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Ireland's future Research Infrastructure needs

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Martijn Poel
Anke Nooijen
Thyra de Jongh
Matthias Ploeg
Frank Zuijdam

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Management summary

Research Infrastructures are crucial for the advancement of Science, Technology and Innovation (STI). According to the European Commission, the term 'Research Infrastructures' refers to "*facilities, resources and related services used by the scientific community to conduct top-level research in their respective fields*." Examples are scientific equipment, sets of instruments, archives and ICT-based infrastructures.

The definition of Research Infrastructures also encompasses technical operators; (bespoke) buildings; access and support services; and, in specific cases, R&D and education programmes that are linked to the Research Infrastructure and research centres that are the custodians of Research Infrastructures.

The process of *updating Ireland's STI priorities*, over the course of 2014 and 2015, requires an update of Ireland's strategy with respect to Research Infrastructures. For this update the Department of Jobs, Enterprise and Innovation commissioned a study with the following *objectives:*

1. Take stock of the Research Infrastructure investments made to date, in light of the national STI priorities.
2. Identify any future investment needs in the period to 2020 (and beyond) that may be strategically required for the achievement of national STI priorities.

The emphasis of the study is on meeting the second objective. The study approach combined desk research, interviews, a survey about future Research Infrastructure needs and six workshops.

The main conclusions with respect to *taking stock* of past investments in Ireland's Research Infrastructures are as follows:

- The Programme for Research in Third Level Institutions (PRTLI) was crucial for developing, implementing and using Research Infrastructures in Ireland.
- Between 2000 and 2015, PRTLI has awarded €1.2 billion in exchequer and private matching funding for buildings, research centres, research equipment, research programmes and training (in particular structured PhD programmes).
- Outside PRTLI, HEA awarded €88m of direct exchequer funding via the Research Equipment Renewal Grant and Research Facilities Enhancement Schemes. Other substantial investments in Research Infrastructures have been made by Science Foundation Ireland (SFI), domain-specific departments and agencies (in health, agriculture, energy, etc.) and research performing organisations themselves.
- In total, Irish national government invested between €60m and €80m per year in Research Infrastructures.
- Due to these investments, Ireland's research community can now use a broad range of Research Infrastructures for a variety of scientific domains and application areas.
- Under PRTLI cycles 4 and 5 together, a total of €153 million in funding was provided for 20 structured PhD programmes. This concerns the specific costs of developing and operating structured PhD programmes but also the generic costs of PhD projects for a number of cohorts of students.
- Within a period of 10 years, structured PhD programmes have become the norm for PhD education in Ireland. Partly due to PRTLI, the number of PhD students in Ireland increased more substantially than in several other European countries.
- Researchers and other stakeholders stressed the issue of uncertainty about future support by Irish national government for Research Infrastructures (priorities, funding, governance, etc.), structured PhD programmes and funding of PhD education in general.

The main conclusions with respect to *future investment needs* are as follows:

- The Call for Ideas revealed well-motivated needs for Research Infrastructures. The set of 114 Ideas includes Research Infrastructures with a narrow or broad definition, e.g. a focus on equipment or plans for new research centres.
- The Ideas are spread across six scientific domains and many Ideas are relevant for two or more scientific domains. Moreover, the set of Ideas is relevant for Ireland's STI priorities and for a range of business areas and societal challenges.
- The Ideas included information about current and expected collaboration. One of the insights that emerged from the set of Ideas (and the interviews and workshops) is that research-performing organisations in Ireland are becoming more embedded in European networks, consortia and projects.

The two elements of this study – taking stock and exploring future needs – are building blocks for improving the Research Infrastructure strategy for Ireland. Our recommendations are as follows:

- Acknowledge that the new STI strategy will influence the new Research Infrastructure strategy. The new STI strategy will set the priorities in terms of scientific challenges, business opportunities and societal challenges that require investments in, among other things, Research Infrastructures. The new STI strategy may also influence the financial resources available for Research Infrastructures.
- The study addressed how decisions about narrow or broad interpretations of Research Infrastructures will have implications not only for Research Infrastructure support programmes but also for programmes and grants for research centres, research programmes, PhD education, etc. We recommend that the scope of RI support programmes includes core facilities and resources as well as (bespoke) buildings, technical operators, access and support services and RI management. In this scenario, one of the main challenges is to ensure that investments in RIs are aligned with funding of research centres, PhD education, etc. One of the main risks is that the pendulum swings from large, systemic programmes such as PRTLI to isolated, uncoordinated investments in Research Infrastructures, research centres, PhD education, etc.
- A long-term financial commitment should underpin the Research Infrastructure strategy. Research Infrastructure investments require a dedicated and long-term strategy, to steer dedicated and sustainable funding. In many other European countries a structural funding mechanism for RIs has been put into place, as they could not be funded out of the block grants of universities and research centres/institutes nor from the budget of research councils.
- Ireland needs a Research Infrastructure roadmap to establish the prioritisation of national and pan-European Research Infrastructures; align Research Infrastructure priorities with STI priorities; facilitate political support at all policy levels; help to define national and regional budgets; and allow for long-term financial commitment by public and private stakeholders. The process of developing the roadmap should engage relevant ministries, agencies, industry, etc. The roadmap should be updated every 3 or 4 years.
- Ireland could benefit from installing a Permanent Committee on Ireland's Research Infrastructures, or allocating responsibilities to an existing committee or research council. The roadmap and the allocation of funding for Research Infrastructures need strategic leadership. Other responsibilities of the committee could be to increase the visibility and accessibility of Research Infrastructures (and address the issue of access charges); to develop a time schedule for dedicated Research Infrastructure calls (in collaboration with the organisation(s) that implement the calls); to set the criteria to assess proposals (scientific excellence, societal and business relevance, collaboration rather than duplication, etc.); and to develop a framework for monitoring the output and impact of Research Infrastructures.

1. Introduction

1.1 Objectives of the study

The importance of *(large) Research Infrastructures* has increased significantly over the last decades. Research Infrastructures (RIs) are crucial to the advancement of science in all scientific fields. It is only with (unique) research facilities that one can make material visible or carry out pioneering experiments. These Research Infrastructures also contribute to a more efficient way of working in the world of science and are often a focal point for multidisciplinary research. Moreover, RIs are a key instrument for bringing together a wide array of stakeholders, including industry, to look for solutions to many of the problems facing society today.[1]

The *Irish national government* acknowledged the importance of Research Infrastructures for achieving the objectives of Ireland's National Development Plan (2000-2006 and 2007-2011) and Ireland's Science, Technology and Innovation priorities (adopted in 2006 and updated in 2010/2011). The main government-financed intervention is the Programme for Research in Third Level Institutions (PRTLI). This programme is coordinated by the Higher Education Authority (HEA) and funded by the Department of Education and Skills (2000-2010) and the Department of Jobs, Enterprise and Innovation (2010-ongoing). Using five calls for proposals, PRTLI has invested in buildings, large Research Infrastructures, specific items of research equipment, research centres, research programmes and structured PhD programmes. Both HEA and Science Foundation Ireland (SFI), established in 2003, launched dedicated calls for research equipment. In addition, a number of government departments (such as Agriculture, Food and the Marine), public agencies (such as Enterprise Ireland and IDA) and research councils provided grants for research equipment and Research Infrastructures in general. Moreover, universities, Institutes of Technology and research performing organisations such as Tyndall Institute used some of their funding (such as block grants and core funding) to invest in Research Infrastructures.

The process of *updating Ireland's Science, Technology and Innovation priorities*, over the course of 2014 and 2015, requires an update of Ireland's strategy with respect to Research Infrastructures.

The *objectives of this study*, commissioned by the Department of Jobs, Enterprise and Innovation, are to:

3. Take stock of the Research Infrastructure investments made to date, in light of the national STI priorities.
4. Identify any future investment needs in the period to 2020 (and beyond) that may be strategically required for the achievement of national STI priorities.

The emphasis of the study is on meeting the second objective, while exploring existing and emerging needs ('gaps and opportunities'), focusing on RIs of national and international relevance and addressing the importance of national and European/international collaboration. In addition, the study addressed investments in *structured PhD programmes* as this has been an important element of PRTLI.

The results and recommendations of the study aim to feed into the process of updating Ireland's STI strategy. Elaboration and implementation of the recommendations will depend on the updated STI strategy (priorities, budgets, governance, etc.). In short: there is interaction between updating the STI strategy and updating the Research Infrastructure strategy.

[1] See Technopolis, *The role and added value of large-scale research facilities* (2011).

The next three paragraphs will introduce the concept of Research Infrastructures, the approach of the study and the structure of the report, respectively.

1.2 Research Infrastructures

According to the European Commission, the term 'Research Infrastructures' refers to "*facilities, resources and related services used by the scientific community to conduct top-level research in their respective fields.*"[2] The definition by the European Commission specifies the following elements:

- Major scientific equipment or sets of instruments;
- Knowledge based-resources, such as collections, archives or structured scientific information;
- Enabling ICT-based infrastructures such as Grid, computing, software and communication; and
- Any other entity of a unique nature essential to achieve or enable excellence in research.

Research Infrastructures can be single-sited or distributed (such as medical imaging equipment and grid computing, respectively), physical or virtual (such as libraries and software tools, respectively), fixed at one location or mobile (such as clean rooms and research vessels, respectively).

The associated *human resources* such as technical operators, archivists, database experts and overall management are included in the definition of Research Infrastructures. In the context of 'facilities' the definition also covers (bespoke) *buildings* that accommodate Research Infrastructures. In the context of 'related services' the definition includes *access and support services*. Examples are providing access to biobanks, repositories and test beds and assisting users with data analytics, technology development, testing and certification. These services can be provided to colleagues as well as third party users. In nearly all cases, this concerns researchers that work in industry, academia, organisations for applied research and public agencies (e.g. in the field of meteorology and environment).

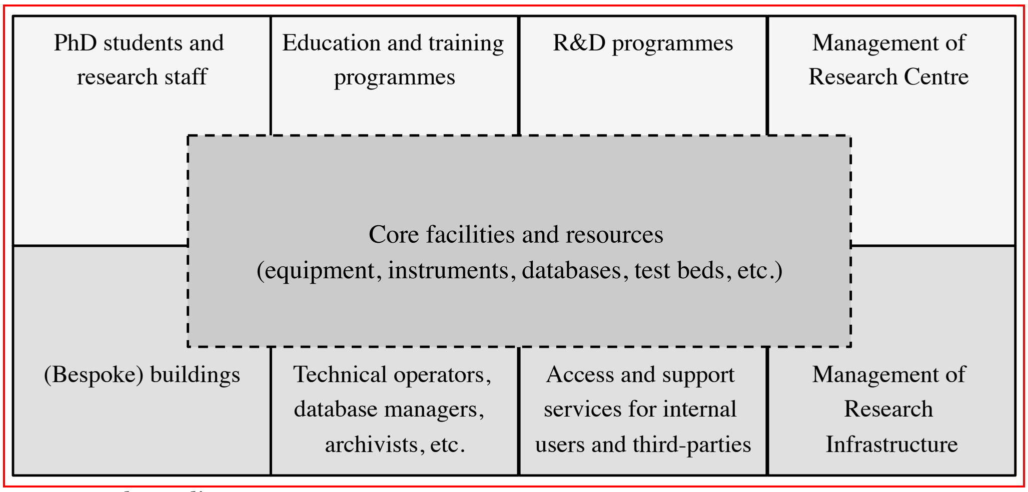
As with any definition, there are grey areas. For instance, *R&D, education and training programmes* can be entangled with a specific RI with the aim of improving the functionalities of a RI, expanding databases, being a lead user, collaborate with external lead users, building a user community, etc. The link between a research and education programme and a RI may also be small and indirect (reputation effects, incidental use, etc.). Along the same lines, a set of unique instruments may be at the very heart of a *research centre*, creating a thin line between the RI and the research centre. Alternatively, the set of instruments may be one of many resources used by a research centre.

Figure 1 (next page) illustrates how a specific Research Infrastructure can be scoped, managed and funded with a relatively narrow or broad scope. In short, a RI can:

1. Be focused on its core facilities and resources;
2. Reflect an integrated approach and also include its (bespoke) building, technical operators, access and support services and/or management; or
3. Reflect a systemic approach in which the RI is entangled with R&D, education and training programmes, over and above researchers and students being merely a user of the RI.

[2] See http://ec.europa.eu/research/infrastructures

Figure 1 Narrow and broad interpretations of Research Infrastructures



Source: Technopolis Group

As mentioned previously, the focus of the study is on *large* Research Infrastructures. This is also referred to as large-scale research facilities. The main characteristic of large RIs is their (potential) national and international relevance, i.e. being used by several research groups inside and outside Ireland. Typical examples are national biobanks, High Performance Computing facilities, national repositories and international databases. The rule of thumb applied in this study, is that large RIs require an initial investment of at least €700,000 Euro.

1.3 Approach of the study

Figure 2 summarises the approach for the *retrospective* part of the study (taking stock of past investments in Ireland's Research Infrastructures and structured PhD programmes) and the *prospective* part of the study (exploring Ireland's future Research Infrastructure needs). As mentioned, the emphasis of the study is on the prospective part. The study consisted of a desk study, 20 semi-structured interviews, a survey and 6 workshops. The data collection and analysis for this study took place between January to June 2015.

Figure 2 Study approach

	Taking stock	**Future needs**
Desk research	X	
20 interviews	X	X
Call for Ideas		X
6 workshops (x 10-15 participants)		X
3 presentations/discussions	X	X

Source: Technopolis Group

The main sources for the *desk research* were documentation by HEA and SFI (such as lists of Research Infrastructure grants and research equipment grants) and reports on

Ireland's Research Infrastructures.[3] Another valuable source has been the LIRE database for Large Items of Research Equipment.[4] Regarding structured PhD programmes, the main sources have been policy documents in Ireland, HEA data and Eurostat statistics on the number of PhD students in selected European countries.

In 18 out of 20 semi-structured *interviews*, questions were asked about past investments in Ireland's Research Infrastructures (priorities, procedures, trends, opportunities and challenges), the current Research Infrastructure landscape in Ireland (strengths, best practices, white gaps and needs) and national and international collaboration in developing and using Research Infrastructures (trends, opportunities and challenges). Interviewees were also invited to formulate recommendations for relevant Irish government departments and public agencies. Lastly, a number of questions dealt with structured PhD programmes (investments, relevance, impact, suggestions). 2 out of 20 interviews, including one group interview facilitated by the Irish University Association, focused on structured PhD programmes.

A *Call for Ideas* (survey) was used to explore future Research Infrastructure needs in terms of facilities and resources, academic relevance ('the science case'), relevance for Ireland's 14 STI priorities ('the strategy case'), industry relevance ('the innovation case'), collaboration with national and international stakeholders ('the partnership case') and rough estimates of investment needs (distinguishing between initial investments and annual operational costs). In the context of the science case, the Call for Ideas contained a question on the primary and secondary scientific domain. The list of six scientific domains is adapted from the OECD:[5]

- Natural Sciences, Mathematics & Computer Sciences
- Engineering & Technology
- Medical & Life Sciences
- Environmental & Agricultural Sciences
- Social Sciences & Humanities
- E-infrastructures & E-science

The Call for Ideas was sent to 160 research performing organisations, including university research centres (large and mid-sized centres), university faculties, Institutes of Technology, SFI Research Centres, Enterprise Ireland/IDA Technology Centres, Tyndall Institute, Teagasc and the Marine Institute. Upon suggestions made by senior representatives of universities, the Call for Ideas was forwarded to a number of small university research centres as well as to the Digital Repository Ireland and the Irish University Association.

In *six workshops* with 10 to 15 stakeholders (researchers, directors of research centres, directors of Research Infrastructures, Vice Presidents for Research, representatives of public agencies, etc.) the results of the Call for Ideas were validated. In short: did the survey capture the Research Infrastructure needs that are circulating in the Irish research community? Which needs should be added? The workshops also allowed for a discussion on a number of needs that emerged in several individual Ideas, submitted in the same or in different scientific domains (cf. multidisciplinary research). Note that a

3 PA Consulting, Ten Years On: Confirming Impacts from Research Investment (2011), HEA/Forfas, Research Infrastructures in Ireland – Building for tomorrow (2007).

4 The LIRE database contains research equipment items that require at least €100.000 Euro initial investments costs. As such, the database contains medium-sized and large items.

5 Revised Field of Science and Technology (FOS) classification in the OECD Frascati manual (version 26-Feb-2007, DSTI/EAS/STP/NESTI (2006)19/FINAL). The sixth, cross-cutting, domain of E-infrastructures and E-science is added because of its relevance for Research Infrastructures.

workshop was organised for each of the six scientific domains. Lastly, workshop participants were challenged to formulate recommendations about future governance and funding of Ireland's Research Infrastructures.

The *draft results* of the study were presented and discussed in a Technology Ireland meeting (with representatives of DJEI, EI, HEA and SFI); in a meeting with the Minister for Jobs, Enterprise and Innovation and the Minister for Skills, Research & Innovation; and in a meeting of the Inter-Departmental Committee on Science, Technology and Innovation.

1.4 Structure of the report

This report is structured in the following way. Chapter 2 provides an overview of the policy context. Chapter 3 discusses past investment in Ireland's Research Infrastructures. Chapter 4 addresses the PRLTI funding for structured PhD programmes. Chapter 5 contains the results of the Call for Ideas. Chapter 6 presents the main conclusions and recommendations.

2. Policy context

2.1 National STI strategy in Ireland

In the early 2000s, Ireland committed itself to drastically increase its investment in research and development by both government and industry. The increased investment was a centre-piece of the broader National Development Plan (NDP) 2000-2006, and triggered a prolonged period of investment in the expansion of the country's research and technological capabilities, designed to support the development of high-value products and services and propel the economy up the value chain. This included a strengthening of the Programme for Research in Third Level Institutions (PRTLI) initiative to build out Ireland's research infrastructure, and the launch of Science Foundation Ireland (SFI) initiative, to expand Ireland's academic research base in strategic areas of priority.

In the subsequent NDP (2007-11) there was an enhanced focus on developing research into commercial activity by indigenous enterprises, and increasing the quality and quantity of research, development and innovation activities, as highlighted in the Strategy for Science Technology and Innovation 2006-2013 (SSTI). The government's vision for 2013 was for Ireland to be internationally renowned for the excellence of its research, and to be at the forefront in generating and using new knowledge for economic and social progress, within an innovation driven culture[6]. Recognising that science, technology and innovation in Ireland at that time was still relatively underdeveloped, the government defined the following objectives in the national STI strategy:

- Increased participation in the sciences by young people;
- Significant increase in the numbers of people with advanced qualifications in science and engineering;
- Enhanced contribution of research to economic and social development across all relevant areas of public policy including agriculture, health, environment and the marine and natural resources;
- Transformational change in the quality and quantity of research undertaken by enterprise - both directly and in cooperation with third level institutions;
- Increased output of economically relevant knowledge, know how and patents from those institutions;
- Increased participation in international S&T cooperation and transnational research activity;
- An established international profile for Ireland as a premier location for carrying out world class research and development;
- Greater coherence and exploitation of synergies to mutual advantage in the development of STI policy on the island of Ireland.

The SSTI set out a roadmap for Ireland to develop as a centre of world-class research by significantly increasing its research capacity and international outputs. However, resource constraints and the economic downturn meant that, de facto, policy has been focused mainly around four core strategic policies:

1. Prioritisation of public funds into areas of research that offer most potential for economic recovery and social progress;
2. Consolidation of resources in units of scale and scientific excellence;
3. Increased collaboration to maximise return on investment and to optimise success under EU Framework programmes; and
4. Facilitating the translation of knowledge and the transfer of technology into jobs.

[6] Irish government. Strategy for Science Technology and Innovation 2006-2013.

In 2010, the government set up a Research Prioritisation (RP) steering group, tasked with making recommendations to the Government on focus areas for the next phase of Ireland's science, technology and innovation strategy. In its findings report the steering group concluded that policy in the area of research and innovation had served the country well, and that the broad areas around which budgets had been oriented (e.g. ICT and biotechnology) had been appropriate for building a broad base of excellence in fundamental research, underpinning science and technology.[7]

However, it also concluded that it was now appropriate to move towards a more top-down, targeted approach, and to focus investments so as to have critical mass in areas that link more precisely to current and likely future societal and economic needs. Specifically, it set out 14 areas for the Irish Government to steer its €500m scientific research budget in order to drive commercialisation, and ultimately translate innovative scientific research into jobs. The 14 priority areas are:

- Future Networks & Communications;
- Data Analytics Management, Security & Privacy;
- Digital Platforms, Content & Applications;
- Connected Health & Independent Living;
- Medical Devices;
- Diagnostics;
- Therapeutics – synthesis formulation, procession and drug delivery;
- Food for Health;
- Sustainable Food Production and Processing;
- Marine Renewable Energy;
- Smart Grids & Smart Cities;
- Manufacturing Competitiveness;
- Processing Technologies & Novel Materials;
- Innovation in Services and Business Processes.

With regard to infrastructures, the RP steering group concluded that given the significant investment in physical infrastructure that has taken place in recent years, there will be significantly less investment required in new buildings and equipment in the coming years. Investment in the years ahead should be targeted at the maintenance of equipment and specific integrating infrastructure required for the priority areas. Examples of integrating infrastructure as mentioned by the RP steering group:

- Clinical and translational research infrastructure - an integrated national system of clinical and translational research capacity that can help Ireland capture the local and global benefits of investment in health related research;
- Data repositories - serviced by experts to capture and enable the exploitation of publicly available data from research and administrative sources to benefit future research;
- E-infrastructure - underpins all research endeavours in the country.

This resulted in the recommendation by the RP steering group that "Funding programmes for physical infrastructure should adapt to recognise the current priority to maintain and support the operation of existing infrastructure, while also incentivising the sharing of resources, thereby utilising their full capacity. A key requirement to achieve this will be a national inventory of all significant publicly funded infrastructure and equipment."

In addition the RP steering group identified a number of important science and technology platforms that will underpin the priority areas - Basic Biomedical Science, Nanotechnology, Advance Materials, Microelectronics, Photonics and Software Engineering - recognising that this is not an exhaustive list.

RP steering group formulated in total thirteen recommendations aimed at improving the efficiency and effectiveness of the STI system, which were adopted by the government in 2012. The implementation of research prioritisation is the government's primary STI

[7] Report of the Research Prioritisation Steering Group, 2011.

policy goal for the five-year period, 2013-2017. A RP Action Group was established to drive the implementation of the recommendations by re-aligning the majority of competitive public research funding around the priority areas and to enhance framework conditions general for these areas to thrive.

The first Progress Report on the implementation of Research Prioritisation was published on July 4th 2014. With regard to Research Infrastructures, a number of actions were taken, among which:

- The Higher Education Authority (HEA) has completed a national inventory of all significant publicly-funded research infrastructure and equipment. A database of Large Items of Research Equipment (LIRE) has been developed and is online accessible (www.hea.ie/lire).
- In parallel with compiling this national inventory, HEA has developed guidelines for the Higher Education Institutions on providing access to users from the institutions and enterprises. The key principle embodied in the guidelines is that by default, all public funded equipment should be available to users from other HEIs and from enterprise.
- SFI has set out an access charge plan that allows researchers to include access charges to major infrastructure as a line item in the budgets of their grant applications.
- Separately, the Marine Institute continues to operate a National Research Vessel Access Programme, which is an infrastructure access support programme that provides researchers with access to the national research vessels. The programme maximises the use of this significant state investment in world-class research infrastructure and provides researchers with opportunities to partner with European colleagues, building future research collaborations.
- Infrastructure investments of the Environmental Protection Agency have been limited and typically linked to existing infrastructures, thereby enhancing the use of shared resources and locations.
- The Health Research Board is investing in the infrastructures, networks and ancillary supports that are fundamental enablers of health research. Current HRB infrastructure investments include support for the three Clinical Research Facilities at Cork University Hospital, University College Hospital Galway and St James Hospital Dublin, as well as the Centre for Advanced Medical Imaging (CAMI) there. Furthermore, the HRB is making progress towards establishing a national bio-banking system and support infrastructure in conjunction with others. It is also developing a national clinical research framework to link clinical research facilities and centres across the country and ensure common standards, high quality data management and policy development, and act as a one-stop-shop for enterprise engagement with this infrastructure.[8]

At this point, the most important national financers of RI investments are HEA through the Programme for Research in Third Level Institutions (PRTLI) and Science Foundation Ireland (SFI). Through PRTLI €1.2 billion in exchequer and private matching funding has been invested in research infrastructures from 2000-2015. Between 2004 and 2012 SFI has invested €67m through its dedicated research equipment and RI calls (in addition to generic investments in SFI Research Centres). Chapter 3 elaborates on investments made by HEA and SFI.

[8] National Research Prioritisation Exercise: First Progress Report, June 2014.

2.2 EU support for Research Infrastructures

(Large) Research Infrastructures are among the most expensive scientific expenditures; frequently enormous capital investments are required. Therefore, there is a need for bringing resources together and for collaborating on a national, European or even global scale. At the national level, many countries have developed an RI roadmap; Ireland developed such a roadmap in 2007.[9] At the European level there are the European Strategy Forum on Research Infrastructures (ESFRI) Roadmap and the RI support schemes under the EU Framework Programmes. Through international collaborations and participation in EU funded projects, researchers are able to increase access to infrastructures and secure funding for infrastructures.

EU support for RIs in the context of its Framework Programmes (FPs) began with FP2 (1987-1991). A significant milestone was the establishment of the European Strategic Forum on Research Infrastructures (ESFRI) in 2002. ESFRI brings together representatives of EU Member States and of the European Commission. It is a strategic instrument to develop the scientific integration of Europe and to strengthen its international outreach. The on-going mission of ESFRI is to support a coherent and strategy-led approach to policy-making on research infrastructures in Europe, and to facilitate multilateral initiatives leading to the better use and development of research infrastructures, at EU and international level.[10] The ESFRI roadmap will be updated in 2016.[11] Aside from ESFRI, the FPs also offer funding opportunities for RIs. The main focus of these funding schemes is on integration and coordination and the preparatory phase of RIs.

In 2012 the European Commission launched the Reinforced European Research Area Partnership for Excellence and Growth. The launch document sets out the ERA priorities, among them the effective investment and use of research infrastructures. According to the Commission, the challenges are:

- To ensure national commitments to the implementation of the ESFRI Roadmap;
- Achieve maximum value-for-money from investment at all levels;
- Overcome obstacles to construction and operation;
- Ensure open access for researchers to RIs across Europe.

