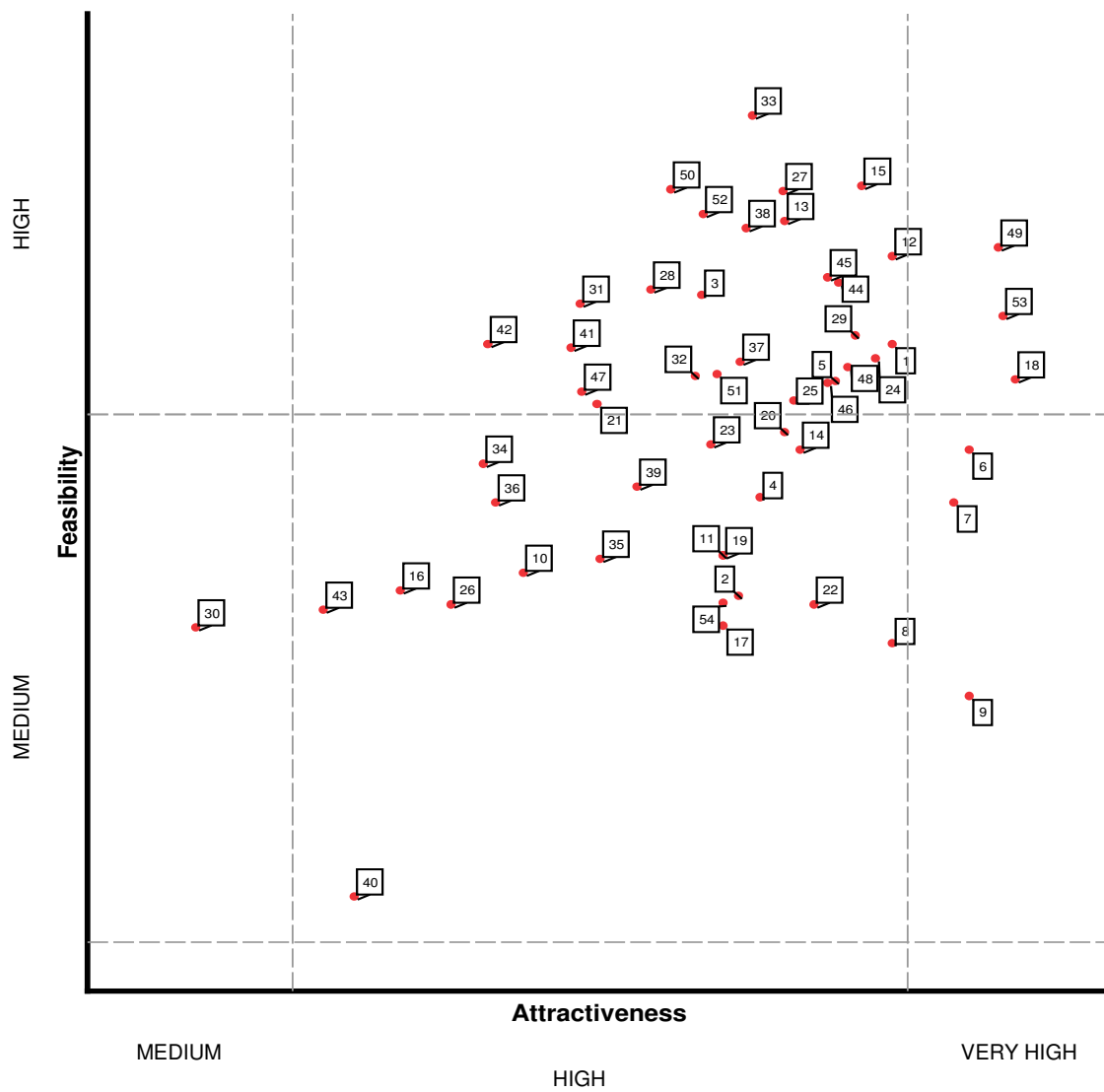
UL, CRPs, CEPS/INSTEAD

The domains identified from the strategies /annual reports of key Luxembourg research institutions.

8.2 Domains assessment through the questionnaire

This table and matrix summarises the questionnaire results and displays domains in terms of their perceived attractiveness and feasibility.

1 Water management	20 Health and environment	39 Housing, civil and urban engineering
2 Biodiversity and conservation	21 Biochemistry and cell biology	40 Supramolecular functional materials
3 Natural environment management	22 Biotechnologies	41 Engineering
4 Earth observation	23 Technologies for health	42 Business opportunities from space
5 Climatology, natural environment and catastrophes forecasting	24 Food and human nutrition	43 Industrial design technology
6 Ecotechnologies	25 Agriculture	44 Demography, childhood, youth and interregional relations
7 Bio energies	26 Animal sciences	45 Language diversity and linguistic competences
8 Photovoltaic solar energy	27 Telecommunications	46 Social Integration and Social Exclusion
9 Hydrogen as a fuel source	28 Multimedia	47 Culture, history and identity
10 Sustainable production and products	29 Interactive computing technologies	48 Cognition and learning
11 Sustainable transports and logistics	30 Intensive calculation and calculation grid (removed at EWS)	49 School, work, qualifications
12 Cardiovascular diseases	31 Software (removed at EWS)	50 Economy and finance (removed) at EWS
13 Oncology	32 Modeling and simulation technologies	51 Economic urban and rural development (removed at EWS)
14 Neurosciences, neurological and mental diseases	33 Business and information technology	52 Management, Business studies and innovation (removed)
15 Infectious diseases and immunity	34 Engineering- simulations and solutions	53 Welfare state
16 Rare diseases, handicaps, regenerative medicine	35 Miniaturizing electronics (removed)	54 Regulation, Governance and European Integration
17 Implants, transplants and organ regeneration	36 Adaptivity	Other E-Services (added at EWS)
18 21st century challenges and lifestyle related diseases	37 Nanosciences and nanotechnologies	Other Security and trust (added at EWS)
19 Substance use and addiction	38 Materials with novel properties	Other Improving Business Environment (added at EWS)



Feasibility vs. attractiveness Matrix