In order to achieve these goals stronger and more focused RI support is needed. The 2011 *Debrecen Declaration*[12] acknowledged a number of synergies between Structural Funds and Framework Programme funding for the design, preparation and construction of RIs, and recognised that the lack of joint programming initiatives contributed to imbalances in RI distribution in Europe. The Commission underlined the importance of pooling regional, national and European Union funds and urged that member States (re)confirm their financial commitments for the construction and operation of RIs. Furthermore, it was proposed that the European Research Infrastructure Consortium (ERIC) legal instrument should be used to better link RIs, but that new legal forms of partnerships should also be used for the creation of stronger linkages between RIs and regions.

Large Research Infrastructures are one of the priority areas in Horizon 2020. The aim of the European Commission is to "endow Europe with world-class research infrastructures that are accessible to all researchers in Europe and fully exploiting their potential for scientific advancement and innovation." In order to achieve this, the EC has formulated three lines of activities.

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[9] Forfas, Research Infrastructures in Ireland – Building for tomorrow (2007).

[10] http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri

[11] http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri-roadmap

[12] http://www.wire2011.eu/upload/document/34/Debrecen%20Declaration.pdf

- The first activities are targeted to the development of new world-class research infrastructures. Support will be provided for the implementation and operation of the research infrastructures listed on the ESFRI Roadmap. Support will cover the preparatory phase of new ESFRI projects, and the implementation and the operation phases of prioritised ESFRI projects. Further world-class facilities will also be part of this action.
- The second set of activities aims at optimising the use of the national facilities by integrating them into networks and opening their doors to all European researchers. This is a continuity of the so-called Integrating Activities under FP7.
- The third action will support further deployment and development of ICT based e-infrastructures which are essential to enable access to distant resources, remote collaboration, and massive data processing in all scientific fields.[13]

More concrete lines of action of the Commission in this respect will be:

- Support access to RIs through Horizon 2020, as well as support the on-going overall integration of EU RIs, particularly those awarded ERIC status.
- Encourage Member States to link RI roadmaps to the ESFRI roadmap and smart specialisation strategies in Structural Funds co-financed research and innovation programmes, and reinforce the capacity of less favoured regions to host and participate in RIs of pan-European and international interest, and support training programmes for the management of such RIs.
- Develop, in cooperation with ESFRI, e-IRG and other stakeholders, a Charter of Access that sets out common standards and harmonized access rules and conditions for the use of RIs.
- Work with ESFRI to set priorities for implementing the Roadmap and to provide advice and guidance to Member States on overcoming legal, financial or technical obstacles to implementation.
- Define with ESFRI, e-IRG and other stakeholders common evaluation principles, impact-assessment criteria and monitoring tools that can be applied in regional, national and European programmes to help combine funds from different sources.
- Work with e-IRG to promote the alignment of EU and national approaches to eRI development and use.[14]

The strategy of the EC regarding RIs will be to align different funding streams (regional, national and European) and to stimulate better linkages between RIs. The EU policy can give guidance in identifying options for international collaboration and EU funding. Under the new Horizon 2020 Research Infrastructures programme –aimed at endowing Europe with world-class research infrastructures that are accessible to all researchers in Europe and beyond– there are four thematic areas:

- INFRADEV – for the development of infrastructures (€199m);
- INFRA-IA – to increase access of infrastructures (€140m);
- E-INFRA – support for e-Infrastructures (€177m); and
- INFRA-SUPP – a variety of support measures (€38.5 m).

[13] http://ec.europa.eu/programmes/horizon2020/en/area/research-infrastructures

[14] Communication form the Commission, Reinforced European Research Area Partnership for Excellence and growth, July 2012.

The MERIL database provides an overview of all currently openly accessible RIs in Europe of supranational relevance across all scientific domains (e.g. from archives and statistical offices to biobanks, satellites and particle accelerators).[15]

3. Investments in Ireland's Research Infrastructures

3.1 Introduction

Substantial investment in RIs in Ireland has taken place through programmes such as those run by HEA (mainly the Programme for Research in Third Level Institutions - PRTLI) and Science Foundation Ireland (SFI). Other investments in RI have been made by the European Commission (mainly FP7), by universities and IOT (e.g. from core funding), Tyndall, Teagasc and the Marine Institute (e.g. from block grants), research calls by domain-specific departments, public agencies (Enterprise Ireland, Health Research Board, Environment Protection Agency, etc.), investments by industry, philanthropy, etc.

This chapter describes in more detail the investments made to date in RI in Ireland, focussing on the PRTLI and SFI investments and to some extent FP7 funding.

3.2 PRTLI

The PRTLI research funding scheme was set up in 1998 by HEA. With PRTLI, HEA introduced the first competitive excellence initiative in Ireland. This was followed by the establishment of the SFI, in 2003, and the Irish Research Council for Science Engineering and Technology (IRCSET) and the Irish Research Council for Humanities and Social Sciences (IRHSCC), which also fund tertiary research. Together these reforms have significantly increased the level of funding for research in higher education institutions in Ireland. PRTLI was funded under the National Development Plan 2000-2006, with assistance from the European Regional Development Fund and with private funding through a public/private financial framework.[16] Since 1998 five PRTLI funding cycles have taken place (Figure 3).

Figure 3 Five funding cycles of PRTLI

	Announced	Funding Period	Buildings & Equipment (€M)	Research Programmes & People (€M)	Total (€M)
Cycle 1	1999	2000-2003	177.5	28.6	206.1
Cycle 2	2000	2001-2004	48.8	29.7	78.5
Cycle 3	2001	2002-2006	178.0	142.4	320.4
Cycle 4	2007	2007-2013	131.3	129.4	260.7
Cycle 5	2010	2011-2015	248	99.6	347.6
		Total	**783.6**	**429.7**	**1213.3**

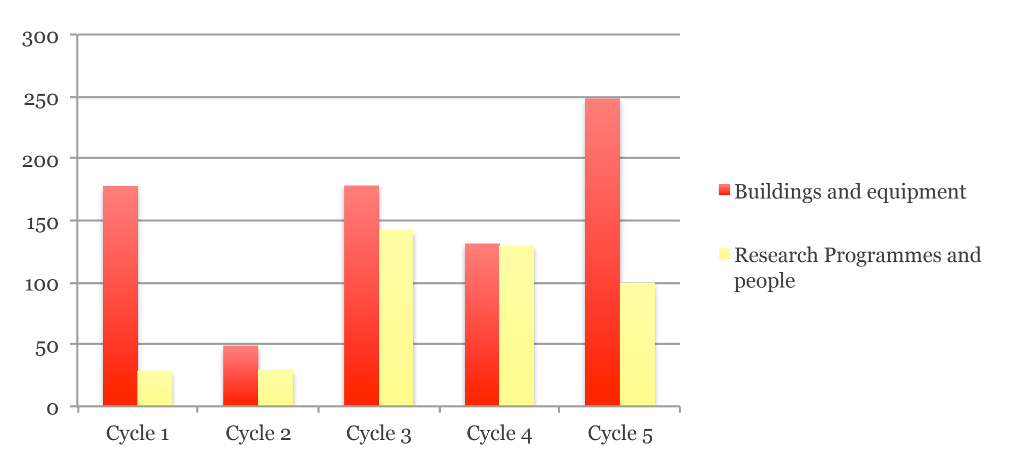
Source: HEA

[15] http://portal.meril.eu/converis-esf/publicweb/startpage?lang=1

[16] The Programme for Research in Third level institutions (PRTLI) Impact Assessment, Volume 1. Report by the international assessment committee, 2004.

Figure 4 presents the investments in the two main categories of PRTLI: buildings and equipment and Research Programmes and people.

Figure 4 Funding awarded under PRTLI programme (x €1m)



Source: HEA

To date PRTLI has awarded €1.2 billion in exchequer and private matching funding, of which 65% on buildings and research equipment.

The 5th Cycle of PRTLI funding (2011-2015) is currently approaching its conclusion, with approved projects completed or well underway (and ending in 2016). PRTLI provides integrated financial support for institutional strategies, programmes and infrastructure in key areas of research, spread across all disciplines. PRTLI funds projects in new or emerging research areas, personnel and other technical support for projects, research equipment, and buildings. In the 4th and 5th cycle, there is less emphasis on buildings and more emphasis on research platforms/communities and collaborative research programmes. Projects funded under the 4th and 5th Cycle also include structured PhD programmes (see Chapter 4).

In general, PRTLI supports research in science, technology, humanities and the social sciences, including business and law.

The objectives of the PRTLI programme are:[17]

- To enable a strategic and planned approach by third level institutions to the long-term development of their research capabilities, consistent with their research missions and with their existing and developing research strengths and capabilities.
- To promote the development of high quality research capabilities in third-level institutions, so as to enhance the quality and relevance of graduate and postgraduate output and skill at all levels.
- Within the framework of these objectives, to provide support for outstandingly talented individual researchers and teams within institutions and the encouragement of co-operation between researchers both within the institutions and between institutions – having regard to the desirability of encouraging inter-institutional co- operation within and between the two parts of the binary system and within Ireland, the EU and internationally.

Through the first three funding cycles 45 centres and initiatives were supported across

[17] The Programme for Research in Third level institutions (PRTLI) Impact Assessment, volume 1. Report by the international assessment committee, 2004.

five thematic research areas. The top 3 investments of PRTLI are presented in Figure 5 per call.

According to an economic impact assessment performed in 2011, the investments so far have resulted in marked increases in research outputs (e.g. publications), a threefold increase in the human capital research base and a validated impact in 50 companies, a commercial impact of €754m, and an employment impact of 1.255 jobs, among others.[18] The impact assessment recognised that the investment programmes (among which PRTLI) have resulted in the rapid growth, expansion and improvement of research in Ireland, but that further investment is needed. However, to ensure 'value for money' a recommendation was made to clarify the targeted commercial and economic impacts at the point of funding and monitored and pursued at every stage of the research process. By doing this, and by taking a very strategic approach to the support of research, focused on building on success and key areas of strength, a platform exists for significant future economic success.

Figure 5 Top 3 of PRTLI's investments per call (based on Direct Exchequer Funding per institution)

	Investment	**Private Funding (*€1000)**	**Direct Exchequer Funding (*€1000)**	**Lead institution**
Cycle 1	Ussher Library	12.888	12.888	TCD
	Conway Institute of Biomolecular and Biomedical Research	12.358	12.358	UCD
	National Centre for Biomedical Engineering Science	8.869	10.692	NUIG
Cycle 2	Environmental Research Institute	5.863	11.041	UCC
	Biopharmaceutical Sciences Network	2.618	6.746	RCSI
	Ecotoxicology, Waste Reduction & Air Pollution	616	1.822	CIT
Cycle 3	National Institute for Cellular Biotechnology (NICB)	1.270	33.013	DCU
	Dublin Molecular Medicine Centre (DMMC)	3.269	20.946	RCSI
	Programme for Human Genomics (PHG)	3.270	17.337	RCSI
Cycle 4	UCD Science Centre	17.547	17.547	UCD
	Nembes - Network Embedded Systems	500	13.578	CIT
	National Programme in Research and Training in (Bio)Pharmaceuticals and Pharmacological Sciences (BioPharma)	0	12.446	DCU
Cycle 5	ESI-PhD-ENS: Earth Systems Institute – Structured PhD programme in Earth & Natural Science	0	6.210	UCD
	Science Centre: TCD/UCD Innovation Alliance: UCD Science Centre – Systems Biology Ireland	0	3.561	UCD
	DAH: Digital Arts and Humanities Structured PhD Programme	0	3.081	DAH

Source: HEA

[18] PA Consulting Group. (2011) Ten Years On: Confirming Impacts from Research Investment. A case study focusing on the direct commercial and economic impacts from exchequer investment into centres and initiatives supported by the Programme for Research in Third Level Institutions (PRTLI) 2000-2006.

In addition to PRTLI, HEA launched a Research Equipment Renewal Grant (2007) and Research Facilities Enhancement Schemes (2008). Here, a narrow definition of RIs was taken. Together, the 2007 grants and the 2008 schemes added up to €88m of direct exchequer funding.

3.3 SFI programmes

Science Foundation Ireland is the national foundation for investment in scientific and engineering research in Ireland. SFI supports investment in Research Infrastructures through dedicated funding calls and other programmes. An important programme in this respect is the Research Infrastructure Programme. The objective of this programme is to support researchers in building and sustaining necessary infrastructural capacity to enable high quality, high impact and innovative research. The emphasis of this programme is on collaborative efforts and on liaising with industry with the goal of strengthening and sustaining Ireland's research base. The RI programme was launched in 2004 with a call for proposals, followed by a call in 2007 and 2012. These three calls resulted in grants (total grants per call) of €5m, €31m and €31m, respectively. Figure 6 shows the top 3 of investments made by SFI per call.

Figure 6 Top 3 of SFI's RI investments per call

	RI	Grant in €	Lead Institution
2004	600Mhz nmr	500.000	TCD
	Antibody isolation system	499.089	DCU
	Laser scanning confocal	483.930	TCD
2007	Helium Ion Microscope	2.134.703	TCD
	Automated System of High- throughput Sub-cloning, Protein Expression and Purification	1.650.686	UCD
	Combined PET/SPECT/CT small animal imaging system	1.541.724	UCD
2012	Aberration-corrected TEM	5.160.342	TCD
	High-Performance Computing infrastructure	3.708.768	DIAS
	Ocean Energy Test Bed	2.299.831	Marine Inst.

Source: SFI

SFI's 2020 Agenda sets out its strategic plan for the period 2013–2020. There are two actions in this agenda that are directly related to Research Infrastructures:

- Invest in the research infrastructure, using Exchequer funds and leveraging funds from EU and other sources, and ensure that the infrastructure is sustained through good access/charge models;
- Increase participation with infrastructure funding sources, so as to better align human resources with infrastructure.[19]

The importance of access models is addressed by SFI as well as HEA (and the European Commission and OECD). The widest possible access to research infrastructures is considered to increase the value for money for the state and for the research community in general. HEA has developed national guidelines for access by researchers to research infrastructure hosted by higher education institutions or other research bodies in Ireland. The document sets out that all research infrastructures in publically funded higher education institutions and other research bodies should be made available for use. Access should not be limited to Irish researchers, but also include international researchers and external users (including, where relevant, researchers from civil

[19] SFI (2013). Agenda 2020. 2013 Review.

society), particularly industry users. The document furthermore describes the guidelines regarding the institutions' access policies, access rates (full commercial rates for industry), use of the RI by external users and the role of research funders.

Increasingly, SFI requires well-developed access plans (including indications about access charges) as part of proposals for RIs. This is to encourage third party use of RIs. A second objective is to increase financial sustainability of RIs by using access charges to cover parts of the annual operational costs. In future SFI Research Programmes, funds may be requested for paying access charges for RIs.

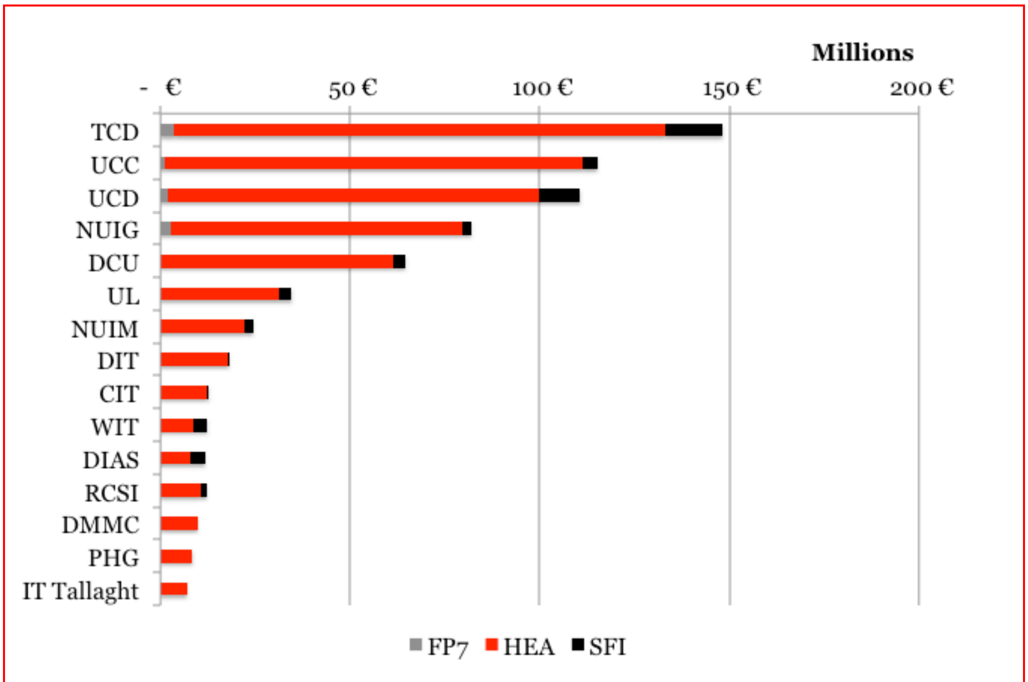
3.4 FP7 funding for Irish Research Infrastructures

Irish organisations accounted for 72 participations in the part of Europe's Seventh Framework Programme for Research and Technological Development (FP7) that is dedicated to Research Infrastructures. Of these 72 participations in research projects/consortia, four participations concern a role as project coordinator (Appendix C). Projects started between 2007 and 2013.

Participations by Irish organisations led to EC grants of, in total, €15.5m. Irish organisations also participated in other parts of FP7 (ICT, energy, environment, health, SSH, etc.) in which RIs are developed, installed or used. A rough estimate is that the direct financial contribution of FP7 to Ireland's RIs added was around €20m.

Figure 7 illustrates that organisations in Ireland that were successful in acquiring FP7 projects/funding, obtained substantial RI funding in national programmes. To some extent, this is because participation in European programmes such as FP7 and Horizon 2020 requires national matching funds and/or the availability of RIs.

Figure 7 HEA (mostly PRTLI), SFI and FP7 funding of RIs (2000-2013)



Source: Technopolis Group

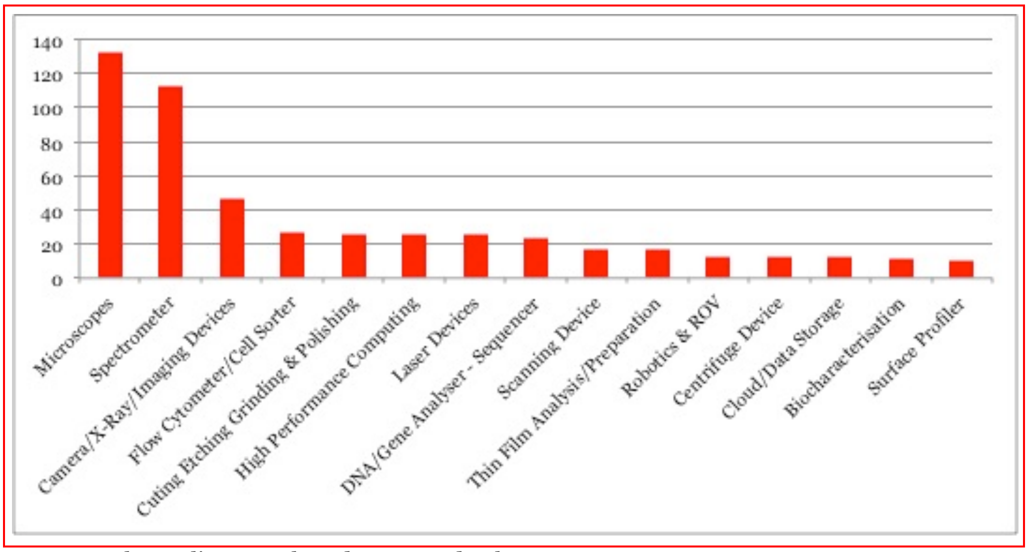
Building on the financial data (and indications) discussed above, our estimation is that Irish national government invested between €60m and €80m per year in Research Infrastructures. As discussed throughout Chapter 2, PRTLI adopted a relatively broad interpretation of RIs.

3.5 The LIRE database: indications about the current RI landscape

In addition to taking a financial perspective on 'taking stock' of past investments in Research Infrastructures, the study team used the LIRE database of Large Items of Research Equipment in Ireland. This online database contains items of €100.000 and more, owned by Higher Education Institutions. As such, the database covers mid-sized and large items of research equipment (and Research Infrastructures in general) while it does not cover the equipment owned by Tyndall, Teagasc and the Marine Institute. The LIRE database is managed by HEA. One of the main objectives is to increase the visibility and accessibility of RIs. Data entry relies on self-reporting. The functionalities of the database have been extended April/May 2015 (e.g. additional search options and contact details).

Figure 8 provides a first indication of the volume and variety of research equipment items currently available in Ireland.

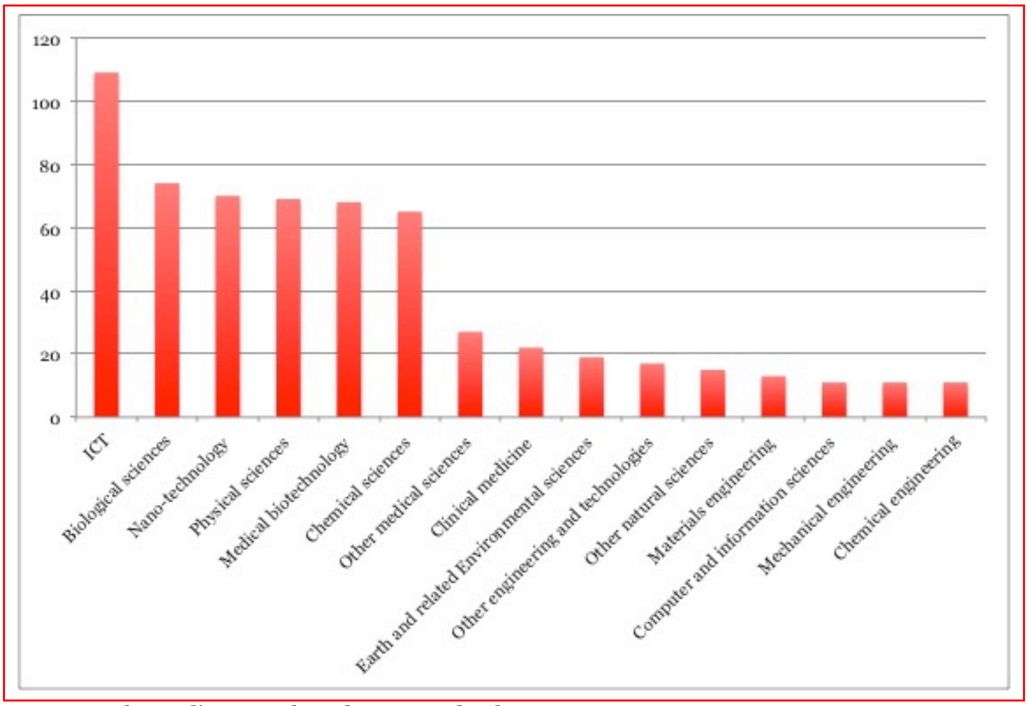
Figure 8 LIRE: top 15 research equipment (number of items)



Source: Technopolis Group based on LIRE database

Figure 9 provides additional information about the number of research equipment items per scientific subdomain (using a categorisation by HEA).

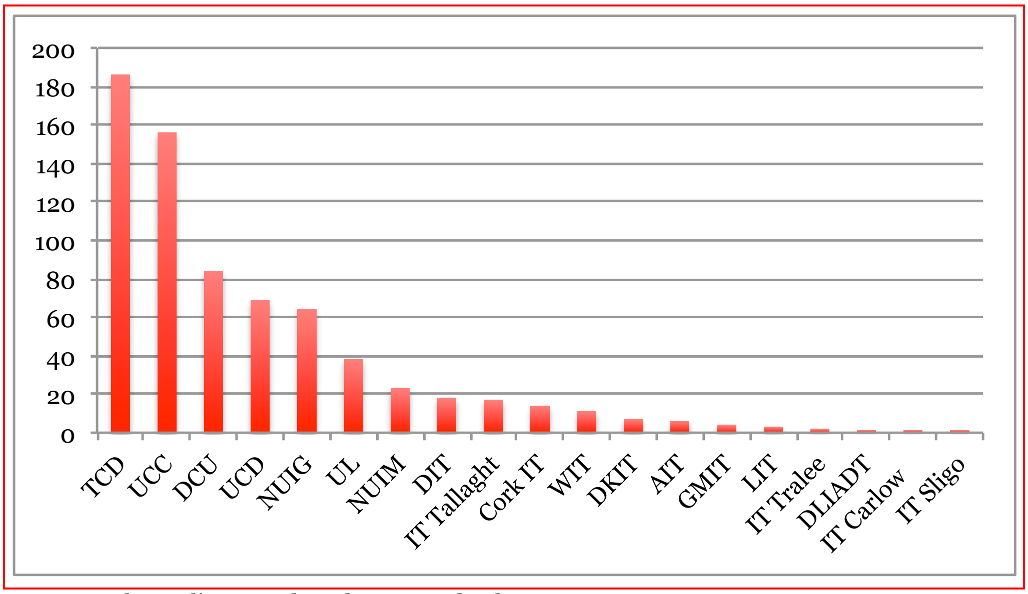
Figure 9 LIRE: number of research equipment items per scientific subdomain



Source: Technopolis Group based on LIRE database

Figure 10 illustrates the distribution of equipment across Higher Education Institutions, which partly reflects the size of these institutions (e.g. TCD and UCD being the largest universities in Ireland, based on the number of students).

Figure 10 LIRE: research equipment per organisation



Source: Technopolis Group based on LIRE database

Lastly, Figure 11 provides details about important loci of research equipment within Ireland's seven universities. Again, this reflects the variety of research equipment and application areas (e.g. chemistry, biotechnology, medical sciences, physics, ICT and engineering).

Figure 11 Units mentioned most often within the seven universities

University	Specific institute/school/affiliation/partner		
TCD	Crann	School of Chemistry	Institute of Molecular Medicine
UCC	Tyndall	Biochemistry	Analytical & Biological Chemistry Research Facility
DCU	National Institute for Cellular Biotechnology	National Centre for Sensor Research	National Centre for Plasma Science and Technology
UCD	Conway Institute of Biomolecular & Biomedical Research	Centre for Synthetic & Chemical Biology	Chemical & Bioprocess Engineering
NUIG	National Centre for Biomedical Engineering Sc.	Experimental physics	Chemistry
UL	Materials & Surface Science Institute	Mobile & Marine Robotics Research Centre	Physical Education and Sports Sciences
NUIM	Biology	Chemistry	National Centre for Geocomputation

Source: Technopolis Group based on LIRE database

3.6 Insights from the interviews

The first main insight from the interviews is the consensus about the crucial role of PRTLI in supporting the Irish research community in catching up with other Western European countries in terms of deploying and using state-of-the-art RIs. This message is consistent with previous reports, e.g. Forfás (2007): Research Infrastructure in Ireland: Building for tomorrow; and PA (2011): Ten Years On: Confirming Impacts from Research Investment.

The second main insight from the interviews is the uncertainty about future investments for maintenance, upgrades/reorientation and new RIs. In short: what will happen after the 5th cycle of PRTLI? All interviewees emphasized the tension between on the one hand RIs requiring a long-term vision, roadmap and commitment by all stakeholders and on the other hand the current uncertainty about public support for RIs in Ireland (in terms of priorities, funding level and governance).

Interviewees confirmed the PRTLI interpretation of RIs, ranging from individual pieces of equipment, suites of equipment, buildings and supporting third parties, to research, training and research centres. One illustration is that, when asked about good practices, interviewees mentioned centres/institutes such as Tyndall, CRANN, the Marine Institute, NIBRT, HEAnet, ICHECH and iCRAG as well as facilities such as the Digital Repository Ireland and SmartBay Ireland.

Interviewees discussed the evolution of PRTLI and the interaction with other relevant programmes. The first three cycles of PRTLI (before the financial and economic crisis) were summarized as catching up, getting used to investments in RI (priority setting, planning of calls, management of RIs, etc.) and having an emphasis on investments in buildings and research centres.

During and following the crisis, the RI landscape was perceived as becoming more diverse, with new research centres/institutes and RIs emerging (the term 'fragmentation' was used) and national and international collaboration increasing at a slow pace (a number of centres are intensifying collaboration and several multinationals are investing in research in Ireland). There is less emphasis on buildings and more emphasis on instruments/facilities (including more databases and e-infrastructures, in line with FP7 priorities) and structured PhD programmes.

The small role of Irish actors in consortia for FP7 Research Infrastructures ('below juste retour') is an illustration of the phase of RI developments in Ireland. Additional steps are needed to become a leader in selected fields.

In the context of increased national collaboration, interviewees discuss access policies and access charges. In general, interviewees agree with SFI and HEA initiatives to increase the transparency and harmonisation of access policies. However, there were questions about the efficiency of procedures, the 'right' level of access charges and whether these charges are sufficient to cover (parts) of the annual operational costs. To some extent, this depends on other research support schemes, e.g. whether grants for individual researchers include a substantial budget for using research equipment. Visibility of RIs is considered an important enabler for increased use of RIs.

4. PRTLI investments in structured PhD programmes

4.1 Background

At the recommendation of the European University Association (EUA), an increasing number of European countries have in recent years begun offering Structured PhD Programmes. These programmes offer graduate students an extensive accredited course programme, designed to help prepare them for careers outside of academia by providing transferable professional skills training. They tend to be more geared towards collaborative and interdisciplinary work than traditional PhD programmes. Structured PhD programmes can differ in their exact form and purpose, with some primarily centred on thematic areas and others more general in nature. The first are often – though not exclusively – cohort-based with synchronised enrolment of students. General programmes, by contrast, more commonly accept new students throughout the year. According to the EUA, by 2010 almost two-thirds of European institutions had established structured doctoral programmes.

Ireland adopted the structured PhD model in 2006. This move was driven by the 2004 OECD recommendations that Ireland double its doctoral graduate output and focus more on preparing graduates for careers outside of academia. Following the launch of the SSTI 2006-2013, structured PhD programmes were rolled out on a national scale and have since become the new standard of doctoral education in Ireland. The PhD graduate skills statement (2010, updated in 2014), published by the Irish Universities Association (IUA), describes the desired learning outcomes and skills for all PhD graduates. Individual programmes therefore all need to be designed to offer appropriate modules for the development of these required skills.

In Ireland, the shift to structured PhD programmes has been supported by funding of national initiatives such as the Strategic Innovation Fund (SIF), IRCSET and in particular PRTLI. PRTLI Cycle 4 already focused on development of enhanced graduate programmes and provided funding for structured graduate education mechanisms, including graduate schools. This move was given even greater momentum under Cycle 5, when support was provided to universities for the creation and further development of structured PhD education initiatives, by funding core student costs, appropriate supervisory and technical capability, mobility costs and delivery of generic, transferable and specialised skills modules associated with the project. It specifically encouraged collaboration between institutions on PhD teaching and training. A key aim was to promote developments that would have a long-term impact on an expanded and enhanced programme of graduate research education.

Under Cycles 4 and 5 together (2007-2015), a total of €153 million in funding was provided for 20 structured PhD programmes (Figure 12). These PRTLI supported programmes are usually cohort-based. The funding provided by PRTLI covers the standard, generic costs of the PhD project, as well as the additional costs that are specifically associated with provision of a structured educational programme. Currently, all seven Irish universities, as well as two Institutes of Technology (Dublin and Cork) and the Royal College of Surgeons in Ireland receive PRTLI funding for one or more programmes.

Figure 12 PRTLI supported Structured PhD Programmes

PRTLI Cycle	Structured PhD Programme	Partner institutes	Funding (million)
Bioscience & Biomedical			
4	The National Graduate Enhancement Programme in (Bio) pharmaceuticals and Pharmacological Sciences	DCU, UCC, UCD, TCD	€12.763
4	The National Bio-photonics and Imaging Platform - Graduate Programme in Cell Signalling & Imaging	DCU, DIT, NUIG, NUIM, RCSI, UCC, UL	€17.787
5	Structured PhD Programme in Molecular and Cellular mechanisms underlying inflammatory processes	TCD, UCD, UCC, NUIG	€7.301
5	ED4LIFE – Structured PhD Education for Life Sciences	CIT, UCC	€0.293
Translational Biosciences & Biomedical			
4 & 5	Molecular Medicine Ireland Clinical & Translational Research Scholars Programme (evolution of Clinician Scientist Training Programme)	NUIG, TCD, UCC, UCD	Cycle 4: €13.427 Cycle 5: €4.317
5	Structured PhD Programme in Biomedical Engineering and Regenerative Medicine	NUIG, UL	€2.764
5	Bio-Analysis and Therapeutics Structured PhD Programme	DCU, RCSI, NUIM, ITT	€5.640
Arts, Humanities & Social Sciences			
4	The Graduate School of Creative Arts and Media (GradCAM)	DIT, NCAD, UU	€2.148
4	The Irish Social Science Platform - National Graduate Programme in Social Sciences	NUIG, NUIM, DCU, UCC, UL	€18.167
5	Digital Arts and Humanities Structured PhD Programme	NUIG, NUIM, RIA, TCD, UCC, QUB, UU	€6.828
Environment, Marine & Sustainable Energy			
4	Environment & Climate Change: Impacts and Responses Graduate Programme	UCC, TCD, NUIG, NUIM, UL, CIT	€5.425
5	Earth Systems Institute Structured PhD Programme in Earth and Natural Sciences	UCD, TCD, NUIG, UL	€9.662
Materials & Technology (includes Platform Technology and ICT)			
4	Network Mathematics Structured PhD Programme	NUIM & TCD	€2.255
4	Lero: The Irish Software Engineering Research Centre and Graduate School	UL	€2.136
4	NEMBES – Network Embedded Systems Graduate Education Programme	CIT, UCC, UCD, TCD	€7.631

4 & 5	INSPIRE- A National Graduate Education Programme in Nanoscience and Nanotechnology (evolution of INSPIRE Graduate School)	NUIG, CIT, DCU, DIT, UCC, UCD, UL	Cycle 4: €11.932 Cycle 5: €3.761
5	Graduate Research Education Programme in Engineering	TCD, UCD, UCC, DIT	€5.364
5	Dublin Graduate Physics Programme	UCD, TCD, QUB	€4.455
5	PhD Programme in Simulation Science	UCD, TCD, NUIG	€3.623
5	Telecommunications Graduate Initiative	TCD, UCD, UCC, NUIM, DCU, DIT, WIT	€5.581
DCU = Dublin City University; NUIG = National University of Ireland, Galway; NUIM = National University of Ireland Maynooth, TCD = Trinity College Dublin; UCC = University College Cork; UCD = University College Dublin; UL = University of Limerick; CIT = Cork Institute of Technology; DIT = Dublin Institute of Technology; WIT = Waterford Institute of Technology; ITT = Institute of Technology Tallaght; NCAD = National College of Art and Design; RCSI = Royal College of Surgeons in Ireland; RIA = Royal Irish Academy; QUB = Queen's University Belfast; UU = University of Ulster			

Source: HEA

This study aimed to document universities' experiences with implementation of structured PhD programmes and identify key challenges and risks. In particular, the study focused on whether universities have been able to mainstream these programmes into their activities, structures and budgets, and whether the current funding model is sustainable.

To assess universities' experiences with structured PhD programmes, a group interview was conducted with deans and coordinators of graduate studies from Dublin City University, University College Dublin and Trinity College Dublin, and representatives of the IUA. Additionally, issues concerning the structured PhD programmes were discussed in 18 interviews that focused on Research Infrastructures.

A concise desk review was conducted to review experiences with the implementation of similar structured programmes for graduate education in Germany, the Netherlands and Denmark. The purpose of this review was to identify common challenges as well as potential solutions, appropriate to the Irish context.

4.2 Findings

4.2.1 Structured PhD programmes in Ireland

Based on interview data, the move to Structured PhD Programmes in Ireland appears to have been received rather positively by the various parties involved. The universities report high satisfaction rates amongst their students, who appreciate the ability to tailor their course work to their individual needs and interests. They can do so by selecting from existing courses (e.g. Masters programmes), modules, master classes, summer schools and seminars. Some courses are organised centrally across the university, whilst others are discipline specific. PRTLI funding has been instrumental in the development of new modules in new and emerging areas of research. Examiners have also provided positive feedback on the quality of the outputs generated by the PhD students, whilst employers have indicated that they feel graduates bring added value through industry-relevant expertise. As illustrated in Figure 12, most PRTLI supported programmes are hosted by more than one institution. Students in these programmes have the opportunity to follow modules at different universities, which has promoted collaboration and exchange between universities and disciplines.

It is plausible that the PRTLI funding directly contributed to the increased enrolment of PhD students in the period following the introduction of the structured programmes

(Figure 13). A number of other European countries, such as Austria and Denmark, have shown similar upward trends but overall the increase in Ireland is above average (Figure 14). It should, however, be noted that in recent years the enrolment has been declining again, particularly in areas of science, mathematics and computer sciences (Figure 15). This underscores the need to continue investing in doctoral education in Ireland.

Figure 13 Number of PhD students enrolled in Ireland in the period 2003–2013

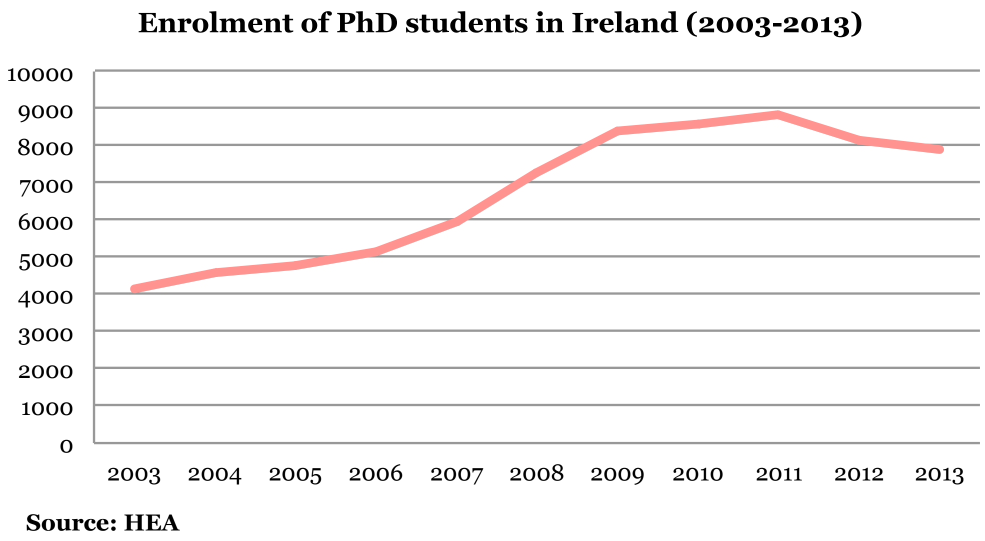


Figure 14 Trends in enrolment of PhD students in selected European countries

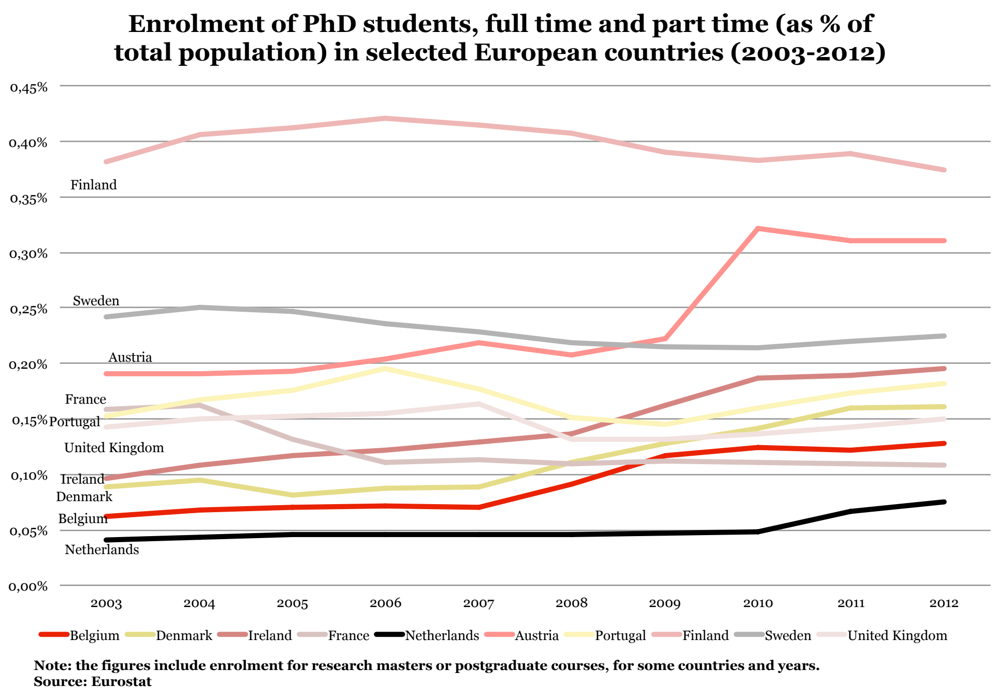
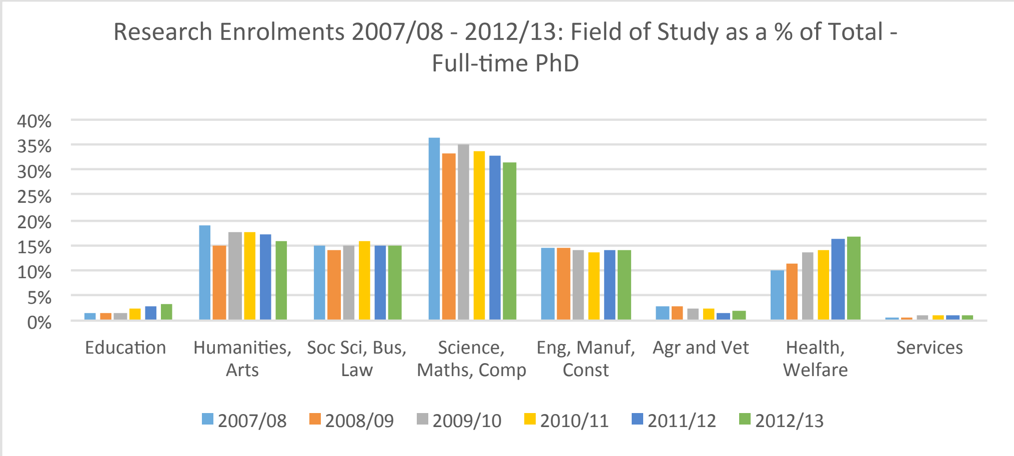


Figure 15 Relative rates of enrolment of PhD students per scientific domain



Structured PhD programmes in combination with PhD grants (provided by PRTLI and other programmes) could increase chances that PhD students finalise their thesis within the target period of four years. Confidential data provided by the Irish University Association indicates that this effect emerged in a number of universities (the average time between admittance of PhD students and finalisation of the PhD thesis being reduced by three to six months). This effect appears to depend on the exact details of grants and other mechanisms of supporting PhD students and, hence, the time that PhD students have to spend working in the labour market (for additional income). Recent data provided by one university, covering a period in which a smaller proportion of PhD students are funded by PRTLI, indicates that a smaller proportion of PhD students finalise their thesis within the target period of four years.

Despite the generally positive reception and the impact on enrolment, structured PhD programmes have experienced a number of significant challenges. First, an important risk identified by several interviewees is that of potential overburdening of students. With an increased course load for development of general skills that are not specific to the research focus, students have less time to devote to their main research tasks and writing of the thesis.

Moreover, the problem of overburdening extends to university administrators, programme coordinators and faculty as well. Because of the degree of interuniversity collaboration and information exchange, the structured programmes require more administration than traditional PhD programmes, which were run primarily through the individual research institutes. To cope with this increased administrative load, interviewees indicate that at their respective universities the PRTLI supported programmes are coordinated by dedicated administrative officers. Further additional costs are incurred by the need to develop new teaching modules. These universities express an inability to absorb the additional costs associated with the creation and operation of the structured programmes into their core funding. This apparent inability to mainstream these programmes threatens their long-term sustainability. The PRTLI funding is thus considered a prerequisite for successful programme continuation. It is, furthermore, noted that the programmes are often also highly reliant on individual 'champions' at their institution.

The additional costs associated with structured programmes over traditional PhD education have not been sufficiently mapped. It is likely that these vary significantly between individual programmes, depending on their size, duration and novelty. Some programmes have been comparatively small, with single cohorts of students. For such programmes there is limited opportunity to recoup the initial costs associated with their creation. In this light, interviewees called for more focus on continuing and, where necessary, adapting existing programmes with a proven track record rather than continuously creating new programmes based on the prevailing 'mood of the day'. Some cost savings might be realised by reducing unnecessary duplication of modules across programmes and universities, provided this is done with sufficient care to ensure availability of essential courses for all students.

4.2.2 Structured PhD programmes in other countries

4.2.2.1 The Netherlands

In the Netherlands graduate education follows both the more traditional PhD format and that of the structured programmes. Increasingly, graduate education in the Netherlands is being provided through graduate schools. Here, PhD students follow a combination of compulsory general skills classes and subject specific electives. Although most universities still employ the traditional model, there is a noticeable shift towards more structured programmes. The University of Twente, for example, as of 2014 has switched completely to structured programmes, delivered through its Twente Graduate School. PhD students compose their own educational programme, along the lines of their discipline cluster. Graduates are required to complete a programme worth 30 European Credit points, of which half are for general academic skills and career development. For the 2014-2015 academic year the additional costs for this programme have been borne by university funds designated for staff development of PhD students.[20] These are, however, considered insufficient and the university is currently seeking a more structural solution to address the funding gap for subsequent years.

4.2.2.2 Germany

Similar to the Dutch model, PhD candidates in Germany have a choice between traditional 'individual' doctorate programmes and structured programmes. Although most students are still on the first path, structured programmes are becoming increasingly popular. It is estimated that currently 8% of doctoral candidates in Germany are participating in structured programmes.[21] Most of these programmes are provided by the around 200 "Research Training Groups" (Graduiertenkollegs), and the 45 graduate schools (Graduiertenschulen). Graduate education at Research Training Groups follows a focused research programme and the number of participants is restricted. By contrast, programmes at the graduate schools vary in size, structure and thematic scope, depending on the strategies of the coordinating host institutes.

The Research Training Groups are funded by the German Research Foundation (DFG) for a funding period of 4.5 years and a maximum of two funding periods. An individual doctoral researcher can receive funding for 36 months. The graduate schools, on the other hand, are supported by the Excellence Initiative. The German states also support a number of structured doctoral programmes at individual higher education institutions. It is not known to what extent these different funding mechanisms influence the success and sustainability of individual Structured PhD Programmes in Germany.

4.2.2.3 Denmark

Denmark currently has two programmes that have some kinship to the structured PhD programmes in Ireland: the Industrial PhD Programme, and the structured programme in Innovation and Entrepreneurship at Copenhagen Business School (CBS). The first responds to the need for more programmes that better prepare PhD candidates for careers in industry, and strengthens the ties between academia and the private sector.[22] The second focuses on general skills development and improvement of the academic quality and competitiveness of PhD graduates in Denmark.

[20] In the Netherlands PhD students have the status of salaried employees.

[21] The German doctorate – A guide for doctoral candidates (2015), Federal Ministry of Education and Research. Available at http://www.research-in-germany.org/en/jobs-and-careers/info-for-phd-students/how-to-obtain-a-phd.html.

[22] http://innovationsfonden.dk/en/application/erhvervsphd

The Industrial PhD programme is a long-standing three-year industrially focused research project and PhD education. The project is carried out by a PhD candidate in collaboration between a company where the candidate is employed and a university. The candidate's work is equally divided between the company and the university. This programme is funded by Innovation Fund Denmark, which provides a grant to the private sector company involved.

In 2010 CBS introduced the first fully structured PhD programme in Denmark.[23] This PhD programme in Innovation and Entrepreneurship started with a cohort of 7 students, all foreign, and was funded by the Danish Research Council. As is common in Denmark, the programme has a duration of only three years. Consequently it has proved difficult to balance offering sufficient training and adequate time for research. A self-evaluation of the research unit where the programme is taught notes that the resources for the programme are limited as much of the funds go towards the stipends of candidates (similarly to the Netherlands, in Denmark PhD candidates receive a wage).[24] It, furthermore, observes that this type of programme is labour intensive, posing significant demands on the time of faculty members who are involved in teaching and supervision. It is therefore felt that at the existing levels of resources, this type of programme would not be scalable or sustainable for the long run.

4.3 Conclusions

Structured PhD programmes have been successfully rolled out across all Irish Universities. This move has been widely welcomed by students, universities and future employers alike. The programmes are felt to have contributed to the quality and relevance of graduate education in Ireland, boosting Ireland's competitiveness in the market for higher education. The programmes, however, are overly reliant on external support from, in particular, PRTLI as universities are unable to fully absorb the associated costs. The reliance on PRTLI is further exacerbated as under the current model the funds are needed not only for the additional costs associated with the structured programmes, but also to cover the basic costs of PhD projects. Consequently, the sustainability of many of the programmes is in question. It is therefore essential for the future of PhD education in Ireland to identify more sustainable funding models.

Experiences from the Netherlands, Germany and Denmark, illustrate the need for sustained financing, preferably with a solid base of core funding. To better understand universities' financial support needs for offering graduate education, it would be beneficial to have an adequate breakdown of costs, distinguishing between the costs of creation of new programmes and the operational costs for continuation of existing programmes. If future support schemes for structured PhD programmes were to focus mainly on the additional, specific costs of structured PhD programmes, other funding schemes and core funding would become more important to support graduate education in Ireland.

[23] http://cbsobserver.dk/innovating-innovation-phd-cbs

[24] Copenhagen Research Unit on Open Innovation and Entrepreneurship (CRUISE), World Class Research Environment at the Copenhagen Business School, 2008- 2013: Self-evaluation report (2011), prof. K. Laursen.

5. Results of the Call for Ideas

5.1 Introduction

This Chapter presents the results of the Call for Ideas and additional insights that emerged during the six validation workshops.

Section 5.2 provides the overall results across the six scientific domains. Based on an analysis of the set of 114 Research Infrastructure Ideas that have been submitted the results demonstrate,

- What are the needs in terms of the balance between scientific domains;
- Between upgrades/reorientation of existing RIs and the need for new RIs;
- Between Research Infrastructures that are defined narrowly or broadly, between initial investment costs and annual operational costs;
- Between different types of expected users;
- Between investments that are expected from different types of stakeholders?

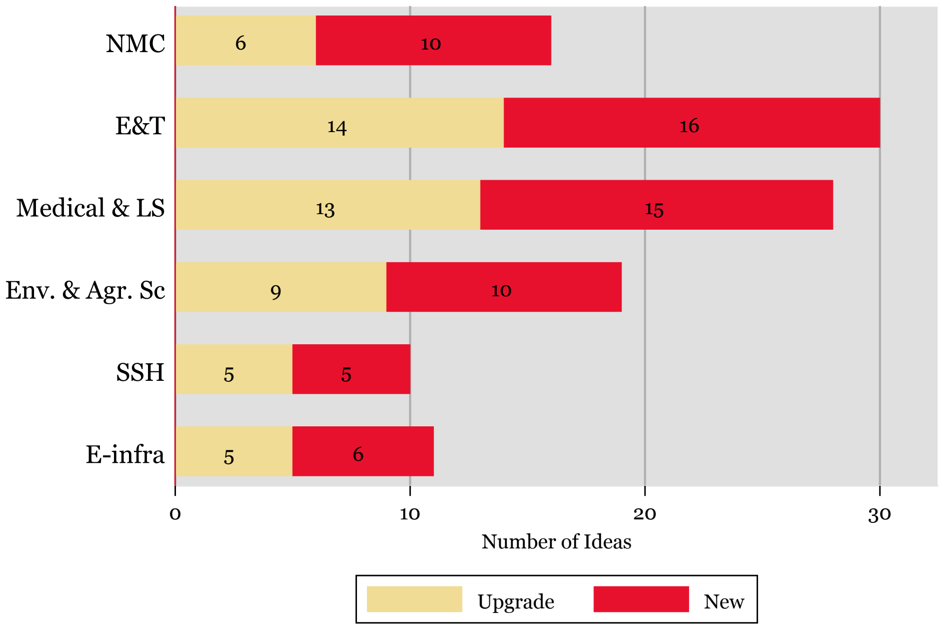
Section 5.2 also includes additional insights obtained during the workshops.

Section 5.3 provides additional details about the RI Ideas within, and across, the six scientific domains. The full list of Ideas is provided in Appendix D.

5.2 Analysis across scientific domains

Figure 16 (next page) illustrates how the total number of 114 Research Infrastructure Ideas is spread across the six scientific domains that are referred to in this study. Figure 16 also presents how many Ideas concern an upgrade or reorientation of an existing RI (such as technological improvements, new functionalities, increased scale, integration of several RIs and increased accessibility) and how many Ideas concern a new RI.

Figure 16 Number of Ideas per scientific domain: upgrade and new RIs



(N = 114)
Q: Please choose the situation which applies to your RI

Source: Technopolis Group

A first observation is that most Ideas have been submitted for the scientific domains of *Engineering & Technology (E&T) and Medical & Life Sciences*. In 30 and 18 Ideas, respectively, respondents ticked E&T and Medical & LS as the primary scientific domain. To some extent this may reflect that E&T and Medical & LS require substantial investments in RIs (and benefited from PRTLI) and the high variety of research centres in these fields (SFI Research Centres, centres within one university, Institutes of Technology, collaborative centres between universities and hospitals, between universities and industry, etc.). These organisations appear to be responsive to calls about Research Infrastructures, which may also be influenced by their scale (e.g. large faculties of science and engineering).

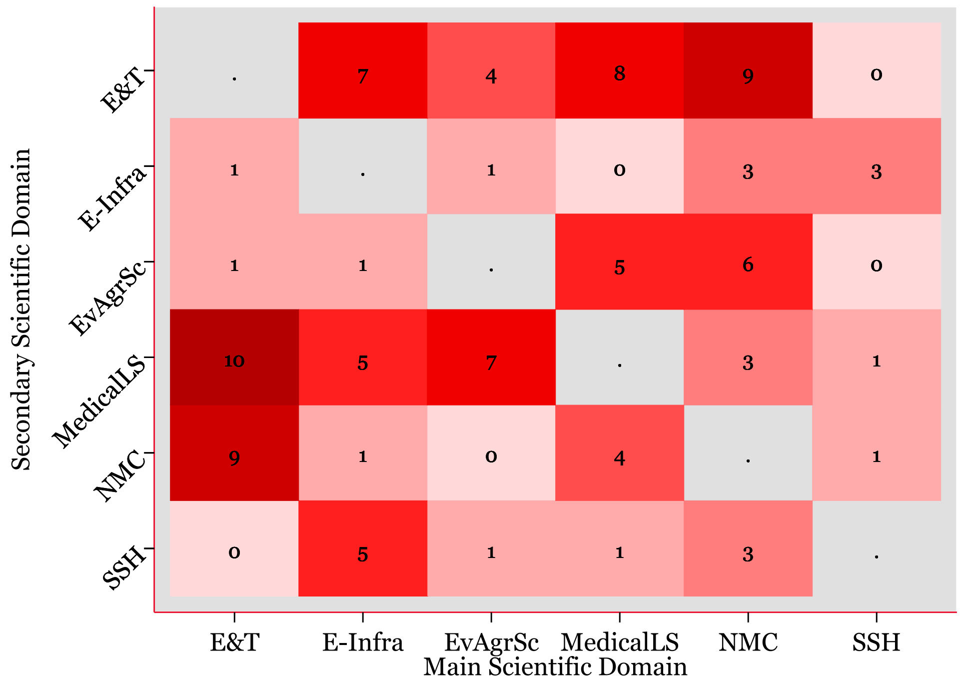
With respect to Engineering & Technology, workshop participants mentioned that another explanation for the large number of Ideas is the horizontal, generic relevance of E&T, with many Ideas submitted under E&T while being relevant for one or more other scientific domains.

A second observation is that around half the Ideas concern *new Research Infrastructures*. This subset of Ideas includes, for example, new initiatives in areas such as aerospace, wind energy, astronomy/telescopes, financial research, digital arts, pilot production lines and suites of equipment to support SMEs in their research and innovation process. Other Ideas on new Research Infrastructures clearly build on existing Research Infrastructures and research centres, e.g. next generation DNA sequencing, next generation X-ray tomography, developing a national biobank, moving from wireless campuses and cities to wireless regions, investing in a new infrastructure for High Performance Computing and broadening the scope of national repositories (adding more types of information). As such, the picture about upgrade versus new Research Infrastructure is nuanced. Still, it underlines the importance of striking a balance between launching new RIs and investing in maintenance and upgrades of existing RIs, while avoiding fragmentation of the Irish landscape of Research Infrastructures and research centres.[25]

The same point was made during several workshops. The majority of statements suggested a balance that is close to 2/3 of investments in maintenance, upgrades and reorientation of existing RIs and 1/3 of investments in new RIs.

For nearly all Ideas, respondents were able to indicate the *secondary scientific domain of the Research Infrastructure* (while some respondents took the liberty to indicate two 'secondary' scientific domains). Figure 17 illustrates that many different combinations of primary and secondary scientific fields were mentioned in the Ideas. The Ideas contain additional (qualitative) information about the expected relevance of RIs for scientific challenges in one or several scientific domains.

Figure 17 Main and secondary scientific domain of RI Ideas



Source: Technopolis Group

During the workshops it was stressed that several Ideas are relevant for three or more scientific domains. A first 'triangle' is between RIs in the domain of Natural Sciences, Mathematics and Computer Science (NMS), Engineering & Technology (E&T) and Medical & Life Sciences. Examples are RIs that support imaging and spectroscopy, 3D printing, rapid and/or personalised manufacturing of medicines and developing and piloting manufacturing processes (e.g. for medical devices) that are monitored by means of sensors (smart manufacturing). Examples at the intersection of Medical & Life Sciences and Environmental & Agricultural Sciences are RIs that support smart agriculture, biotechnology and food science.

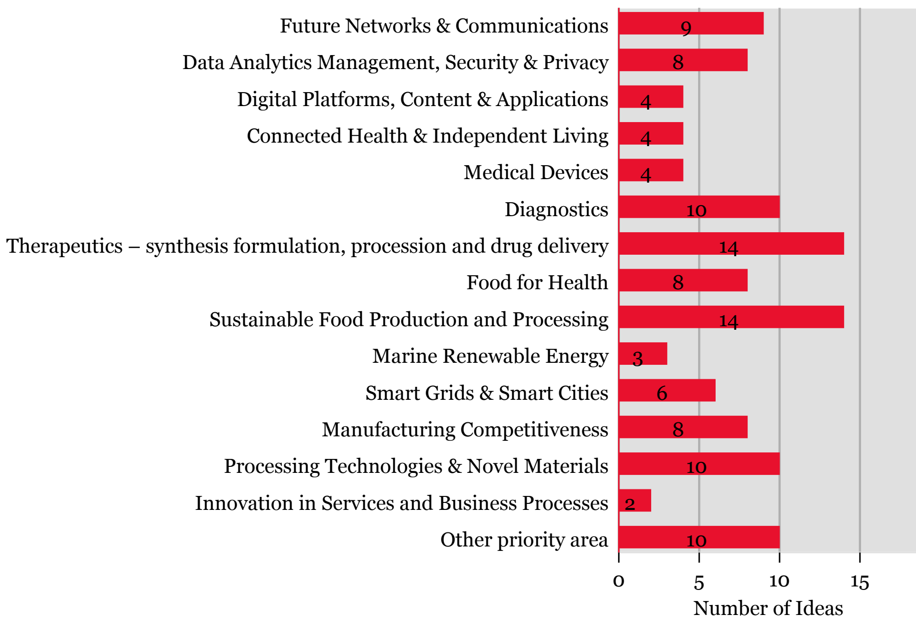
[25] This point was emphasised by the Research Prioritisation steering group, in its first Progress Report on the implementation of Research Prioritisation (published July 4th 2014).

Research Infrastructures submitted under E-infrastructures/E-science are relevant for one or several other scientific domains. By means of example, NMC: High Performance Computing, E&T: human computer interaction, Medical & Life Sciences: personalised health diagnostics, Social Sciences and Humanities (SSH): a major upgrade and reorientation of the Digital Repository of Ireland.

RIs in the domain of SSH also interact with NMC, especially Computer Sciences, while pursuing digital humanities. During the workshops it was also mentioned how SSH addresses the behavioural and societal aspects of advances in Medical & Life Sciences (e.g. personalised medicine and therapeutics) and environmental sustainability (e.g. adoption of energy efficient solutions by industry and households).

The set of RI Ideas, within and across scientific domains, covers a large number of Ireland's Science Technology and Innovation priorities (Figure 18). Respondents indicated the most relevant STI priority. Most respondents provided additional (qualitative) information about the economic, social and environmental relevance of their Ideas.

Figure 18 Number of RI Ideas per STI priority



(N = 114)

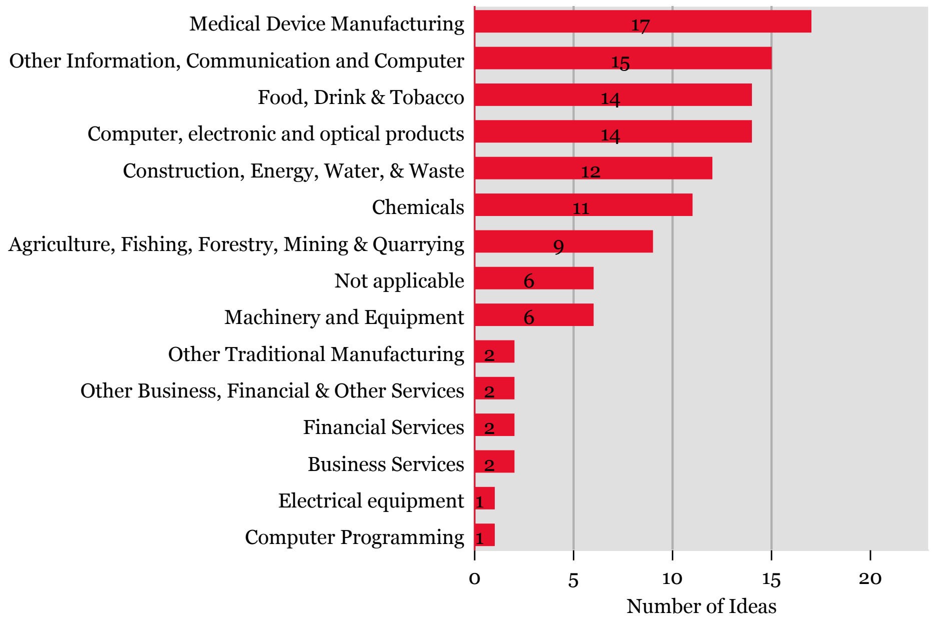
Q: Please choose the priority area which is most relevant for your RI

Technopolis Group

A number of STI priorities are closely linked, e.g. in the field of ICT, Health, Materials/Processes/Manufacturing and Agriculture/Food. In each of these four fields, more than 20 Ideas have been submitted. In Health, the emphasis is on diagnostics, medicine and therapeutics rather than medical devices. Few Ideas were linked to the STI priorities Marine Renewable Energy and Innovation in Services and Business Processes.

Along the same lines, the set of RI Ideas is expected to be relevant for the main business areas in Ireland (Figure 19). Respondents indicated the most relevant business areas. Taking the perspective of business areas instead of STI priorities, the picture is more positive for Medical Device Manufacturing, Water and Energy.

Figure 19 Number of RI Ideas per business area



(N = 114)

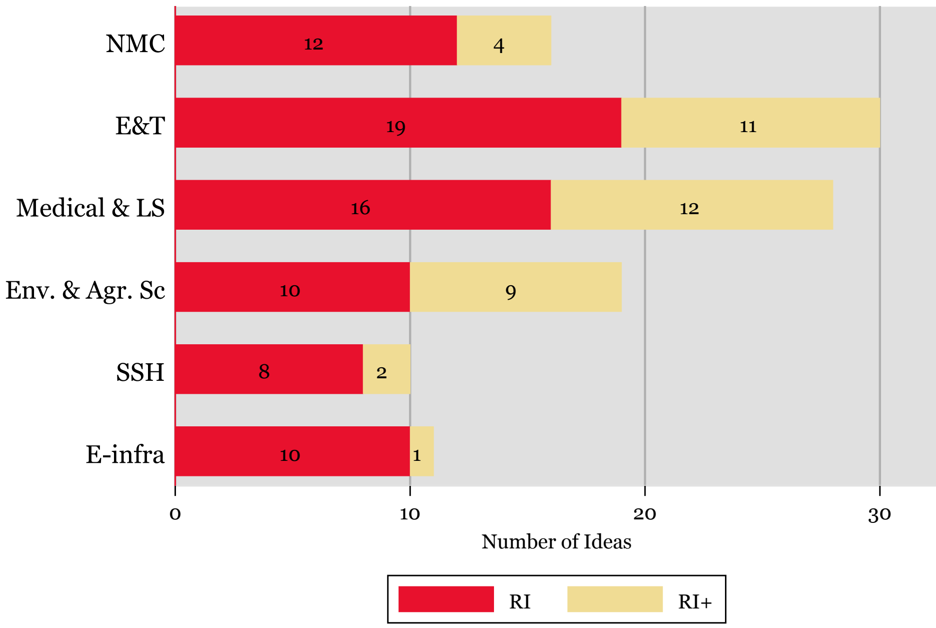
Q: Please indicate which business areas are most relevant for your RI.

Source: Technopolis Group

As discussed in Chapter 1, the European Commission definition of Research Infrastructure (and PRTLI) allows for *narrow and broad interpretations* of Research Infrastructures. The study team coded each Idea either as RI (when the emphasis of the Idea is on facilities and resources and supporting elements such as bespoke buildings and technical operators) or RI+ (when the emphasis of the Idea is on a research programme or research centre, with a small role for facilities and resources such as equipment and databases). The study team relied on indications such as the titles, key words and investment needs of Ideas. For example, a national biobank vs. a national research centre; a Idea that contains details about research equipment or about research programmes; and initial investments estimated between 1 and 20 million Euro or between 20 and 60 million Euro.

Figure 20 provides an indication about the ratio between RIs with a small and broad definition of RIs, to emerge from the Call for Ideas.

Figure 20 Ideas with a narrow or broad interpretation of RI



(N = 114)
Q: Please choose the situation which applies to your RI

Source: Technopolis Group

In three scientific domains (NMC, SSH and E-infra/E-science), nearly all Ideas reflect a narrow interpretation of Research Infrastructures. The main explanation is that existing research centres are considered to be effective and efficient host institutions for upgraded or new RIs. Moreover, the description of many RIs in these three scientific domains refers to providing access services to third party users but does not elaborate on the type of support and consulting services to be provided. In the other three scientific domains (E&T, Medical & Life Sciences and Environmental & Agricultural Sciences), a substantial number of RIs is perceived as requiring a new research centre. This concerns research areas such as medical devices, smart manufacturing, building research and innovation, aerospace and aviation and management and visualisation of research data. A number of Ideas concerns SME support services.

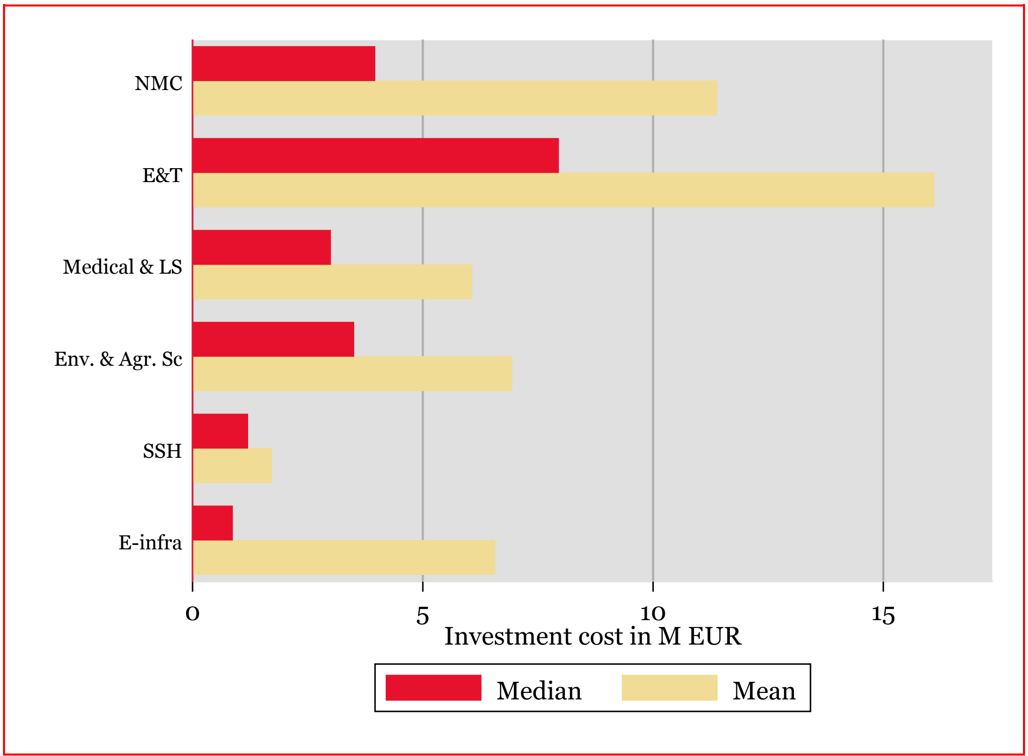
Workshop participants mentioned how a Call for Ideas about Research Infrastructures may trigger very ambitious responses, especially when there is uncertainty about other programmes and funding schemes that may be (dis)continued or launched after the presentation of Ireland's new STI strategy (mid 2015) and political discussions about funding. In sum: the Call for Ideas provided the research community with an opportunity to communicate their needs to policymakers and funding agencies.

The extent to which public support programmes for RIs emphasise narrow or broad interpretations of RIs has implications for *investment costs*. The Call for Ideas is explorative and does not (!) include selection or prioritisation. Still, rough estimates of investment costs, provided by respondents, can inform future discussions about investment needs. The Call for Ideas included questions about initial investment costs and annual operational costs. Adding up the investment costs for all 114 Ideas would lead to a total of around €1b. In this scenario, operational costs would be around €200m per year. Note that these costs can be covered by several organisations.

Initial investment costs, based on needs and estimates, are very different between the six scientific domains. The needs in E&T are most substantial, followed by NMC, Medical & LS and Environmental & Agricultural Sciences. The main explanations are the number of RI Ideas per domain, different domains requiring different types of RI (e.g. compare pilot production lines in E&T with biobanks in Medical and Life Sciences and databases and surveys in SSH) and the ratio between RIs with a narrow or broad interpretation of RIs (see above on narrow interpretations in the domains of NMC, SSH and E-infra/E-science).

Before elaborating on the stakeholders that are expected to cover parts of the costs, it is possible to indicate how a small number of expensive (e.g. broadly defined) Research Infrastructures influences total investment needs or costs. Figure 21 illustrates how the median of initial investment costs for RI Ideas lies between €1m and €4m (depending on the scientific domain). Due to a small number of RI Ideas that would require more than €20m, the mean of initial investment costs lies between €6m and €16m (depending on the scientific domain). The same mechanism applies to annual operational costs, although the absolute figures are lower.

Figure 21 Estimated initial investment costs of RI Ideas: median and mean

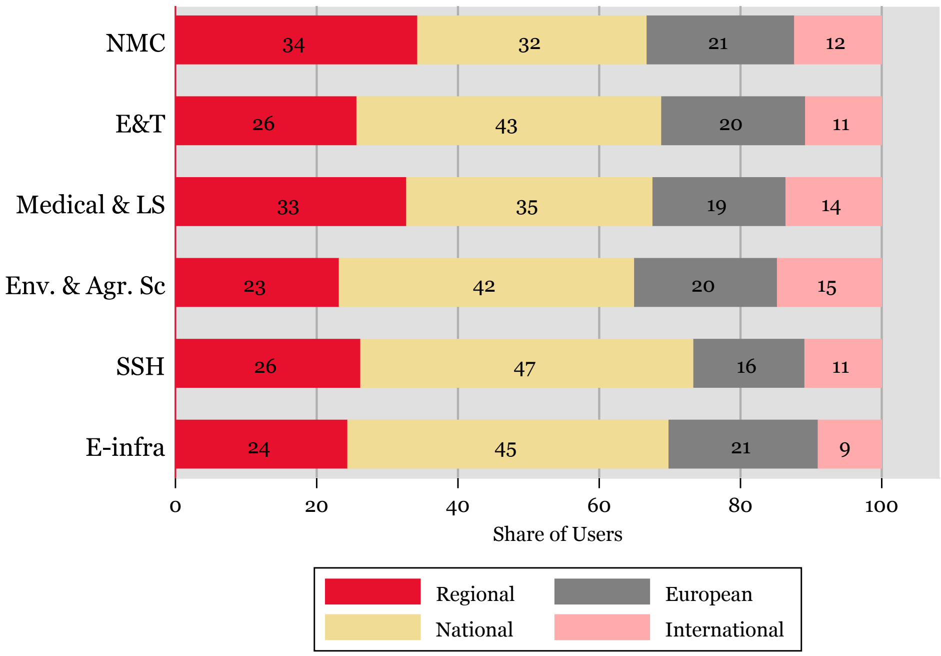


Source: Technopolis Group

The last topic to be addressed in this section is *expected use of RIs* and possible implications for *covering the costs of RIs*. In nearly all Ideas, respondents indicated that the range of RI users includes colleagues, partners and third party users from academia, applied research and industry.

Moreover, respondents expect a balance between users from the same regions (e.g. users from the same organisation, campus, city or regional cluster), from Ireland (e.g. users from other cities), Europe (e.g. users from partners in academic and business networks and research consortia) and other parts of the world (e.g. academic partners and business partners). Figure 22 indicates that, in this respect, the expected differences between scientific domains are small.

Figure 22 Expected users of RIs



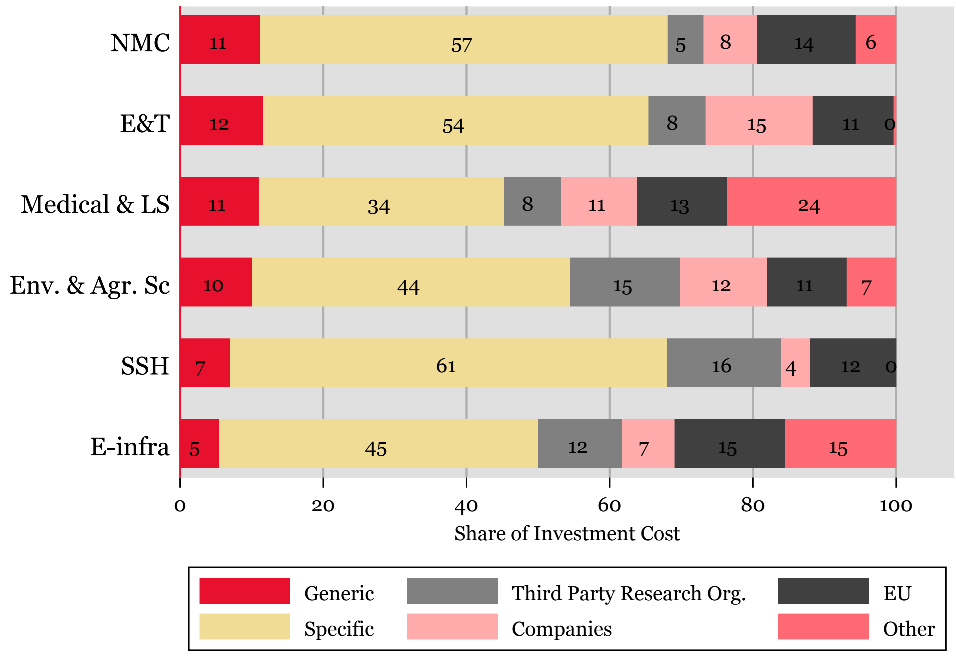
Q: Please choose the situation which applies to your RI

Source: Technopolis Group

Workshops participants elaborated on the incremental process of Irish organisations getting into more international networks (European Research Infrastructures, RIs on the ESFRI roadmap, FP7 and Horizon 2020 consortia, Joint Programming Initiatives, European Institutes of Technology, etc.) and capturing more central positions in these networks. This would lead to, among other things, higher levels of European and international users of RIs in Ireland.

In exploring the types of stakeholders that are expected to cover the initial investments costs of RIs, the Call for Ideas distinguished between third party research organisations and companies, support programmes funded by Irish national government (generic/block funding and RI-specific programmes), European Union programmes (such as Horizon 2020) and others (such as philanthropists, trust funds, meteorology institutes and other public sector users). Workshop participants agreed that the expectations with respect to financial contributions by companies (even when including in-kind contributions) and by EU programmes are optimistic. This also applies to the expectations regarding covering the annual operational costs (Figure 23). However, it is realistic to expect third party research organisations and companies (in their role as users) to cover a larger share of annual operational costs than initial investment costs.

Figure 23 RI Ideas: covering initial investment costs

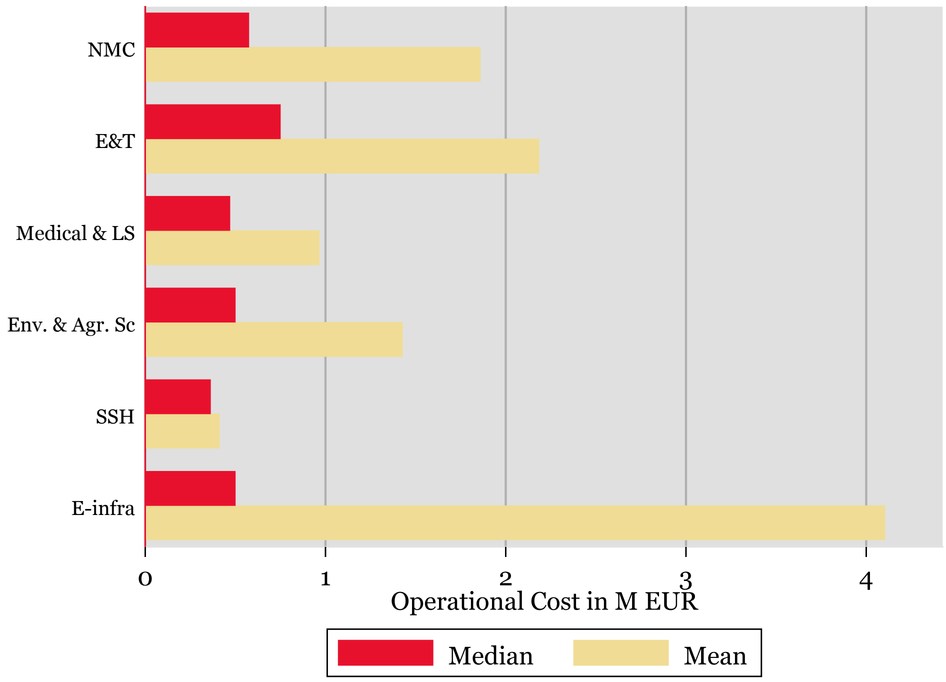


Q: Please indicate how the RI will be funded

Source: Technopolis Group

Workshop participants agreed that the expectations with respect to financial contributions by companies (even when including in-kind contributions) and by EU programmes are optimistic. This also applies to the expectations regarding covering the annual operational costs (Figure 24). However, it is realistic to expect third party research organisations and companies (in their role as users) to cover a larger share of annual operational costs than initial investment costs.

Figure 24 RI Ideas: covering annual operational costs



Source: Technopolis Group

If Irish stakeholders would cover their part of the initial investment costs of the set of RI Ideas, the required contributions from EU programmes would be 10 times higher than the actual contributions in FP7 (€170m compared to €15-20m, see Chapter 3). Examples of other relevant EU programmes are the European Regional Development Fund and its national and regional implementation (that provided parts of the funding of PRTLI) and instruments of the European Investment Bank.

The results about covering the costs of RIs triggered a discussion about access policies and access charges. Workshop participants concluded that visibility of RIs and high quality access and support services are crucial. The implementation of access charges should be as efficient as possible (minimising transaction costs). This could be done, for instance by keeping track of individual users and sending integrated invoices to these users, their organisation or a public agency that provides funding for RIs (and compensating RIs that succeed in attracting third party users).

The discussion about covering the costs of RIs also fuelled the discussion about national collaboration. This concerns the use of existing RIs but also collaboration in developing ideas and proposals for upgrades and new RIs. In each of the six workshops, participants recognised a number of possible synergies between RI Ideas that are submitted by different organisations. The next section elaborates on the RI Ideas within, and across, the six scientific domains.

5.3 Additional details about the Ideas per scientific domain

5.3.1 Natural Sciences, Mathematics & Computer Sciences

The following types of Research Infrastructures emerged from the set of 16 Ideas in the scientific domain of NMC:

- Several Ideas about spectroscopy and imaging.
- Several Ideas about smart campuses and smart cities.

- Ideas about robotics, financial research, geosystems, astronomy and telescopes (the Southern Earth Observatory), geocomputation and earth observation, terahertz optical measurement.
- A number of horizontal/generic Ideas:
  - Fundamental and applied materials science and fabrication
  - Open modular data
  - Centre for innovation in Science, Technology, Engineering and Mathematics (STEM)
  - Collaborative Research Platform (middleware, access, bandwidth)

During the workshop it was recommended to add/expand RI needs related to ultra-high broadband, data storage and High Performance Computing. To some extent, these types of RI were submitted in the domain of E-infrastructures and E-science.

5.3.2 Engineering & Technology

The following types of Research Infrastructures emerged from the set of 30 Ideas in the scientific domain of E&T:

- A large number of horizontal/generic Ideas (related to materials, engineering and manufacturing) and a small number of Ideas with a focus on one application area (medicine, medical devices, wind energy and aerospace and aviation).
- The horizontal/generic Ideas all have different focal areas: nanofluidics, therapeutics, nanodevices, precision manufacturing, photonics, polymer, solid processing, characterisation, crystallisation and high density materials.
- Several Ideas aim to bridge the gaps between, or integrate, fundamental research, applied research, prototyping and innovation (cf. 'concurrent research').
- Several new centres/hubs, using a suite of equipment, intend to support product development, process innovation, prototyping and testing in collaboration with SMEs.
- Several Ideas contain living labs, vast networks of sensors (cf. the Internet of Things), cloud computing and/or big data. One example is a smart cities RI that resembles RIs submitted under NMC and E-infrastructures and E-science.
- In addition, Ideas were submitted concerning hydrometallurgy, building research and ocean field robotics.

Workshop participants recommended to add RI needs in software and middleware engineering (e.g. to develop applications for smart manufacturing, smart agriculture, smart cities, climate change modelling, etc.) and design, pilot and test environments to explore the SSH aspects of robotics.

5.3.3 Medical & Life Sciences

The following types of Research Infrastructures emerged from the set of 28 Ideas in the scientific domain of Medical & Life Sciences:

- RIs and centres for personalised health diagnostics and personalised medicine (e.g. using a combination of DNA sequencers and -omics analysis equipment such as proteomics, metabolomics and elementomics).
- Sampling technologies for biotechnology and functional foods.
- Enabling technologies and equipment: microscopes (electron and confocal), spectrometers, biomarkers, biobanks, imaging techniques, high-throughput technologies, in vitro en in vivo modelling systems, etc.

- Animal facilities, with an emphasis on large animals, mini-pigs and germ free facilities.
- Upgrades of existing RIs to GMP standards (Good Manufacturing Practice).
- Ideas related to flow cytometry and chomography.
- Ideas that linking fundamental, clinical research and therapeutics.

Workshop participants added health data analytics and cyclotrons and stressed the importance of next generation DNA sequencing.

5.3.4 Environmental & Agricultural Sciences

The following types of Research Infrastructures emerged from the set of 19 Ideas in the scientific domain of E&A Sciences:

- A food processing research centre and a food processing innovation lab.
- A RI for Agriculture and Food Science Education, Research and Innovation.
- A stable isotope facility (e.g. for food research and nutrition studies,).
- Smart agriculture (using sensors, wireless networks, GPS, etc.).
- Measurement facilities for crop varieties, grassland science, soil research, land management and carbon fluxes in peatlands.
- Facilities to test mechanisms to increase environmental sustainability, e.g. by means of bioenergy/biorefinery and a demonstration centre.
- Marine omics.
- Specimen bank.

Workshop participants added wave tanks for marine research, secondary processing of critical materials, forestry research, water research (e.g. wave and tidal energy), off-shore wind energy platforms (for which Idea was submitted under Engineering & Technology), energy storage, measuring carbon fluxes and, more in general, facilities to monitor and reduce climate change.

5.3.5 Social Sciences & Humanities

The following types of Research Infrastructures emerged from the set of 10 Ideas in the scientific domain of E&A Sciences:

- Several digital archives, repositories, data centres or portals.
- Databases and High Performance Computing to enable analysis of financial data.
- A service re-imagination lab, to analyse, test and stimulate innovation in services and processes as well as 'servitization' of goods.
- A driving research centre, using simulators and EEG equipment.
- Analysing the behavioural aspects of environmental sustainability.
- Genealogy using IT applications, network analyses, natural language processing, translation and linked data.

Workshop participants added big data for public sectors, living labs in which creative industries can improve health therapeutics (e.g. music and dance therapy) and makers' labs to increase the role of creativity and design-thinking in innovation (STEAM: Science, Technology, Engineering, Art & Design and Mathematics).

5.3.6 E-infrastructures & E-science

The following types of Research Infrastructures emerged from the set of 11 Ideas in the scientific domain of E-Infra:

- High Performance Computing (HPC).
- Digital repositories for SSH, health data and research results in general.
- An upgrade of the Irish Research eLibrary.
- Living lab for social innovation.
- A visualisation and human-computer interaction lab.
- Assistive technologies research centre.
- Earth observation, using instrumentation for data acquisition, integration, analysis, modelling, visualization, interpretation and dissemination, for areas such as agriculture, forestry, marine ecosystems and energy.

Workshop participants mentioned the importance of moving from smart campuses and smart cities to smart regions and smart Ireland. It was also mentioned how the efficiency of RIs can be increased by moving towards horizontal approaches, e.g. research data repositories that cut across scientific domains (and by developing one online database with all RIs that are available in Ireland, cf. the LIRE database).

6. Conclusions and possible next steps

6.1 Taking stock: a substantial volume and broad range of Research Infrastructures

The main conclusions with respect to *taking stock* of past investments in Ireland's Research Infrastructures are as follows:

- Among the interviewees there was consensus that the Programme for Research in Third Level Institutions (PRTLI), coordinated by the Higher Education Authority (HEA), was crucial for developing, implementing and using Research Infrastructures in Ireland.
- In five cycles, spanning a period from 2000 to 2015, PRTLI has awarded €1.2 billion in exchequer and private matching funding for buildings, research centres, research equipment, research programmes and training (in particular structured PhD programmes). Gradually, the emphasis shifted away from buildings, while giving more emphasis on collaborative research programmes (especially in the fourth and fifth cycle). Around 65% of PRTLI funding concerns buildings and research equipment. Although a number of PRTLI-funded buildings are not dedicated to hosting research facilities, most of the PRTLI investments in buildings have a direct relevance for research in general or research facilities in particular.
- Outside PRTLI, HEA awarded €88m of direct exchequer funding via the Research Equipment Renewal Grant (2007) and Research Facilities Enhancement Schemes (2008).
- Other substantial investments in Research Infrastructures have been made by Science Foundation Ireland (SFI). Via calls in 2004, 2007 and 2012, a total of €67m was invested in RIs.
- In addition, investments in RIs have been made by research performing organisations themselves (over and above matching PRTLI exchequer funding) and by domain-specific departments and agencies in health, agriculture, marine, communications, energy, etc. Note that investments were also made by industry, philanthropists, trust funds and other organisations.
- In total, Irish national government invested between €60m and €80m per year in Research Infrastructures. Note that this estimation is based on a relatively broad interpretation of RIs as explained in Chapter 1 and as applied in PRTLI. To some extent, investments were required to 'catch up' with Western European countries that have a long tradition of substantial investments in research.
- Due to the investments mentioned above, the research community in Ireland can now use a broad range of Research Infrastructures. The overview of PRTLI investments (projects/infrastructures and beneficiaries) and the LIRE database (LIRE stands for Large Items of Research Equipment in Ireland) both indicate the availability of a range of RIs for a variety of scientific domains and application areas Reports about the first three cycles of PRTLI and our set of interviews provide examples of impact of PRTLI-funded Research Infrastructures (enabling and driving national collaboration, providing a platform for international collaboration, empowering researchers, RIs that are perceived as best practices in terms of research output, increased collaboration with industry, etc.).
- During the interviews and workshops, researchers and other stakeholders stressed the issue of uncertainty about future support by Irish national government for Research Infrastructures (priorities, funding, governance, etc.).

6.2 Taking stock: structured PhD programmes have become the norm

- Structured PhD programmes can increase the quality and efficiency of PhD education, broaden the skill set of PhD students and increase their employability.
- Under PRTLI cycles 4 and 5 together (2007-2015), a total of €153 million in funding was provided for 20 structured PhD programmes. A number of other programmes were used to support the development and implementation of structured PhD programmes.
- Within a period of 10 years, structured PhD programmes have become the norm for PhD education in Ireland. Currently, all (full time) PhD students in Ireland take part in structured PhD programmes or have the possibility to benefit from individual modules/courses.
- The number of PhD students in Ireland increased more substantially than in several other European countries. Interviewees mentioned that PRTLI funding contributed to the increased number of PhD students, although more recently these numbers started to decline.
- Interviewees stressed the uncertainty about future funding of structured PhD programmes. PRTLI provided a substantial yet temporary investment in structured PhD programmes. Universities mention their inability to absorb the specific, additional costs of operating and improving structured PhD programmes ('modules and coordination') into their core funding. Interviews and desk research were also clear in the relevance of PRTLI in not only funding the specific, additional costs of structured PhD programmes but also the generic, basic costs of PhD projects (for a number of cohorts of students).
- A quick scan of structured PhD programmes in Denmark, Germany and the Netherlands provided inspiration for funding models for these programmes. No best practices were identified. Moreover, the quick scan indicated that the implementation of structured PhD programmes is more mature in Ireland than in Denmark, Germany and the Netherlands.
- One of the considerations for funding structured PhD programmes is to distinguish between the specific, additional costs of PhD programmes and the generic, basic costs of PhD training. Both elements require predictable, long-term funding. A range of funding models can be considered (e.g. specific programmes and adapting the parameters to calculate block grants).

6.3 The Call for Ideas revealed substantial and well-motivated RI needs

- The Call for Ideas led to 114 Ideas spread across six scientific domains and including many Ideas that are relevant for two more scientific domains. Moreover, the set of Ideas is relevant for Ireland's Science, Technology and Innovation priorities and for a range of business areas and societal challenges.
- The Ideas also included information about current and expected collaboration, national and international. One of the insights to emerge from the set of Ideas (and the interviews and workshops) is that research-performing organisations in Ireland are becoming more embedded in European networks and consortia/projects.
- During a series of six workshops, a small number of additional RI needs were mentioned. A number of areas were identified for increased collaboration in the process of developing Ideas into plans. Examples are RIs that integrate, fundamental research, applied research, prototyping and innovation; RIs that focus on medical devices, wireless cities, research repositories, High Performance Computing and data analytics.
- The list of 114 Ideas, included in Appendix D, illustrates the relevance of RIs for research and provides inspiration for follow-up discussions between stakeholders in Ireland. For 101 Ideas, we got permission to publish the summary.

6.4 Possible next steps

The two elements of this study – taking stock of Ireland's RI investments to date and exploring Ireland's future needs in RIs – are building blocks for improving the RI strategy for Ireland. In this final section we suggest a number of steps for developing and implementing an improved RI strategy for Ireland.

The new STI strategy will influence the new RI strategy

The new Science, Technology and Innovation strategy for Ireland (to be published in 2015) will be important for setting a number of priorities for an improved RI strategy. This concerns, for example, the priorities in terms of scientific challenges, business opportunities and societal challenges that require investments in, among other things, Research Infrastructures. The new STI strategy may also influence the financial resources that will be available to support RIs.

As mentioned in Chapter 1, this study about RIs is also intended to feed into the new STI strategy ('it's a two-way street'). Among other things, the study explored the need for upgraded and new RIs within, and across, scientific domains. Moreover, the study addressed how decisions about narrow or broad interpretations of Research Infrastructures will have implications not only for RI support programmes but also for programmes and grants for research centres, buildings, research programmes, PhD education, etc. For example, when the distinction between Research Infrastructures and research centres is applied in a strict way, there should be close coordination between the programmes that support Research Infrastructures and the programmes that support research centres. Both programmes are interdependent (centres could need RIs, while RIs ideally are embedded in/linked to research centres and their research staff). Such a 'systemic approach' is one of the challenges for governance (see below). The main risk is that the pendulum swings from large and systemic programmes such as PRTLI to isolated, uncoordinated investments in Research Infrastructures, research centres, PhD education, etc.

A long-term financial commitment underpinning the RI strategy

The 5th Cycle of PRTLI funding (2011-2015) is currently approaching its conclusion and it is of utmost importance that the government provides a new perspective on future funding of RIs. PRTLI was a comprehensive funding scheme providing integrated financial support for different objectives (buildings, research centres, research programmes, research equipment and Research Infrastructures in general, structured PhD programmes, etc.). Although this approach was beneficial to many stakeholders, there are good arguments for a dedicated funding stream for RIs. Given the amount of money that should be invested in (large) RIs, there are risks in mainstreaming it in other funding mechanisms. For one thing, RI investments require a dedicated and long-term strategy, to steer dedicated and sustainable funding. In many other European countries a structural funding mechanism for RIs has been put into place, as they could not be funded out of the block grants of universities and research centres/institutes nor from the budget of research councils. Moreover, a more targeted funding stream will allow assessing proposals for (new) RIs against each other rather than with other entities (such as research centres). This allows for a fair and transparent decision making process. Finally, a dedicated programme for RIs enables monitoring, impact assessment and improvements of this programme.

Funding for RIs should be at a sufficient level. RIs require significant means, not only for initial investment costs but also to cover annual operational cost for many years (technical operators, providing access and support services, maintenance, incremental upgrades, etc.). Taking into account past RI investments in Ireland and other European countries, an annual budget of between €50 million and €80 million seems appropriate for Ireland.

Development of a RI roadmap, to be updated every 3 or 4 years

Many European countries have developed national roadmaps for RIs. Often they used the ESFRI Roadmap as a reference. The roadmaps establish the prioritisation of national and pan-European RIs; align RI priorities with STI priorities; facilitate political support at all policy levels; help to define national and regional budgets; and allow for long-term financial commitment by public and private stakeholders. There is no consensus on the definition of the term roadmap. Roadmaps typically focus on new Research Infrastructures, only a few deal with the upgrade of existing RIs (or maintenance of RIs). The purpose and the approach can vary a great deal. Some roadmaps are broad vision statements, while others delve deeply in the details of the proposed projects.

When a country undertakes a new roadmapping exercise it is important to involve different stakeholders: the scientific community, governmental authorities (all relevant departments and funding agencies), industry and other societal stakeholders. Besides scientific arguments most often non-scientific priorities are taken into account. Among these priorities are political goals, societal challenges, national and/or regional development objectives, imperatives linked to technology development, innovation and economic competitiveness and job creation (e.g. addressing priority sectors and skills shortages). The Australian roadmap process, for example, was organized according to the principle of societal challenges, including an 'Environmentally Sustainable Australia', 'Promoting and Maintaining Good Health' and 'Understanding Cultures and Communities.' Most roadmaps however are structured along the lines of scientific domains. To some extent, matrix approaches are used, e.g. confronting scientific challenges and societal challenges.

The relative importance of public funding of RIs (compared to funding by industry and others) underlines the importance of engaging all relevant public organisations in the process of preparing a roadmap. More in general, one of the challenges of a roadmap exercise is to organise a process that is inspiring, effective, efficient and inclusive. It should be a continuous process in the sense that the roadmap has to be updated every 3 or 4 years.

Content wise the RI roadmap for Ireland could encompass a number of elements:

- A focus on RIs with national or international relevance. RIs should fit EU agendas such as ESFRI and EU funding schemes, in particular Horizon 2020. One of the challenges is to define (unique) niches for Ireland. Another challenge is to not forget essential equipment, such as High Performance Computing and imaging equipment, for which it is easy to fall behind other countries.
- A narrow yet integrated interpretation of RIs. At the heart of RIs are the facilities and resources (such as equipment and databases) while these are integrated with essential elements such as bespoke buildings, technical operators and providing access and support services. In many cases, an existing research centre/institute is well positioned to be the custodian of a new RI. If a new research centre is required, especially when this centre requires substantial investments, it is preferable to use other support programmes to fund the research centre.
- Allow for upgrades/reorientation of existing RIs as well as investing in new RIs. The roadmap must cover new trends and developments but should also build on investments done in recent years. The latter will allow capitalising on these investments. The balance between new and existing RIs could shift over time. Given the substantial past investments in Ireland's RIs, one option is to first emphasise upgrades/reorientation of existing RIs (in the new roadmap) while gradually creating more room for new RIs (in updates of the roadmap).
- Continue the emphasis on RIs that support research at low Technology Readiness Levels (including basic research) but explore the need for RIs that are relevant for low as well as high TRL levels (including pilots, test beds and living labs).

Install a Permanent Committee on Ireland's Research Infrastructures, or allocate responsibilities to an existing committee or research council

The roadmap and the allocation of funding for RIs need strategic leadership. In some European countries this task is assigned to specific research councils, like in Sweden and Belgium. In other countries there is a specific (permanent) committee for Research Infrastructures, like in the Netherlands and Finland. The mandate of the specific research council or committee is to steer the strategic process (coordinate the roadmapping exercise and the updates of the roadmap), advise the government on budget allocation and RI policy and set the framework for the calls for proposals. The council of the committee can set priorities for the calls for proposals and determine the timing and size of these calls.

To some extent, the activities of the Permanent Committee reduce the influence of the organisation(s) that is (are) responsible for implementing the calls, monitoring progress and administering the financial aspects of funding RIs. The committee should ensure the right level of commitment of the relevant stakeholders.

The Permanent Committee should also oversee the process of increasing the visibility and accessibility of Ireland's RIs. In this respect it is recommended that the LIRE database also encompasses RIs outside higher education institutes. In terms of access policies and access charges, there are advantages in continuing the alignment of Ireland's policies with those that are developed and updated by ESFRI and OECD. One of the challenges is to set and administer access charges in a way that balances accessibility for users and financial sustainability of RIs. There are few best practices as the balance depends on the national setting (e.g. the size and restrictions of research grants) and the specificities of RIs and scientific domains (e.g. the types of users).

Lastly, the Permanent Committee should take responsibility for developing a framework for monitoring and assessment of the output and impact of RIs. Although there is a time lag between RI investments and the emergence of scientific, economic, social and environmental impact, well-established indicators are available to monitor output and the mechanisms (pathways) via which output can lead to impact. For instance, the framework should include indicators for collaboration (between various types of actors), scientific output (patents, publications, citations, etc.), human capital (enrolment and dissertations of PhD students, vocational training, etc.) and economic impact (revenues of suppliers of the RI, employment created by deploying and operating the RI, use of the RI by industry, number of start-ups created or supported by the RI, etc.). As such, the Permanent Committee would be in a position to provide regular updates about the effects of investments and any reasons to improve relevant support programmes.

The launch of regular, dedicated calls for RIs

The last step in the implementation of a new RI strategy is the launch of actual calls for proposals for RIs. Preferably there must be regular calls, annual or bi-annual, depending on the budget, priorities, etc. There could be a certain variety of calls, e.g. bigger and smaller calls and calls for upgrades and new RIs.

For the assessment of the submitted proposals a transparent and well-defined set of criteria is required. The set of criteria must correspond with the framework set out in the STI roadmap. Examples of criteria used elsewhere are:

- The science case: contribution to the advancement of science;
- The talent case: the added value for 'brain gain' and 'brain circulation';
- The innovation case: contribution to innovation and 'Grand Challenges';
- The partnership case: the role of RI in existing and new partnerships, national and international (with a preference for collaboration rather than duplication);
- The strategy case: positioning of RIs in the national STI strategy;

- The business case: budget needed for the development and exploitation of the RI (investment costs, operational costs, depreciation, access charges, etc.);
- The technical case: technical feasibility of the RI;
- The management case: institutional embedding and management capabilities; and
- The accessibility case: visibility, access and support services, access charges and utilisation plan.

Peer review is the most common approach to assess the proposals. Peer review ensures an independent expert assessment and allows for a diversity of opinions to be brought to the table. As reviewers are experts in their field it secures a thorough quality check.

A source of inspiration for improving the decision making process in Ireland is the dual assessment structure that is used in Flanders. The Hercules Foundation in Flanders has two committees for the assessment of RI proposals. The scientific committee reviews the science case while the Hercules Invest Commission reviews the business, technical and management case. The Hercules Invest Commission looks in particular at the budget (for initial investments, operating costs, depreciation, personnel, materials), technical feasibility and utilisation plan. The commission investigates whether the investment plans are sufficiently realistic and objective. The commission also assesses whether any opportunities exist other than those identified in the application, with respect to inter-institutional cooperation, cooperation with domestic or foreign research centres, scientific associations, or companies.

Appendix A PRTLI Research Infrastructure grants

PRTLI Cycle 1

	Project/Infrastructure	Institution
1	Advanced Materials Science Inst.	TCD
2	Biomedical Engineering	NUIG
3	Biopharmaceutical Sciences	RCSI
4	Bioscience Institute	UCC
5	Biosciences Research	NUIM
6	Biotech & Environ	IT Carlow
7	Conway	UCD
8	Food and Health	UCC
9	Humanities and Social Sciences	TCD
10	Humanities Research	UCC
11	ISSC	UCD
12	IT & Adv. Computation	TCD
13	Library	TCD
14	Molecular Cell Biology	TCD
15	MSSI	UL
16	Nanofabrication	UCC
17	NC Plasma Science	DCU
18	NC Sensor Research	DCU
19	Neuro-degeneration	TCD
20	Optical & Spectr.	DIT
21	Polymer Science	AIT
22	RINCE	DCU

Source: HEA

PRTLI Cycle 2

	Project/Infrastructure	Institution
1	Biopharmaceutical Sciences Network	RCSI
2	Conway Institute	UCD
3	DMMC - TCD component	UCD/TCD
4	DMMC - UCD component	UCD
5	Ecotoxicology, Waste Reduction & Air Pollution	CIT
6	Environmental Research Institute	UCC
7	Environmental Science	NUIG
8	Health Informatics (incl DIT)	TCD
9	Human Settlement	NUIG

	Project/Infrastructure	Institution
10	National Institute for Regional and Spatial Analysis	NUIM
11	Sustainable Treatment, Recycling & the Reuse of Biosolids	ITSligo
12	Urban Institute	UCD

Source: HEA

PRTLI Cycle 3

	Project/Infrastructure	Institution
1	5th floor Biosciences	UCC
2	Analytical Chem	UCC
3	Bioengineering	TCD
4	Bioscience	UCC
5	Biosolids	Sligo IOT
6	BMES	NUIG
7	Boole Informatics	UCC
8	BSU	UCC
9	Conway	UCD
10	CPND-Grid	DIAS
11	CSCB	UCD
12	DMMC	RCSI
13	ECI	NUIG
14	Eco-electronics	UCC
15	Environmental Risk	UCC
16	Food and Health	UCC
17	HII	UCD
18	HSHC	NUIG
19	IAMS	TCD
20	IIIS	TCD
21	IITAC	TCD
22	Integrative Biology	UCD
23	Irish-Scottish	TCD
24	ISSC	UCD
25	M-Zones	Waterford
26	Marine Science	NUIG
27	Material Sc.	UL
28	Mediterranean	TCD
29	Nanoscience	UCC
30	Neuroscience	TCD
31	NICB	DCU
32	PHG	RCSI
33	Postgrad Library	UCC
34	Structural Change	NUIG
35	TRIP	TCD

Source: HEA

PRTLI Cycle 4

	Project/Infrastructure	Institution
1	Centre of Applied Science for Health (CASH)	IT Tallaght
2	Clinician Scientist Fellowship Programme	NUIG
3	Clinician Scientist Fellowship Programme	RCSI
4	Clinician Scientist Fellowship Programme	UCD
5	Clinician Scientist Fellowship Programme	TCD
6	Clinician Scientist Training Programme	UCC
7	e-INIS	DIAS
8	e-Inis - The Irish National E-Infrastructure	UCC
9	e-INIS the Irish national eInfrastructure	TCD
10	e-INIS The Irish National e-Infrastructure	NUIM
11	e-INIS: the Irish National e-Infrastructure	NUIG
12	Environment & Climate Change: Impacts & Responses	CIT
13	Environment & Climate Change: Impacts and Responses	NUIG
14	Environment and Climate Change: Impacts and Responses	NUIM
15	Environment and Climate Change: Impacts and Responses	UCC
16	Environment and Climate Change: Impacts and Responses	TCD
17	Environment and Climate Change: Impacts and Responses	UL
18	Graduate School in the Creative Arts & Media GradCAM	DIT
19	Graduate School in the Creative Arts & Media GradCAM	NCAD
20	Humanities Serving Irish Society (HSIS)	NUIM
21	Humanities Serving Irish Society (HSIS)	UCD
22	Humanities Serving Irish Society (HSIS)	TCD
23	Humanities Serving Irish Society (HSIS)	DCU
24	Humanities Serving Irish Society (HSIS)	NCAD
25	Humanities Serving Irish Society (HSIS)	NUIG
26	Humanities Serving Irish Society (HSIS)	RIA
27	Humanities Serving Irish Society (HSIS)	UCC
28	INSPIRE - Integrated Nanoscience Platform for Ireland	DCU
29	INSPIRE - Integrated Nanoscience Platform for Ireland	CIT
30	INSPIRE - Integrated Nanoscience Platform for Ireland	DIT
31	INSPIRE - Integrated Nanoscience Platform for Ireland	NUIG
32	INSPIRE - Integrated Nanoscience Platform for Ireland	UCC
33	INSPIRE - Integrated Nanoscience Platform for Ireland	UCD
34	INSPIRE - Integrated Nanoscience Platform for Ireland	TCD
35	INSPIRE - Integrated Nanoscience Platform for Ireland	UL
36	Irish Food & Health Research Alliance (IFHRA)	UCC
37	Irish Food & Health Research Alliance (IFHRA)	UCD
38	Irish Food & Health Research Alliance (IFHRA)	UL
39	Irish Social Science Data Archive	UCD
40	Irish Social Sciences Platform (ISSP)	DCU

	Project/Infrastructure	Institution
41	Irish Social Sciences Platform (ISSP)	NUIG
42	Irish Social Sciences Platform (ISSP)	NUIM
43	Irish Social Sciences Platform (ISSP)	UCC
44	Humanities Serving Irish Society (HSIS)	UL
45	Lero: The Irish Software Engineering Research Centre and Graduate School	UL
46	National Biophotonics & Imaging Platform [NBIP]	NUIG
47	National Biophotonics & Imaging Platform [NBIP]	DCU
48	National Biophotonics & Imaging Platform [NBIP]	DIT
49	National Biophotonics & Imaging Platform [NBIP]	NUIM
50	National Biophotonics & Imaging Platform [NBIP]	UL
51	National Biophotonics & Imaging Platform [NBIP]	RCSI
52	National Biophotonics Imaging Platform (NBIP)	UCC
53	National Programme in Research and Training in (Bio)Pharmaceuticals and Pharmacological Sciences (BioPharma)	DCU
54	National Programme in Research and Training in (Bio)Pharmaceuticals and Pharmacological Sciences (BioPharma)	UCC
55	National Programme in Research and Training in (Bio)Pharmaceuticals and Pharmacological Sciences (BioPharma)	UCD
56	National Programme in Research and Training in (Bio)Pharmaceuticals and Pharmacological Sciences (BioPharma)	TCD
57	Nembes - Network Embedded Systems	CIT
58	Network Mathematics	NUIM
59	Serving Society: Management of Future Communications Networks and Services	WIT
60	WIT Integrated Research Building	WIT
61	UCC Biosciences Cell Biology and Cell Signalling New Space	UCC
62	UCD Science Centre	UCD

Source: HEA

PRTLI Cycle 5

	Project/Infrastructure	Institution
1	Academy	TCD
2	Academy	UCD
3	AdvancingMed	NUIG
4	AHSSRB	NUIG
5	Bio-AT	DCU
6	Bio-AT	ITT Dublin
7	Bio-AT	NUIM
8	Bio-AT	RCSI
9	BME&RM	NUIG
10	BME&RM	UL

	Project/Infrastructure	Institution
11	BSI West	UCC
12	CREATE	CIT
13	DAH	NUIG
14	DAH	NUIM
15	DAH	RIA
16	DAH	TCD
17	DAH	UCC
18	DGPP	TCD
19	DGPP	UCD
20	EconPoL	TCD
21	EconPol	UCD
22	ED4Life	CIT
23	EHSI	DIT
24	EIRE	WIT
25	ERC:GI	TCD
26	ERC:GI	UCD
27	ERI@MErC	UCC
28	ESI-PhD-ENS	NUIG
29	ESI-PhD-ENS	TCD
30	ESI-PhD-ENS	UCD
31	ESI-PhD-ENS	UL
32	Food & Health	UCC
33	GradChem	DIT
34	GradChem	TCD
35	GradChem	UCD
36	GREP-ENG	DIT
37	GREP-ENG	TCD
38	GREP-ENG	UCC
39	GREP-ENG	UCD
40	ICT Infrastructure	NUIM
41	INSPIRE	CIT
42	INSPIRE	DIT
43	INSPIRE	DCU
44	INSPIRE	NUIG
45	INSPIRE	UCC
46	INSPIRE	UL
47	IPSE	UCD
48	ITN	TCD
49	ITN	UCC
50	ITN	UCD
51	IVI-Phase-2	NUIM
52	MMI	NUIG

	Project/Infrastructure	Institution
53	MMI	TCD
54	MMI	UCC
55	MMI	UCD
56	MolCellBiol	NUIG
57	MolCellBiol	TCD
58	MolCellBiol	UCC
59	MolCellBiol	UCD
60	Nanoremedies	TCD
61	Nanoremedies	UCD
62	NAVR (RIA)	DIT
63	NAVR (RIA)	NUIG
64	NAVR (RIA)	NUIM
65	NAVR (RIA)	RIA
66	NAVR (RIA)	TCD
67	NCAMR	UL
68	NRF-TRH	DCU
69	ScienceCntr	UCD
70	SimSci - PhD	NUIG
71	SimSci - PhD	TCD
72	SimSci - PhD	UCD
73	SmartBay	DCU
74	SmartBay	Marine Institute
75	SmartBay	NUIG
76	TCDBIOMED	TCD
77	TGI	DIT
78	TGI	DCU
79	TGI	NUIM
80	TGI	TCD
81	TGI	UCC
82	TGI	UCD
83	TGI	WIT
84	TYFFANI	UCC

Source: HEA

Appendix B SFI research equipment and RI grants

2004 Equipment Call

	Research equipment	Institution
1	Antibody isolation system	DCU
2	RT-PCR and LIMS	DCU
3	Bio-imaging & Bio-processing suite	NUIG
4	Laser scanning confocal	NUIM
5	Auto femtojet microinjection	CSI
6	BiaCore + consumables	UCC
7	Cell sorter	TCD
8	Laser scanning confocal	TCD
9	600Mhz nmr	TCD
10	Consolidated imaging suite	UCD
11	500MHz NMR	UCD
12	Ultracentrifuge, protein sequencer, HPLC	UL
13	Computer controlled inverted microscope	TCD
14	Cell sorter	NUIG
15	Phenomics laboratory + Husbandry support	RCSI

Source: SFI

2007 Equipment Call

	Research equipment	Institution
1	1,500 Plate-capacity Automatic Crystallization Plate Imager	UL
2	8 Station Comprehensive lab Animal monitoring system	RCSI
3	A Coordinated HPC and data application for TCD	TCD
4	AB 7900HT Fast Real-Time PCR System (with Low Density Gene Array Upgrade)	DCU
5	ABI 3130xl Genetic Analyzer (16 capillary DNA sequencing system)	TCD
6	Acton 2750 Spectrometer	TYN

	Research equipment	Institution
7	Agilent E5052B Signal Source Analyzer	TYN
8	Agilent High Resolution Spectrometer	TYN
9	An X-ray Photoelectron Spectrometer upgrade for a variable temperature ultra high vacuum scanning tunnelling microscope	DCU
10	Applied Biosystems 7500 FAST Realtime PCR System	NUIG
11	Array of high speed EMCCD cameras and Data Interface/Collection Equipment	NUIG
12	Automated Peptide Synthesiser	RCSI
13	Automated System of High- throughput Sub-cloning, Protein Expression and Purification	UCD
14	BD LSR II Flow Cytometer	UCC
15	Biacore A100	DCU
16	Chirp sub-bottom seismic reflection profiler	NUIG
17	Combined PET/SPECT/CT small animal imaging system	UCD
18	Compound semiconductor cleaning and passivation system	DCU
19	Compound Specific Stable Isotope Ratio Mass Spectrometer Hyphenated to Mass Selective Detector	DCU
20	Confocal Microscope with add on capability for Raman Spectroscopy	AIT
21	Confocal-Atomic Force Micrscope-Total Internal Reflection Fluorescence Microscope	UCD
22	CRANN E-beam Evaporator	TCD
23	Digital holographic microscope	NUIM
24	Dual Beam FIB/FEG SEM	UCD
25	Dual-Beam Focused Ion Beam (FIB) System	TYN
26	DVB-H 'All-in-One' Testbed	UL
27	Field-emission scanning electron microscope	DCU
28	Flow Cytometry Cell Analyzer/Sorter	TCD
29	Gas Chromatographer coupled to a flame ionisation detector & mass spectrometer	APC UCC
30	Helium Ion Microscope	TCD
31	High Content Live Cell Imaging Platform	RCSI
32	High Frame Rate Stereo Particle Image Velocimeter (PIV)	TCD
33	High Performance Computing Cluster	UCD

	Research equipment	Institution
34	High Performance Computing Cluster	UCC
35	High Resolution Diffuse Optical Tomography System	NUIM
36	High Resolution scanning electron microscope (HRSEM)	TCD
37	High Resolution UPS/XPS Surface Science System	TCD
38	High-performance liquid chromatography, electrospray ionisation tandem mass spectrometer	UCD
39	Hitachi TM-1000 Tabletop Microscope and Ancillaries	UL
40	IR bundle	DCU
41	IVIS ® imaging system Spectrum series	RCSI
42	Laser ablation ion counting analytical system	UCD
43	Liquid-handling robotics for Luminex-based genotyping	UCC
44	Low noise, High Resolution, Spectroscopy System for material characterization at Telecomm Wavelengths	TYN
45	MALDI-TOF/TOF mass spectrometer	DCU
46	Mass spectrometer	UCD
47	Mesoscale Discovery Sector Imager 2400	TCD
48	Microwave Reactor	UCD
49	Mini Secondary Ion Mass Spectrometry (SIMS) System	DCU
50	MRI Coil Upgrade	DCU
51	Nanosecond Laser Transient Absorption Spectrometer with tunable excitation	TCD
52	Next Generation DNA Sequencer	TCD
53	Next Generation sequencing platform (Solexa Genome Analyzer)	UCD
54	On-Wafer Microwave Vector Network Analyser Measurement Capability to 110GHz+	UCD
55	PDS1000 HE TM Hepta TM system, housing/operational unit, gas supply and regulator	NUIM
56	Quantitative PCR Instrument.	NUIM
57	Real time PCR Platform (Stratagene)	NUIG
58	Real time PRC instrument with assoc peripherals	NUIG
59	Real-time PCR instrument	TCD
60	Research Microscope with diascopic, episcopic, interference contrast illumination and high resolution image analysis	TCD

	Research equipment	Institution
61	Scanning Near Field Optical Microscope (SNOM)	TCD
62	Scientific Microwave System	NUIM
63	Single Crystal X-Ray Diffractometer	UCC
64	Small Angle X-ray Scattering (SAXS) System	UCD
65	Spinning disk confocal microscope system	UCD
66	Tecnai G2 Spirit BioTWIN electron microscope	UCD
67	The VersaDoc Model 4000 molecular imaging system	DIT
68	Tip-Enhanced Raman Spectrometer (TERS)	TCD
69	TIRFM (Total Internal Reflection Fluorescence Microscopy)	NUIG
70	Tissue engineering for orthopaedic applications: the use of collagen scaffolds for the development of bone graft substitutes	RCSI
71	Total external reflection x-ray fluorescence spectrometer for the compositional analysis of thin films	TYN
72	Triple Quad Mass Spectrometer for Quantitative Biomolecules	NUIG
73	Triple quadrupole mass sepctrometer for quantitative proteomics	UCD
74	UCD CASL SenseTile System	UCD
75	Ultrafast High Rep Rate Laser Amplifier System	UCD
76	Ultrafast Photo Electron Emission Microscope, PEEM	UCD
77	Upgrade of Shamrock Deposition T ool	TCD
78	Vector Signal Analyzer for Wireless Communications	NUIM
79	Viral purification equipment	TCD
80	Zeiss LSM 5 LIVE confocol microscope	TCD

Source: SFI

2012 Research Infrastructure call

	Research Infrastructure	Institution
1	Advanced Fibre-Waveguide Packaging	TNI
2	2D ESI LC-MS/MS incorporating automated table top peptide synthesis	UL
3	3D Multi Material Printing System	UL
4	500 MHz Nuclear Magnetic Resonance Spectrometer	UCD
5	Aberration-corrected TEM	TCD

	Research Infrastructure	Institution
6	Advanced materials/surface characterization system including XPS/AES/SIMS	UCD
7	Analytical Ultra Centrifuge	NIBRT
8	BD Accuri® C6 flow cytometer	Teagasc
9	Bioflux Microfluidics System for Cell Analysis under Shear	NUIG
10	Cross Flow Filtration Unit – GMP	UCC
11	CryoViz whole small animal cryo-imaging system	NUIM
12	Diagnostic Ultrasound: novel system with Elastography & Ultrafast Doppler	TCD
13	Environmental SEM with in-situ Raman Microscopy	UL
14	FAME Testbed	WIT
15	Flow Cytometry Cell Sorter	TCD
16	Glovebox-mounted Scanning Probe Microscope (SPM) system	WIT
17	High Resolution MicroCT Scanner	NUIG
18	High Speed Photonic Device and System Testbed (Real-time oscilloscope)	TNI
19	High-Performance Computing infrastructure	DIAS
20	ICP-HRMS mass spectrometer	CIT
21	Imaging X-Ray Photoelecton Spectrometer (iXPS)	UL
22	Ion Torrent DNA Sequencing Platform	Teagasc
23	Laser Welding System	TNI
24	Lazr Label-free in vivo Microvascular Tomography	NUIG
25	Long-term In-Vivo Electrochemical (LIVE) Neurochemical Behaviour Equipment	NUIM
26	Magnetron Sputtering System with Mult-Metal targets	TNI
27	MALDI-TOF mass spectrometer	CIT
28	Materials Deposition, Characterisation and Process Development System'	TNI
29	MRI Systems upgrade (Avance lll platform with MRI Cryoprobe, etc.)	TCD
30	Multifunctional Supercritical Fluid (SCF) and extrusion and injection moulding system	WIT
31	National Ocean Energy Test Facility Enhancement	UCC
32	National Transgenic and Germ Free Facility	UCC

	Research Infrastructure	Institution
33	Next generation X-ray Micro Tomography (XMT) system	WIT
34	Ocean Energy Test Bed	Marine Inst.
35	Pharmaceutical Powder Extrusion Suite	UL
36	Polymer Composites Processing Suite	UL
37	Real Time Digital Simulator System	UCD
38	Solder Ink-Jet Dispenser	TNI
39	Thermo Scientific Q Exactive benchtop LC-MS/MS mass spectrometer	NUIM

Source: SFI

Appendix C Participation of Irish organisations in FP7 RI projects

Note that this list of participations only concerns the Research Infrastructure programme in FP7. As such, it excludes participations by Irish organisations in other parts of FP7 (ICT, energy, SSH, etc.) that may be relevant for Research Infrastructures.

	FP7 project title	Grant year	Organisation (in Ireland)	Role
1.	MNT Europe Extension	2008	UCC	Participant
2.	Preparing for the construction of the Digital Research Infrastructure for the Arts and Humanities	2008	HEA	Participant
3.	Preparing for the construction of the Digital Research Infrastructure for the Arts and Humanities	2008	HEA	Participant
4.	Global Ocean Observing Infrastructure	2008	MarI	Participant
5.	European clinical research infrastructures network for clinical trials and biotherapy - preparatory phase for the infrastructure	2008	MMI	Participant
6.	European clinical research infrastructures network for clinical trials and biotherapy - preparatory phase for the infrastructure	2008	HRB	Participant
7.	Providing an Infrastructure for Research on Electoral Democracy in the European Union	2008	TCD	Participant
8.	European Multidisciplinary Seafloor Observation	2008	MarI	Participant
9.	Upgrading the Survey of Health, Ageing and Retirement in Europe – preparatory phase	2008	UCD	Participant
10.	Biobanking and Biomolecular Resources Research Infrastructure	2008	MMI	Participant
11.	Biobanking and Biomolecular Resources Research Infrastructure	2008	HRB	Participant
12.	Biobanking and Biomolecular Resources Research Infrastructure	2008	IPPOSI	Participant
13.	Preparatory Phase for a Deep Sea Facility in the Mediterranean for Neutrino Astronomy and Associated Sciences	2008	DIAS	Participant
14.	European Research Infrastructures Network of National Contact Points	2008	HEA	Participant
15.	Federated E-infrastructure Dedicated to European Researchers Innovating in Computing network Architectures	2007	JUNIPER	Participant
16.	Federated E-infrastructure Dedicated to European Researchers Innovating in Computing network Architectures	2007	HEANET	Participant
17.	Enabling Grids for E-sciencE III	2008	TCD	Participant
18.	E-SCIENCE GRID FACILITY FOR EUROPE AND LATIN AMERICA	2008	UCC	Participant
19.	A Pan-European Species-directories Infrastructure	2008	ECOSERVE	Participant
20.	A Pan-European Species-directories Infrastructure	2008	SMEBD	Participant
21.	A Pan-European Species-directories Infrastructure	2008	NUIG	Participant
22.	Integrating European research infrastructures for micro-nano fabrication of functional structures and devices out of a knowledge-based multimaterials' repertoire	2009	TCD	Participant
23.	Optical Infrared Coordination Network for Astronomy	2009	NUIG	Participant

24.	Support study for the identification of potential needs and possibilities for an integrated European infrastructure network of animal facilities in ruminant physiology and breeding	2008	Teagasc	Participant
25.	Longitudinal Enhancement and Access imProvement of the SHARE infrastructure	2008	UCD	Participant
26.	Integration of European Simulation Chambers for Investigating Atmospheric Processes - Part 2	2009	UCC	Participant
27.	TOWARDS AN ALLIANCE OF EUROPEAN RESEARCH FLEETS	2009	MarI	Participant
28.	Pan-European Research infrastructure on High Performance Computing for 21st century Science	2008	TCD	Participant
29.	Multi-Gigabit European Research and Education Network and Associated Services (GN3)	2009	HEANET	Participant
30.	Pan-European infrastructure for management of marine and ocean geological and geophysical data	2009	Dep. CEN	Participant
31.	Pan-European infrastructure for management of marine and ocean geological and geophysical data	2009	UCC	Participant
32.	The Heliophysical Integrated Observatory	2009	TCD	Participant
33.	Distributed Dynamic Diversity Databases for Life	2009	NUIG	Participant
34.	European Network for co-ordination of policies and programmes on e-infrastructures	2009	HEA	Coordinator
35.	Open Access Infrastructure for Research in Europe	2009	TCD	Participant
36.	Multinational Advancement of Research Infrastructures on Ageing	2010	UCD	Participant
37.	A pan-European infrastructure for quality in nanomaterials safety testing	2011	UCD	Coordinator
38.	A pan-European infrastructure for quality in nanomaterials safety testing	2011	TCD	Participant
39.	European Plate Observing System	2010	Dep. CEN	Participant
40.	Aerosols, Clouds, and Trace gases Research Infrastructure Network	2011	NUIG	Participant
41.	AQUAculture infrastructures for EXCELLence in European Fish research	2011	AquaTT	Participant
42.	Marine Renewables Infrastructure Network for Emerging Energy Technologies	2011	UCC	Coordinator
43.	Marine Renewables Infrastructure Network for Emerging Energy Technologies	2011	SEAI	Participant
44.	TOWARDS A JOINT EUROPEAN RESEARCH INFRASTRUCTURE NETWORK FOR COASTAL OBSERVATORIES	2011	MarI	Participant
45.	European Grid Initiative: Integrated Sustainable Pan-European Infrastructure for Researchers in Europe	2010	TCD	Participant
46.	IP Networks as a Service	2010	HEANET	Participant
47.	IP Networks as a Service	2010	TCD	Participant
48.	Enhancing Grid Infrastructures with Virtualization and Cloud Technologies	2010	TCD	Participant
49.	PRACE - First Implementation Phase Project	2010	NUIG	Participant
50.	European Middleware Initiative	2010	TCD	Participant
51.	SeaDataNet II: Pan-European infrastructure for ocean and marine data management	2011	MarI	Participant
52.	Data Service Infrastructure for the Social Sciences and Humanities	2011	NUIM	Participant
53.	Strengthening International Dimension of Euro-Argo Research Infrastructure	2011	MarI	Participant
54.	European Clinical Research Infrastructures Network - Integrating Activity	2012	MMI	Participant
55.	Collaborative EuropeaN Digital/Archival Infrastructure	2012	TCD	Coordinator
56.	Support Infrastructure Models for Research Data Management	2011	HEA	Participant

57.	Financial Study for Sustainable Computing e-Infrastructures	2011	NUIG	Participant
58.	SCIentific gateway Based User Support	2011	TCD	Participant
59.	PRACE - Second Implementation Phase Project	2011	NUIG	Participant
60.	2nd-Generation Open Access Infrastructure for Research in Europe	2011	TCD	Participant
61.	GLObal Robotic telescopes Intelligent Array for e-Science	2011	UCD	Participant
62.	Strengthening the cooperation between the US and the EU in the field of environmental research infrastructures	2012	MarI	Participant
63.	Optical Infrared Co-ordination Network for Astronomy	2012	NUIG	Participant
64.	Infrastructure for Systems Biology - Europe	2012	UCD	Participant
65.	Fixed Point Open Ocean Observatories Network	2013	SLR Consulting Ireland	Participant
66.	Fixed Point Open Ocean Observatories Network	2013	MarI	Participant
67.	Building an European Research Community through Interoperable Workflows and Data	2012	TCD	Participant
68.	New operational steps towards an alliance of European research fleets	2013	MarI	Participant
69.	PRACE - Third Implementation Phase Project	2012	NUIG	Participant
70.	Advanced Research Infrastructure for Archaeological Dataset Networking in Europe	2012	THE DISCOVERY PROGRAMME LBG	Participant
71.	Multi-Gigabit European Research and Education Network and Associated Services	2013	HEANET	Participant
72.	Multi-Gigabit European Research and Education Network and Associated Services	2013	WIT	Participant

Appendix D List of 114 Ideas

The Ideas (and summaries) are categorized under the following scientific domains:

1. Natural Sciences, Mathematics & Computer Sciences
2. Engineering & Technology
3. Medical & Life sciences
4. Environmental & Agricultural Sciences
5. Social sciences & Humanities
6. E-infrastructures & E-science

Natural sciences, Mathematics and Computer sciences (16 Ideas)
1. Distributed Smart Campus
TSSG **Jerry Horgan**
Current smart-element technology and deployments operate in isolated 'data islands'. In order to generate value, these islands must be integrated in a meaningful way. This RI proposes to create distributed clusters of smart elements forming 'smart areas' and building to smart campuses. As a pilot, we propose using two WIT campuses for their diversity, locations and ease of access. The first is WIT Main Campus on the Cork Road, Waterford – a city centre location classed as community facilities in the Waterford City Development Plan. The second is WIT West Campus at Carriganore - a green field site neighbouring agricultural and technology-based industry sites. Both campuses have different profiles (population, building density, open spaces, and use) and are easily interconnected. This RI would provide an open innovation environment and data sets for use in research and development. The deployment of internal and external environmental sensors (motion detectors, air quality, temperature, humidity, air flow and contact sensors) would enable all levels of research on applications of aggregated data from these environments. Usage domains include health (ambient assisted living, ergonomics), mobile services (real time contextual data), building management (security, safety, environmental optimisation) and green ICT (smart data centres, low powered computing).
2. National Financial Research Centre (NFRC)
Financial Mathematics and Computation Cluster (FMC2) **John Cotter**
The National Financial Research Centre will create a globally recognised national centre of financial research, which will provide a critical underpinning for the future development of the international financial services sector in Ireland
3. Accelerate - Collaborative Research Platform
TSSG **Jerry Horgan**
The Accelerate Platform is a secure integration platform for academic and industry researchers in Ireland to accelerate innovation and faster progression of pre-commercial research into commercial products and services providing: • Access to nationwide reliable, high speed bandwidth • Interoperability between different ICT Platforms • Web portal for researchers to access a federation of test facilities • Security, authentication and authorisation features to ensure confidentiality and integrity of participant experiments • Detailed information on each test facility and research interests • Online reservation of test-bed resources and bandwidth • Access to European and international research infrastructures The Accelerate Platform is, in the main, technology neutral as it concentrates on the delivery of middleware. The approach proposed introduces a major paradigm shift through its emphasis on middleware and services. It supports

the strategic evolution of the platform with minimum disruption to the platform users while protecting existing and future state investment. The platform will allow public test-bed facilities in Ireland to be integrated and co-ordinated to can help position Ireland as a global leader in emerging information and communications technologies by allowing Ireland to build capability in high potential industries such as big data and analytics, smart sensors, cloud computing and the future Internet.

4. Open Modular Research Data Centre

TSSG
Jerry Horgan

This RI proposes an open, modular data centre. It will serve the mechanical/electrical engineering domains with its access to electrical and cooling system open data. It will serve the basic research community with the live information gathered from sensors and will serve the ICT domain by providing capacity to run trials, experiments and other validation exercises. The proposed RI will also deliver an easily replicable design that can be reused as required in other areas. The facilities of this data centre map to many of the STI priorities with particular focus on areas A, B and K. TSSG industrial partners and associated research centres have already indicated support for neutral trial sites, which is a key enabler to collaborative exploitation of research and development. This comes from the results of activities already conducted with a broad spectrum of partners-types in the existing smaller scale datacentre at TSSG in WIT's West Campus over the past 5 years.

5. European Southern Observatory

Cork Institute of Technology
Niall Smith

ESO is the foremost astronomical research facility on the planet, the most productive (and most cited) with its telescopes primarily based in Chile. ESO provides state-of-the-art research facilities to astronomers and is supported by Austria, Belgium, Brazil, the Czech Republic, Denmark, Finland, France, Germany, Italy, the Netherlands, Poland, Portugal, Spain, Sweden, Switzerland and the United Kingdom, along with the host state of Chile. Several other countries have expressed an interest in membership. ESO's main mission, laid down in the 1962 Convention, is to provide state-of-the-art research facilities to astronomers and astrophysicists, allowing them to conduct front-line science in the best conditions. The annual Member State contributions to ESO are approximately 140 million Euros and ESO employs around 680 staff members. By building and operating a suite of the world's most powerful ground-based astronomical telescopes enabling important scientific discoveries, ESO offers numerous possibilities for technology spin-off and transfer, together with high technology contract opportunities and is a dramatic showcase for Irish industry. It also provides one of the strongest STEM outreach programmes of any RI facility on the planet, providing inspirational activities from primary level through to retirees. ESO's state of the art suite of telescopes and detectors cover the electromagnetic spectrum from the mm to the optical, allowing it address some of the fundamental issues of astrophysics today. ESO has just begun construction of what will be the largest optical telescope in the world, the European Extremely Large Telescope (E-ELT). The community of astronomers in Ireland is alone in Europe without dedicated access to observing facilities, and regards ESO membership as its top priority.

6. Centre of Physics for Health

University College Dublin (UCD)
Professor Padraig Dunne

The proposed RI will be a key component of the Centre of Physics for Health (CoPH), which will strive to lead the translation of fundamental physics understanding and emerging state-of-the art technologies into health and clinical applications. These developments should allow us to:

- see disease earlier
- treat disease more effectively
- enable the development of personalised medicine
- drive discovery that makes diagnostics and treatment of disease affordable
- build interdisciplinary excellence from our strong physics base
- train the next generation of researchers and clinicians driving Physics for Health.

It is our vision to deliver all of the above by expanding our current clinical and fundamental research activities through the creation of a well-funded Centre of Physics for Health, building on our research strengths and our national and international collaborations.

Key new infrastructure to enable the operation of this Centre and expand its future operations will include a small-animal, image guided radiotherapy facility, and the use of a clinical therapy accelerator located at St Luke's Hospital, which will be converted to a research facility for radiotherapy. A third component is a central laser and imaging research facility, to allow the development of a laser-based proton source for radiobiology studies and new imaging tools.

7. National Institute for Fundamental and Applied Materials Science and Fabrication Technologies (working title)

National Centre for Sensor Research, Dublin City University
Professor Dermot Diamond

Ireland has invested heavily in (nano)materials science research, by providing strategic infrastructure, well-equipped facilities, and research initiatives of varying scale. However, this effort remains largely fragmented reflecting the diversity of National and International funding, despite obvious benefits to research quality and the impact that would accrue from a more linked-up approach. To an extent, this is recognised by the research community, and efforts are happening to attempt to improve collaboration between institutions and key teams/centres. However, while this is having a positive impact, it is relatively limited in scope, and does not capture the full scale of the opportunity or range of potential players, as 'nano' is only a sub-set of what is encompassed in this vision. In addition, investment in nano-related materials research is under attack due to the large scale of the investments involved and the inherently long-term fundamental nature of much of this research. But new technologies will revolutionise the pathway to utilisation of new materials, dramatically reducing the cycle time from concept to productisation. This RI is focused on the integration of emerging high precision 3D materials fabrication and characterisation technologies and the creation of cross cutting initiatives that can combine exquisite control of 3D nano/microstructure with highly innovative materials emerging from our current teams and centres. It will require a gap analysis to identify key elements that are missing from the national research landscape, and a coordinating team to manage the complex interplay between the various building blocks of the overall vision. The potential impact of this vision is enormous, mobilising the existing national research capacity across biology, chemistry, physics and engineering to create new prototype devices and services for emerging global markets.

8. The Smart Mini-City

University College Dublin
Peter Scott

The proposed research infrastructure is a network of sensors and actuators across the 350 acre UCD campus to act as a test bed and demonstrator of Smart City systems at the scale of the UCD campus. This can incorporate transport, lighting, heating, security, parking, waste management, groundskeeping and more. As Europe's largest urban parkland campus, UCD is an excellent scaled down analogue of a city. It incorporates apartments, offices, labs, sports facilities, public transport links, shops, restaurants, teaching facilities, parkland, and even a cinema. UCD would not only be a smart city at a tractable scale for research and innovation, it would also bypass one of the greatest barriers to deploying testbed systems in full cities – i.e. overlapping bureaucracy, budgets and decision making. A normal city will have a multitude of organisations with separate but overlapping remits for the management and delivery of all the city's systems. Navigating such a maze of control has greatly hindered the development of smart city systems. UCD is a single decision-making body and can therefore make holistic choices about deploying and evaluating such test systems at a pace that could not be matched outside.

9. Irish Centre for Innovation in Science, Technology, Engineering, and Mathematics (I-STEM)

University College Cork
Professor Martyn Pemble

The Irish Centre for Innovation in Science, Technology, Engineering and Mathematics (I-STEM) will provide a national portal for the exploitation of expertise and innovation through academic-industry partnership. Ireland houses the top global pharma, food and medical device companies; clustering of these companies in Cork makes it the obvious location for I-STEM. It will house facilities designed to provide research-led teaching beyond CPD level and enrich links between academia and industry. Facilities include purpose-built industry suites; clean rooms; state-of-the-art environmentally-controlled instrument suites; dedicated facilities providing specialist services/key enabling technologies required to meet the needs of the expanding industrial sectors

listed above; underpinning technologies; purpose-built specialist systems/laboratories, equipment and incubation facilities to translate knowledge to commercial enterprise across the value chain. I-STEM will consolidate strategic national/international collaborative links with academia, Research Centres/Institutes and the SME/MNC sectors. It will specifically target those collaborators whose research activity best complements I-STEM capabilities and expertise for optimisation of return. This hub for excellence and innovation will provide the evidence-base for the promotion of state-of-the-art, research-led, under- and post-graduate teaching. It will produce the fit-for-purpose, industry-ready, graduates required to sustain the strategically focused workforce Ireland needs to provide maximum benefit in support of the knowledge economy.
10. Process Flow Spectroscopy (ProSpect); Advanced Reaction Understanding using Flow Nuclear Magnetic Resonance (NMR) Spectroscopy
University College Cork **Professor Anita Maguire**
This RI investment will support the development of a state-of-the-art flow NMR spectroscopy facility, allowing direct observation of pharmaceutical process reactions as they occur – the first of its kind within the EU. The facility, operating within the SSPC, will offer the pharmaceutical industry in Ireland a unique competitive technical advantage, as no other equivalent cluster of pharmaceutical companies globally has access to such capability; it will thereby enhance Ireland's reputation as a leading location for state-of-the-art pharmaceutical process chemistry. Access to the facility will be enabled through the SSPC for researchers and companies in Ireland, and their international collaborators. The RI will consist of a 600 MHz NMR spectrometer specially adapted to allow solutions to flow from nearby laboratory reaction vessels through the NMR probe, enabling periodic data acquisition/sampling at a rate not currently possible through conventional NMR methods. Detailed mechanistic insight into processes and undesired side reaction pathways can be discovered uniquely through this approach thereby enabling exquisite levels of process control. The knowledge, experience and academic/industrial collaborative activity of the proposed host location [Maguire et al J. Org. Chem. 2011, 76, 9630] will provide the framework for academic and industrial engagement, worldwide.
11. Development of a terahertz optical measurement and characterisation facility
Maynooth University **Professor Bernard Mahon**
Space Terahertz Research is a key area for future Irish technological development. Maynooth University has a long heritage in design, analysis and electromagnetic (EM) modelling of far-infrared antennas and optical systems for both astronomy and atmospheric physics, particularly for satellite based projects of the European Space Agency. Terahertz (THz) technology is the name given to exploitation of the EM frequency band from 0.3 to 3 THz. A large number of commercial applications are being developed in this part of the EM spectrum including in the security industry, biomedical research, materials technology and secure communications. In fact, THz radiation, which lies between infrared and microwave frequency bands, spans the last part of the EM spectrum to be commercially exploited. For example, being non-ionizing like microwave radiation, THz radiation can penetrate a wide variety of materials such as clothing, cardboard, plastics and ceramics allowing safe non-invasive testing. Exciting commercial possibilities now exist for exploiting our research expertise in terahertz technology particularly in the optical characterisation of materials and also in supporting detector development. In order for Ireland to be eminent in this sphere, provision of sophisticated measurement facilities capable of operation across the complete terahertz band combined with fast multi-approach simulation tools is critical.
12. FluoreSpec – The Fluorescence correlation Spectroscopy Centre
Maynooth University **Professor Bernard Mahon**
Fluorescence Correlation Spectroscopy (FCS) is a technique that allows the diffusion of a fluorescently labelled molecule to be measured at the focus of a confocal microscope. It is a highly specialised technique, but has been available commercially since the 1990s. There have been significant improvements to the instrumentation since then, and modern instruments are suitable for a variety of different applications, including live cell measurements.
13. National Robotics and Mobile Sensing Laboratory (NRMSL)
Maynooth University

Professor Bernard Mahon

This proposal argues for the development of a National Robotics and Mobile Sensing Laboratory (NRMSL) consisting of a single site RI located at Maynooth University providing a set of mobile robotic hardware and sensing platforms that will be available for use by researchers across the university and commercials sectors. Although the principal focus of the laboratory will be to bring together and leverage expertise in the robotics and mobile computer vision community, the lab will provide facilities that support research across a broad range of scientific disciplines that share a common aim of processing, analysing and interpreting data captured from mobile sensor platforms. Such disciplines include mobile mapping, geocomputation, visual computing, augmented reality, mobile & wearable computing, wireless sensor networks, the Internet of Things (IoT), etc. Specifically we envisage investment to principally support the procurement of: (i) indoor humanoid and wheeled robot platforms (e.g. platforms from PAL Robotics, Rethink Robotics, Aldebaran, Kuka, etc.), (ii) outdoor field and aerial robotics platforms (e.g. platforms from ClearPath Robotics, DJI, Ascending Technologies, etc.) (iii) a high precision indoor motion capture system in a dedicated open research space(e.g. VICON, PhaseSpace, etc.) (iv) sensing systems (e.g. vision, FLIR, lidar, Velodyne) and low-power mobile vision processing units (e.g. from companies such as Movidius, Nvidia, Qualcomm, etc.) (v) an integrated navigation system for field robotic experiments (e.g. Applanix) (vi) a number of state-of-the-art multi-GPU workstations for high performance image and video processing, 3D reconstruction, deep learning, visual processing, etc. The laboratory will support existing researchers but would require full-time technical support staff to centralise expertise required to assist researchers in using the systems, and, would potentially require new purpose built space.

14. iMARL: Insitu Marine Laboratory for Geosystems Research

Irish Centre for Research in Applied Geosciences (iCRAG)
Christopher Bean

We will develop the first multi-disciplinary sea-floor scientific laboratory for the NE Atlantic. It will be situated offshore Ireland, beyond the coastal zone. It will be a distributed but synchronised system with platform landers sampling a wide range of geophysical and geochemical parameters including: acoustic monitoring; passive seismic monitoring; temperature; salinity; seabed currents; sea floor strain; sea floor tilt; sediment oxygen fluxes; sea-floor pressure fluctuations. It will (i) close the gap on an information blind spot that is hampering our estimation of offshore resources, offshore geohazards and offshore deep marine engineering infrastructure integrity, (ii) establish baseline climate related insitu ocean monitoring, (iii) serve as a translational (lab to field) test-bed for sensors in extreme environments, (iv) challenge niche enterprises to develop mooring and communications systems in a power-starved cable-free environment as we deliver real time sensing to a terrestrial geophysical data centre, from the deep sea-floor. The data centre will be the 'Front-End' of the National RI facility, and will host access and data management related courses for end-users.

15. Irish Centre for Ultra-high resolution Imaging and Characterisation (CURIC)

Materials and Surface Science Institute (MSSI) University of Limerick
Professor Noel O'Dowd

Our plan will take Ireland's current microscopy capabilities to world-class standard, matching the country's needs and status as a world leader in nano and materials science. The Irish Centre for Ultra-High Resolution Imaging and Characterisation (CURIC), based at UL, will build upon significant expertise and facilities in the Materials and Surface Science Institute and the Bernal Project to establish a beyond state-of-the-art facility. The Centre would provide instrumentation based on light, scanned, X-ray and electron-microscopies, and would include microscopes capable of in-situ and ultra-fast timing experiments (nano & femto seconds), and pico-meter spatial resolution. Such facilities offer unprecedented detail of structure and dynamics of materials from new developments (graphene and beyond) to technologies (nanomaterials for batteries) to model building (cellular toxicology). Instrument performance is often limited by the local environment, rather than the researcher's capabilities. A dedicated infrastructure, designed from the ground up, is needed to take account of factors such as floor vibrations, acoustic noise, electromagnetic fields, and temperature fluctuations. As a site UL's 'green campus' is ideal: remote, but with excellent access. To enable researchers to compete internationally, it is imperative that an ultra-high resolution imaging facility exists in Ireland for pursuit of the most challenging experiments.

16. Geocomputation and Earth Observation
Maynooth University **Professor Bernard Mahon**
This research infrastructure focuses on the capture, storage, analysis and visualization of spatial data. In particular focus will be placed on various kinds of technologies used to capture 3D data including lasers and airborne vehicles – and also on developing new ways of capturing the data. These methods can collect very large amounts of data and industrial development is hindered by bottlenecks in developing tools to process and access it. Furthermore, there is a parallel requirement for the development of tools for analysis and visualization of spatial data. This RI provides tools to interpret the data leading to high societal impact for example analyzing crime patterns, house prices or health policy effectiveness in combination with Earth observation data. A key means of dissemination is the distribution of open source data analysis and visualization tools. This RI is intended to become a hub to provide access to the hardware, software and human resource needs to execute the above research.

Engineering & Technology (30 Ideas)

1. LITMUS Living Laboratory: Addressing an international state of the art piloting and demonstration environment incorporating academia, Industry, municipalities and communities.

The Nimbus Centre, Cork Institute of Technology
Brian Cahill

The Nimbus Centre, Cork Institute of Technology (CIT), is experiencing rapidly growing demand for real-world, that is outside the lab, research and development infrastructure focused on Energy, Water and Smart City innovation. This requires a Living Laboratory environment encompassing the ethos of a quadruple helix, to really test new innovative solutions with the end users who will use it in the end but without the danger of breaking permanent infrastructure that is vital for society and businesses but that is sustainable, can create employment, and can keep the focus on successful innovation and entrepreneurship while meeting the demands of all STI priority areas. The Litmus Living Laboratory environment envisages a experimentation, testing and trialling infrastructure that will become a national focal point for academic and industry researchers to evaluate their innovation within as close to a real world environment as can be made possible. This Living Laboratory will form a national resource with links to participating Industry, national and international Living Laboratories. Relevant research initiatives such as SFI Centres, e.g. Insight, CONNECT, and industry research centres such as UTRC-I, Intel Research, Bell Labs, etc. will be able to take advantage of this infrastructure.

2. A National Medical Device Innovation Hub

Centre for Research in Medical Devices (CÚRAM)
Professor Abhay Pandit

A National Medical Device Innovation Hub incorporating a dedicated Good Manufacturing Practice (GMP) and Good Laboratory Practice (GLP) regulatory compliant facility is proposed. This facility would incorporate innovation incubation units, ISO 13485 and US FDA CFR820 approved Quality Management Systems GMP/GLP scale-up and manufacturing facilities, large animal facilities, where safety, efficacy, immune(toxicology), immunogenetic and pharmaco-dynamics studies could be conducted under GMP conditions with state-of-the-art imaging (MRI, CT, PET), and associated high throughput screening/analysis, advanced protein analysis, biomaterials synthesis, assembly and fabrication all under GMP and GLP regulatory complaint conditions to facilitate the development and validation of next generation biomaterial-based medical device prototypes meeting the needs of both Irish-based and international small and medium size medical device manufacturing companies. The proposed infrastructure would provide a platform for the integration of stakeholders from universities, public and government agencies, hospitals, primary care centres, finance specialists, TTO experts, innovative companies, researchers, clinicians and consumers. This integrated national medical device innovation hub is designed to identify, exploit, develop and deploy innovative products, processes and technologies into healthcare thus contributing to the goal of establishing Ireland as a global leader in innovative patient-centred medical technology solutions.

3. High-speed Electronic and Photonic Test and Measurement Facility in order to develop the materials, components and devices from which next generation optical systems will be constructed

Faculty of Engineering and Computing, Dublin City University
Professor Liam Barry

The desired RI consists of high speed electronic and photonic test and measurement equipment required to reinforce scientific and technological excellence in high-speed devices and components in order to develop the materials, components and devices from which next generation optical systems will be constructed. The development of these systems presents numerous challenges that require new ideas and a rethink of fundamental issues in light generation, nano-photonic materials, nonlinear optics, and ultra-short pulse propagation. These challenges require new RI to undertake this research work.

4. Continuous Solids Processing Pilot Plant (CSP3)
Pharmaceutical Manufacturing Technology Centre **Chris Edlin**
To augment the existing powder processing facilities within the Bernal Institute, there is a requirement for a Continuous Solids Processing Pilot Plant. This facility would be unique in Ireland and would greatly enhance the Research Impact of the existing SFI and EI funded powder engineering research centres hosted within the Bernal Institute: SSPC; PMTC; DPTC. The pilot plant would be a flexible high bay space that would be designed to process particulate materials (pharma, bio-pharma, and medical materials). The manufacturing line would include continuous solids isolation drying and granulation equipment and would be housed in negative pressure containment modules and dust collection system to minimise operator exposure. The facility would also be equipped with a clean room maintained under negative pressure. The integrated manufacturing line would be interfaced with sensors and process analytical technologies (PAT) along the production line. This infrastructure would create a pilot scale manufacturing test bed platform for low volume high value materials (pharma, bio-pharma, and medical materials), which currently account for >70% of Ireland's exports. Critically, our rival/partner research groups in US and EU possess this capability, so we there is a strong case for making Irish research internationally leading in this area.
5. Institute for Building Research and Innovation (IBRI)
University College Dublin **Elizabeth Shotton**
Internationally the building industry faces significant research challenges in meeting ever-greater demands in standards of energy and environmental performance, health and well-being of occupants and closer socio-cultural-economic integration with technology. The UCD Institute for Building Research and Innovation (IBRI) would provide an interdisciplinary facility to promote a more balanced approach to research and innovation in the built environment, addressing the interdependencies between energy generation, distribution and use, building envelope performance, indoor environment and health and the efficient use of limited resources. Such research would be relevant to architects, engineers, contractors, building owners, insurers, industry and regulatory authorities. Facilities would be available to test individual materials and construction systems; model energy systems of buildings or groups of buildings including load shifting, load shaping and virtual storage; and assess indoor environments in relation to health and occupant behaviour using full-scale, real-time simulations in purpose built demonstration buildings, with the capacity to alter facade systems or elements, energy systems and distribution and wireless sensor technologies. Testing and research capabilities would include: indoor environment - airtightness - HVAC systems - wind tunnel testing - thermal conductivity - daylighting - artificial lighting - energy modeling on buildings or groups of buildings - innovative building systems.
6. Institute for Industrial Research Services (IIRS)
CREST **Brendan Duffy**
The Institute for Industrial Research Services (IIRS) will be a national resource that will be influenced by the world renowned infrastructures (e.g. Fraunhaufer, VTT). The IIRS will provide support for activities in industrially applied research in Ireland in the area of materials, with rapid turnaround times on small projects (<5 days ideally). The Institute will be driven by a team whose primary goal will be to enable industries based in Ireland to surpass the needs of the national population and compete for business in the greater European and global markets. The support will take the range from technical advice, testing and analysis to product development and certification. This will be achieved through the: • Establishment of industrial research hubs, supported through new (and where possible existing) research infrastructures such as those associated with Technology Gateways. • Translation of scientific advances into practical applications, through a combination of basic and applied research and industrial practise (GMP, GLP). • Promotion of foresight activities with industrial network partners • Training of staff in short industrially orientated, module based, practical courses Ideally the IIRS will have a network of centres of excellence, with access to existing infrastructural resources including incubation spaces with technology transfer support.

7. Nanofluidics Laboratory
Stokes Institute, University of Limerick **Dr. Jeff Punch**
A Nanofluidics Laboratory is envisaged which will enable scientific understanding of the behaviour of nanofluids, and the creation of associated applications in areas such as biotechnology, pharma, energy, sensors and medical devices. The laboratory will facilitate the following: the synthesis of nanofluids; the characterisation of their physical, thermophysical and chemical properties; the investigation of transport phenomena associated with nanofluids (including nanofluidic-to-microfluidic interfaces, and fluid-surface interactions); computational modelling techniques; and the design, fabrication and characterisation of engineering prototypes to exploit nanofluidic phenomena for a range of applications. The Laboratory will feature clean-room facilities, contemporary fluidic characterisation infrastructure – including state-of-the-art non-invasive flow interrogation equipment – and specific areas for cell culturing to enable in situ bioscientific investigations. The Nanofluidics Laboratory will build upon UL's existing expertise and facilities in microfluidics-related research, and also make extensive use of the materials and surface characterisation infrastructure at the University of Limerick, augmenting it with 'fluid-specific' facilities such as micro-Particle-Image Velocimetry (mPIV), high-resolution Laser Doppler Anemometry (LDA) and high-speed, high resolution optical imaging. The Laboratory will represent a national resource for the investigation and application of nanofluidic phenomena, a topic of relevance to a wide range of disciplines.
8. Nanotechnology Device Fabrication Facility for Smart Integration
Waterford Institute of Technology **Dr. Joseph O'Mahony**
The RI is a bespoke facility dedicated to the design, R&D and prototyping of smaller, smarter and energy autonomous devices and systems. This advanced nano-manufacturing facility comprises a slot-die coater for the deposition of functional materials, an aerosol jet coater for the deposition of biomolecule arrays and a mask based UV photolithography system for nanostructure fabrication. A plasma etcher and sputter coater completes this system. The modular system will be maintained inside a glovebox that will provide control of the local environment to <1ppm oxygen and <1ppm moisture, thus ensuring the stability of the functional materials used in the nano-manufacturing process. This unique combination of R&D prototyping technologies addresses the integration of micro, nano and bio technologies required to develop predictive, reactive and cognitive smart devices. The RI will also comprise laboratory space to house the facility and an adjoining training room to train visiting researchers from industry and academia. The infrastructure will develop a national ecosystem providing access, training and pilot-line production facilities for Irish and European based researchers seeking to develop the next generation of smart, zero-power devices.
9. Thermal and Mechanical Research Suite
Centre for Industrial Services and Design (CISD)-Athlone Institute of Technology **Dr James Kennedy**
This RI will take the form of a single site facility. The desired RI is a suite of thermal and mechanical instruments to characterise polymeric and biomedical based materials. CISD has completed over 1300 project for 316 companies in the past 7 years with a basic and applied research focus. This desired RI will be used to replace aging technology which is 20 years old and it will allow the Centre to expand its research portfolio for the coming years to both industry and academia. A dedicated characterisation suite with the already applied research focused staff allows the potential growth of the Centre and open new opportunity for European funding. This RI will also be used to help us achieve accreditation such as ISO standards which is fast becoming a requirement from industry in particular the pharmaceutical and medical device sectors.
10. Atlantic Ocean Field Robotics Research Centre
University of Limerick, Stokes Institute **Daniel Toal and Jeff Punch**
The proposed Atlantic Ocean Field Robotics Research Centre will operate and develop advanced

marine and airborne robotic technology, platforms and facilities to support the vision for marine renewable energy (MRE), earth observation, monitoring and protection and security among others. Ireland is a leader internationally in MRE RDI with strategic commitment to MRE in the NRPE. UL leads Operations Support Engineering research within the (SFI) MaREI Centre addressing challenges to roll out of utility scale MRE offshore. MRE needs robotic platforms that can deal with strong waves and currents and marine airborne systems must be marinised and rugged with long endurance. The proposed centre builds on the strengths of UL and MaREI in marine and field robotics to support Ireland's ocean and MRE vision. The proposal brings together UL and Shannon Foynes Port Company (SFPC) as strategic partners to provide an internationally leading RDI capability and infrastructure base at Limerick Dock. SFPC, in their master plan to 2041, aim to develop Limerick Dock as a marine technology hub in collaboration with UL. The RI plans will develop special purpose research facilities and marine industrial start-up incubator unit with direct access to the dock with all the associated infrastructure of an operational port in a region with strong marine and aerospace industry.

11. Fourth Generation Manufacturing Facility (4G Man)

University College Dublin
Dr David J. Browne

The new facility will be a hub for development of knowledge-based manufacturing processes and technology, and will include computationally-enabled and digitally-connected manufacturing activities. New algorithms and computational models will be developed and deployed to simulate manufacturing processes and to engineer performance and quality into advanced products. This will reduce expensive trial-and-error experimental tests needed to optimise processes. The facility will house advanced equipment for state-of-the-art manufacture in metals, polymers, and composites. Innovative metal casting processes will lead to high performance components via control of alloy solidification. A large state-of-the-art 3D metal printer, for additive manufacturing of scale, will enable new products from advanced alloys. High precision grinding will be used for surface finishing operation. For polymer composites, a unique high pressure resin transfer moulding will extend the capacity to innovate in this space in Ireland. A suite of advanced characterisation tools will be used for QA purposes.

Following computer simulation, an optimum number of intelligently-chosen experimental runs will be carried out, both to validate the computer models and to assist in training of the models so that they can become process control tools. Arrays of sensors will be used, and wireless communication will enable remote and adaptive control of the process, intelligently via interaction with the simulation tool. Such digital connection of manufacturing and assembly processes will enable data analytics to be used for system optimisation and quality assurance. This will include advanced 4D visualisation and image analysis, robotics and automation, and remote and unmanned oversight via Internet-of-Things approaches.

12. National Wind Energy Research Test Centre

IComp, Irish Centre for Composites Research, University of Limerick (UL)
Dr Trevor Young (and Dr Terry McGrail)

The concept is to develop a national wind energy full-scale test facility which will underpin research innovation critical to overcoming national and European renewable energy targets. The RI will address the priority areas of Marine Renewable energy and Processing Technologies & Novel Materials identified in Irelands STI. The RI will comprise a fully functioning wind turbine (>1.5 MW) with grid connectivity and energy storage capability, with an associated monitoring and experimentation facility (e.g. erosion testing, blade monitoring). The facility, unique within the British Isles, will feed energy into the national grid offsetting turbine and RI operational costs and will simultaneously serve as a full-scale test facility. The West of Ireland is the perfect location for the RI as it is known to be a particularly harsh environment for operating wind turbines (due to local wind effects, moisture and proximity to the Atlantic). The RI will carry out fundamental and applied research central to development and innovation in the global wind energy sector namely; energy storage, materials and aerodynamics. UL is ideally placed to host the RI having expertise in the relevant areas (e.g. weathering, rain erosion, manufacturing/repair of composites materials, energy storage and aerodynamics).

13. Precision Engineering and Manufacture Centre of Excellence

Institute of Technology, Sligo **Dr. David Tormey**
The Precision Engineering and Manufacturing vision for IT Sligo represents an integrated and multi-faceted approach which proposes: ? The establishment of a Centre of Excellence for Precision Engineering and Manufacturing having: o Education & training programmes embracing high quality teaching and learning. o Strategically relevant applied research and innovation. o State-of-the-art facilities. o Increased levels of engagement with industry. This comprehensive plan, which ranges from apprenticeship to Level 10, envisages a coherent suite of teaching, technology transfer and applied research activity which will have National strategic importance, and will contribute, uniquely and significantly, to the development and expansion of the knowledge and skills base for manufacturing in Ireland.
14. Institute for the Development of Innovative Therapeutics
National Institute for Bioprocessing Research and Training **Dr. Jennifer Byrne**
The Institute for the Development of Innovative Therapeutics (IDIR) will address the grand challenge of manufacturing next generation, innovative molecular entities in a cost and time efficient manner to address unmet medical needs. IDIR would position Ireland and Europe as the location of choice to establish high value therapeutic manufacturing employment while assisting affordable access to innovative medicines. The IDIR facility would provide pilot scale, cGMP capabilities to develop robust manufacturing processes for disruptive therapies such as immunotherapies, biosimilars, antibody drug conjugates, gene and cell therapies which are making progress toward commercial launch. IDIR will be a test bed for new manufacturing technologies from continuous manufacturing, biocatalysis, single use technologies, process analytical technologies, novel purification and formulation technologies to develop the facility-of-the-future for the manufacture of innovative therapeutics. Uniquely, IDIR will tackle the complete process from scientific, engineering, regulatory and supply chain issues with the ultimate aim to ensure affordable access for innovative therapies.
15. Towards the Grand Challenge: Fabricating New Medical Devices using Advanced Polymer Manufacturing Technologies
Materials Research Institute [MRI] Athlone Institute of Technology **Professor Clement Higginbotham**
Polymer research at the Athlone Institute of Technology (AIT) is carried out in the Materials Research Institute (MRI). The MRI is recognised as the leading hub for polymer research and development in Ireland, with a long tradition in developing innovative polymer solutions for Irish industry. In an effort to bridge the gap between the existing traditional polymer processing facilities available in AIT and the next generation of advanced manufacturing technology requirements for Irish industry, the research infrastructure needs to be up-graded for future initiatives. In particular, funding is sought for continuous fibre processing, micro-processing, multilayer processing equipment and temperature sensitive additive manufacturing equipment.
16. Additive Manufacturing Post Processing and Characterisation Laboratory
SEAM (South Eastern Applied Materials) Research Center **Dr. Ramesh Raghavendra**
The EOS M280 Metal 3D Printing system at SEAM is the only one of its kind in an academic institution at the moment and as such is the only point of access for research interests in the country. Though SEAM has the EOS M280 system installed and running the development of its full capabilities, its use as a research tool is somewhat hindered through a lack of specific post processing and analysis equipment. A unified post processing and characterisation laboratory containing the necessary pieces of equipment (see the list below) to support SEAM's recently acquired 3D Metal Additive Manufacturing capability is necessary. By its very nature the additive manufacturing technique requires a variety of finishing processes and analysis capabilities to ensure the optimum results. The acquisition of the equipment proposed here will enhance the 3D metal printing, development and design capability in house. It will also be an excellent fit with SEAM's CAD, FEA, CT and other wide ranging materials engineering capabilities. This will enable SEAM to offer a design prototype fabrication and optimisation processes for a range of Irish based

Engineering companies. Specific equipment list (a) Wire EDM (Electrical Discharge Machining) for removal of structures from base plate (b) Milling Machine for reuse of base plate for printing (c) Shot peening equipment for optimised surface finish generation of printed objects (d) Electro-polishing system for surface optimisation of printed objects (e) Optical Emission Spectrometer (OES) –Characterisation of final product (f) X-ray diffraction (XRD) –Characterisation of final product
17. Third Generation X-ray Tomography (CT) L450 System
SEAM (South Eastern Applied Materials) Research Center **Dr. Ramesh Raghavendra**
This system is designed to assist primarily Aeronautical and Automotive Industries. It is designed to investigate very high density materials and/or large assemblies. By securing this system, SEAM, WIT will be the only place in the world to have the full suite of CT systems that can cater for all industries and this will be a significant boost/assist for all industries in the island of Ireland. The phoenix V|TOMEX|X L 450 is a versatile high resolution system for 3D and 2D Computed Tomography and 3D non-destructive X-ray inspection for a wide range of industrial applications. With its granite based 8-axes manipulation stage it is capable of handling very large samples with the highest precision. It is the optimum solution for void and flaw detection and 3D metrology (e.g. first article inspection) of castings. Furthermore, phoenix|x-rays high resolution X-ray technology has many extras like an optionally second X-ray tube allows the v|tome|x L to adapt to any kind of industrial and scientific CT application. This system will cost in the region of €1.6-1.7m plus VAT. This equipment will provide a non-destructive examination technology for product components that facilitates observation of the internal structure of components and assemblies at the micron level.
18. Distributed Data Centre infrastructure built from next generation Software Defined infrastructure to explore inter Cloud build and resilience technologies for an IoT world
CONNECT Centre **Linda Doyle**
This Distributed Data Centre RI will allow up to 50,000 Virtual machines, employing the latest compute/storage and networking technologies for Research into resilient Cloud deployments for Big Data applications. This Data Centre will act as a mirror for the TSSG hosted data Centre, which it will be paired with, and allow for inter Data centre Cloud computing and resilience, through the provisioning of an independent research fibre pair between these Centres. Provision will be made to allow this RI to be physically distributed geographically throughout the country (built from Container technologies), inline with the research themes pursued, allowing co-research with wireless- optical and distributed (deep caching) networking paradigms.
19. I3 Centre Innovation, Instantiation, Industrialisation - An infrastructure for Product and Process Research and Advanced Manufacturing for Smart Systems
Irish Photonic Integration Centre (IPIC) **Paul Townsend**
The facility will be a new-build of an advanced RI for fabrication of a new generation of smart, multi-functional, heterogeneously integrated systems. Such smart systems are becoming ubiquitous in everyday life – personalised and customised technologies and adaptive, energy-efficient sensing and communication systems, all creating the Internet-of-Things. This is mirrored in the customisation and personalisation of manufacturing, which is moving from manufacture in billion dollar factories in low wage / tax efficient economies to manufacture at point of use. The vision is to build a new capability which includes a state of the art wafer fabrication pilot line and extensive capabilities in integration, packaging and additive manufacture (3D printing) to deliver rapid and customisable product development. This will also host facilities for validation of new sub-systems and products in real world environments, enabling companies to de-risk their product development - the ability to 'fail fast' and redesign being critical in the fast paced 'Makerspace' environment into which manufacturing is moving. The RI will operate at higher Technology Readiness Levels than currently available in RTOs, thus enabling translation of ideas and concepts from proof of concept through to Minimum Product Volumes to validate their concepts and bridge the 'Valley of Death'.

20. SSRI Nano to Macro Smart Sensors & Systems Research Infrastructure
Irish Photonic Integration Centre (IPIC) **Paul Townsend**
The facility will be an advanced RI for fabrication of a new generation of smart, multi-functional, heterogeneously integrated systems. Such systems include, for example, intelligent medical diagnostic systems for on-the-body and in-the-body applications, and adaptive, energy-efficient sensing and communication systems for the Internet-of-Things (IoT). The vision is to leverage the convergence of Tyndall's existing capabilities in micro- and nano-scale integrated photonics and electronics and advanced materials to drive a step change in the delivery of advanced smart system prototypes that can be applied across a wide range of applications including communications, health, environment, agriculture and energy. The development of such systems to more advanced levels of technology readiness than is currently possible will be critical for addressing existing gaps in the research innovation cycle in Ireland - the 'valley of death'. The steps that the institute is taking towards this goal are already proving to be highly attractive to industry and this proposed RI aims to greatly accelerate this process. The facility will be based at Tyndall and will involve a capital investment in fabrication and packaging facilities - updating and extending existing facilities by adding a higher level of capabilities in system integration at the nano and macro scales.
21. Dynamic and Real-time Environment for Advanced Microgrid systems with Smart test-bed
International Energy Research Centre (IERC) **Tony Day**
The desired RI will aim to the (i) design of new concepts, (ii) development of existing and emerging microgrid with distributed energy sources technologies, (iii) demonstration of concept in real-time environment and (iv) dynamic performance study of the product/technologies for the seamless integration with the smart grid. The RI will support 4D facilities in smart and intelligent microgrid technologies, ICT infrastructure, and their interaction with the future smart grid environment. The dynamic and real-time testing environment facility will comprise of the concept of universal test-bed structure facility that will be easily reconfigurable in order to accommodate different geographical (Cork, Dublin, Edinburgh etc), resources (solar, wind, diesel, hybrid etc), systems (converters, filters etc) and load (active, reactive, harmonic) a variety of energy plant equipment (both conventional and renewable) systems while it will be combination of hardware and software with interlinked with real-time communication platforms and heavily sensored to facilitate both intelligent operation, monitor, control and management conditions assessment. The construction of the RI will allow also allow the testing of concept/product/network for both existing and emerging technologies in physically and remotely. The most challenging part of this facility will be to make it universal and allow the monitor and control remotely with secured and safely.
22. Experimental Infrastructure to test components, systems and services for the Configuration of Zero Energy Connected Buildings
International Energy Research Centre (IERC) **Tony Day**
The desired RI will aim to the development of new concepts, products and services for the improvement of the energy performance of buildings and the seamless integration of the latter within the smart grid. The RI will support R&D in façade engineering, HVAC systems and solutions, ICT infrastructure, thermal and visual comfort and their interactions and interrelations in the built environment. The full scale facility will comprise of a flexible and adaptable building structure that will be easily reconfigurable in order to accommodate different envelope components and systems (opaque, transparent and dynamic), a variety of energy plant equipment (both conventional and renewable) and heat transmission (radiant, convective and hybrid) systems while it will be fully wired and heavily sensored to facilitate both intelligent monitoring and control and detailed indoor environmental conditions assessment. The construction of the RI will allow the testing of components for both new and renovated buildings.
23. Irish Aerospace and Aviation Research Laboratory (I-AVRL)

University of Limerick - Faculty of Science & Engineering and Kemmy Business School Professor E Magner/Dr. C. McCarthy
The latest forecast from Airbus for 2014-2033 anticipates commercial air traffic growth of 4.7% annually, requiring over 31,350 new passenger aircraft and freighters at a value of US$4.6 trillion. Meanwhile €4.2 billion is being pumped into Europe's latest aeronautical research programme, Clean Sky 2. Ireland punches well above its weight in aviation leasing, flight operations and aircraft maintenance, but has limited involvement in aerospace manufacturing, and draws down relatively low levels of aerospace research funds. With such massive opportunities on offer, countries around the world are developing aerospace strategies, and breaking into the increasingly global aerospace manufacturing supply chain. There is no fundamental reason why Ireland should not do the same. A key enabler for protecting our current aviation industry, attracting Foreign Direct Investment by aerospace companies, and increasing drawdown of aerospace research funding is a well-equipped National Aerospace and Aviation Research Laboratory, along the lines of similar laboratories across Europe. The laboratory, co-located at Limerick and Shannon should include a National Wind Tunnel facility, Flight Simulation Research Centre, a Research and Flight Test Aircraft, a Continuing Airworthiness and Maintenance Research Aircraft, and an Aviation Business Research Centre, with dedicated hangar space, runway access, and company incubation and implant units.
24. Irish SME Innovation Centre
University of Limerick - Faculty of Science & Engineering and Kemmy Business School Professor E Magner/Dr. C. McCarthy
This Centre will shape Ireland's SME factories of the future by developing Innovation Labs focusing on complete life cycle of products and services, using design-thinking methods to develop innovative manufacturing processes that optimise novel materials and energy usage, address automation challenges by encompassing mechatronic systems to interface with materials, parts and products, co-operate safely with factory workers, communication across other factory systems such as finance, marketing, and commercialisation. The Centre will form on-campus RI with research activity, and a spoke regional SME support centres located initially in Shannon, with other spokes forming along the Atlantic highway. In Ireland firms with improved innovation capacity have performed and even grown during the recession. However, indigenous SME's seriously lag behind large Multi-Nationals and foreign owned firms in RD&I spend. Hence, this Centre aims to support SME's to innovate across their entire organisations, from design, innovative manufacturing and automation, business and finance, through to commercialisation of products and services. The centre will enable SME's to access design-thinking led innovation labs with dedicated physical environments, R&D and business support facilities with collaborative workspaces. SME's will engage all RD&I stakeholders (MNC's, Universities, IT's) in multi-disciplinary environments, to create new approaches to products and services development.
25. Pervasive Ireland – Wireless, networking and Cloud enabled service infrastructure to provide an Open platform for IoT research.
CONNECT Centre Linda Doyle
The pervasive Nation is an IoT wireless network spanning 70 sites for complete national coverage with urban, sub-urban and rural reach. It is the first of its kind in Ireland and the first IoT testbed with national coverage internationally. Hosting a broad range of Research grade wireless sensors and actuation technologies, this RI will have Urban, sub-urban and rural reach; support connecting 10's of millions of Things; support an Open Cloud Application Enabling Platform, that will allow device, network, platform and service Research activities. This RI will deliver the infrastructure to support Ireland's IoT Research.
26. Modular pilot processing line facility for materials development and testing
AMBER Centre Colm McAtamney
This new facility will underpin the translation of world leading nanomaterials expertise into

industrially relevant processes. This new infrastructure will allow the development and testing of materials for advanced manufacturing technologies and processes. Capabilities would include 3D printing, ink jet printing, roll to roll manufacturing, machining, polymer processing (extrusion, injection molding) and testing equipment, Nano imprint, Powder Metallurgy capability, selective laser melting to name a few. It will require a new facility to house a modular pilot line containing the above equipment necessary for testing existing and new materials and demonstrating their suitability for industrial processes. An example is additive manufacturing which refers to a process by which digital 3D design data is used to build up a component in layers by depositing material. This would enable 3D objects that are metal, plastic, of bio-compatible materials, or that contain electronics etc to be manufactured using 1D, 2D materials, metals, plastics, biomaterials and composite materials.
27. Centre for Formulation Design to support innovative Pharma /Food/ Medical Device development
University College Cork, School of Pharmacy **Professor Stephen Byrne**
The desired Centre for Formulation Design is the Idea to improve the academic formulation research offering more extensively and formally to external collaborators. External collaborators are academic, SME and large companies in the Pharma, Nutritional and Medical Device sectors. Formulation is the transformation of a therapeutic or nutritional substance to a form that can be used by a patient or clinician, for example a capsule, tablet or coated stent. Formulation employs a number of common technical approaches across pharma, nutrition and medical device sectors. Within Ireland currently there exists a range of research formulation processing equipment and associated regulatory advice that can be accessed through individual institutes and research centres. Trends in formulation approaches are changing to meet patent health needs with moves towards 1) small scale continuous processing, 2) individualised doses for personalised medicine, 3) nanomedicine and 4) aging population. The centre would access existing conventional processing equipment and regulatory expertise. Investment would be requested to meet current gaps to purchase more innovative formulation equipment (continuous blenders and granulators and printing technologies) and provide dedicated personnel to interface with industrial and academic clients.
28. Hydrometallurgy Test bed
Organization and summary confidential
29. Factory of the future in phArmaCeutIcals crystaLisaTion And downsTream procEssing (FACILITATE)
Organization and summary confidential
30. Technology Convergence & Translation Centre
Organization and summary confidential

Medical & Life Sciences (28 Ideas)
1. Centre for Bio-Pharma Imaging
TCIN **Ciaran Conneely**
The new RI (Centre for Bio-Pharma Imaging) will consist of cutting edge equipment including a 7T whole body clinical MRI scanner, Digital 3T MRI scanner, DNP Hyperpolariser and associated IT and bio-banking infrastructure. These tools will underpin the development and characterisation of new molecules or new uses for existing molecules at a pre-clinical and clinical level. Eg. It will provide unprecedented resolution in brain research studies directed towards understanding and treating brain disorders such as Alzheimer's Disease, Depression, Psychosis and ADHD. The new RI will provide tools to support innovation and product development in the medical device and diagnostic industries while training scientists & engineers in cutting edge techniques as part of integrated PhD programmes, industrial training and EU ITN programmes. The new centre will be a resource for Ireland's bio-pharma industry and the discovery process, it will build on previous investments in imaging infrastructure by AP, HEA-PRTLI, SFI and Industry totalling €8m and previous research investments from GSK, Intel & GE totalling €15m. In addition to our existing relationships with bio-pharma companies such as Alkermes, we would also target international pharma companies based in Ireland as well as diagnostics companies such as Phillips Healthcare and Bruker.
2. National Germ Free Facility
Alimentary Pharmabiotic Centre **Sally Cudmore**
Redevelopment of 1st floor of UCC's Biological Services Unit into a new National Germ Free Facility "Genetically defined germ-free animal models colonized with defined microbiota are crucial for progress in microbiome research." Nature Biotechnology 31, 263 (2013). Currently the APC Microbiome Institute has a small Germ Free Platform, the only such research infrastructure in Ireland and one of only a handful in the world. A Germ Free lab is a completely sterile laboratory which permits the rearing of gnotobiotic rodents that have no microbiota (bacteria/viruses/fungi), and so allows the exploration of the role of the microbiota (or components therof) in the development of the hosts' immune, neural and digestive systems, and the maintenance of health status. It also allows researchers to explore how an unbalance (dysbiosis) in the microbiota can predispose towards disease, such as IBD, IBS and rCDI, and the development of therapeutics to rebalance the microbiota. But proving causation and understanding the mechanisms through which dysbiosis might contribute to disease will require the wider adoption of animal models in which factors such as host genotype, microbiome genotype, diet and exposure to drugs can be placed under stringent control. The APC has had a small GF unit since its inception in 2003 (funded by PRTLI), but 12 years later this facility is in serious need of expansion and redevelopment in order to accommodate the growing APC research activities, and in particular interactions with the food, pharmaceutical and biotech industries. In 2012 SFI funded the purchase of equipment for an expanded facility, and UCC has identified suitable space to develop a new facility, but lacks the funds to redevelop the space.
3.National Advanced Microscopy Suite (NAMS)
University College Cork **Professor Mary McCaffrey**
Spinning disk (SD) confocal microscopy, the technology of choice for high-speed 3D imaging of live cells, offers many advantages over confocal laser scanning microscopy (CLSM). Specifically, SD microscopy facilitates acquisition of high-resolution time-lapse images at rates 20 – 50 times faster than CLSM. Considerably lower levels of illumination intensity reduce phototoxicity, allowing detection of subcellular events that occur on the millisecond timescale, as opposed to the second timescale currently possible. Furthermore, the SD configuration allows rapid high-throughput screening of biological samples. A state-of-the-art SD confocal will be incorporated into a National Advanced Microscopy Suite (NAMS). It will be a 'game-changer' for live cell and high-throughput imaging. NAMS will be particularly beneficial to researchers in the molecular cell area (physiology, biochemistry, food science & microbiology), facilitating collaborative endeavour in the detection and recording of cellular events, including calcium 'spikes', reactive oxygen species (ROS), intracellular membrane trafficking, and host-pathogen interactions. It will also provide academic and industrial researchers with a non-destructive method for analysing materials and surfaces. NAMS will increase Ireland's advanced microscopy capacity and eliminate the time-

consuming need for researchers from outside Dublin to travel for access to central facilities, leading to greater opportunity for academic/industrial collaboration at a national level.

4. A Technology Platform for Personalised Health Diagnostics

University College Dublin
Professor Walter Kolch

An integrated omics analysis platform for personalised health assessment for research and clinical purposes, consisting of infrastructure for (i) next generation sequencing (2 sequencers for whole genome/ whole exome sequencing; 2 sequencers for targeted gene panel sequencing), proteomic analysis (2 mass spectrometers for high resolution proteome analysis), metabolomics analysis (2 mass spectrometers for high resolution metabolome analysis), bioinformatics and big data analytics (secure server and database) . The purpose is to provide (i) the first clinically accredited Irish based NGS service for clinical diagnosis and targeted therapy; and (ii) a comprehensive health research platform which allows one to harvest knowledge ascertained through combined omics technologies towards prevention of disease and maintenance of good health.

5. Irish Clinical Trials Research Network (ICTRN)

National University of Ireland, Galway
Professor Tim O'Brien

The aim of ICTRN is to grow clinical research in Ireland by offering a seamless, integrated and coherent system of support for multi-centre clinical research, undertaken by individual investigators and/or industry in Ireland. The system will achieve this by improving access, communication and coordination, reducing fragmentation, harmonising approaches and common standards and enhancing business development functions. ICTRN will be based on a Hub and Spoke model with the Hub represented by a Central Office and the spokes being the 5 Applicant Universities' CRF/Cs. The Central Office will be located in a host organization in Dublin and will be staffed by the Chief Operations Officer, Clinical Trial Liaison Officer, Quality Manager and Clinical Industry Liaison Officer-Medical Devices; the host organization will provide corporate support services. The required peripheral staff within each 'spoke' CRF/C will be seconded on a part-time basis to ICTRN. This will require the host organization within which ICTRN is embedded to have legal agreements with each of the 5 applicant universities. A critical component required for the successful strategic development of ICTRN is that its central office is hosted within an independent legal entity with bespoke, financial, HR and legal capacity that can rapidly respond to customer EoIs.

6. UCD Comparative Medicine Unit

UCD
Mark d'Alton

Flexible, modern biomedical unit with multiple equipment modalities (in house flow cytometry, bench top MRI, CT, SPECT etc.) and with a multi-use, easily adapted holding space.

7. National Genomics Infrastructure for Ireland

College of Science, National University of Ireland Galway
Derek Morris

A National Genomics Infrastructure for Ireland will support Genomics research (both basic and clinical) in Ireland. The plan is for Genomics Core Facilities and Bioinformatics Core Facilities in participating institutions, which will together be supported by cyberinfrastructure in the form of the WASP system (http://www.ncbi.nlm.nih.gov/pubmed/22942009), an open source, advanced software platform for genomics data and which will be implemented by the Irish Centre for High End Computing (ICHEC). A Genomics Core Facility will house the required equipment for preparation/QC of samples and will facilitate flexible access to appropriate-scale next-generation sequencing (NGS) technology (academic or commercial) in order to source the most cost-efficient NGS from an ever-changing market. The plan reflects the modularity of the Genomics process, investing in areas with greatest impact, while outsourcing the actual NGS, which is very process driven and continually getting cheaper. The plan also addresses the major challenge in Genomics, which has shifted from generating data to upstream Experimental Design and downstream Analysis. Rather than purchasing expensive equipment, this plan focuses on developing the required expertise and cyberinfrastructure to support the entire experimental process, thus empowering Irish scientists, who regularly cite lack of support in these areas as a major roadblock to research.

8. Elementomics Centre
University College Cork **Professor Anita Maguire**
The proposed infrastructure of state-of-the-art analytical elemental analysis instrumentation is an opportunity to provide high-throughput quantification, distribution, speciation, identification, and structural characterization for Metallomics and Elementomics, powerful in the fields of science, medicine, health, new materials, pharmaceuticals, nutrition, and the environment.

9. Core Facilities Upgrade NUI Galway
National University of Ireland, Galway **Professor Tim O'Brien**
This Idea is about a major upgrade to existing Research Infrastructure to accommodate the increased loads to allow realisation of potential from massive human and capital investment. The key value of Bio-photonics and Imaging in the Life and Medical sciences is in quantifying molecular activity and placing function in a structural context. Imaging is one of the fundamental tools which underpins nearly all aspects of modern Biomedical Research. NUI Galway is actively developing a coherent and comprehensive Imaging Research Infrastructure including both personnel and instrumentation. The provision of and adequate access to quality imaging technologies is an essential component of the research activities of Curam. The first stage in the realization of this potential was attained via PRTLI 4 funding as part of the National Bio-photonics and Imaging Platform (www.nbipireland.ie) whereby we attempted to harness the full potential of the arsenal of Imaging resources that exist on campus and nationally. This was further consolidated with the recent PRTLI 5 Advancing Medicine through Discovery programme in the provision of key operatives that provide key service provision the microscopic arsenal. The present proposal is intended to allow the full realisation of these vital infrastructural investments and make the next key translational step. This requires the intimate interlacing of technology development industrial innovation and clinical realism. The mission of this centre is to bring profound innovation to healthcare imaging and wellness by pushing the frontiers of technology. The significant upgrade of two key core facilities will help fulfil this Idea.

10. Cryo-electron tomography for biological imaging
Trinity Biomedical Sciences Institute **Tony Byrne**
The Irish National Centre for Electron Microscopy being formed in Trinity College Dublin will bring together the diverse resources of the Advanced Microscopy Laboratory (AML) at CRANN and biological sciences/analysis at the Centre for Microscopy and Analysis (CMA) to create a national facility to support research involving electron microscopy across a broad range of scientific disciplines, including physics, chemistry, biological sciences, geology and engineering. This new centre will also provide industrial partners and clients with access to instruments using a service-centre model with the intention of supporting R&D in microelectronics, aerospace, med-tech, energy, personal care, automotive, life sciences and other industries. There would also will be an extensive multi-discipline, multi-level teaching mandate. Due to the emerging and critical role and relevance of cryo-electron tomography it is proposed to include core infrastructure and technologies for cryo-EM in the National Centre. This new centre will provide the physical and technical support of the required instrumentation and the Institutes of TBSI and CRANN would provide thematic context to drive research and engage industry and third level partners at national and international level.

11. Instrumentation to support research
Trinity Biomedical Sciences Institute **Tony Byrne**
These would greatly enhance or aligned with Priority Areas: 1). Diagnostics, and 2). Therapeutics – synthesis, formulation, drug delivery [1]. High Through-out Screening of Drugs, SiRNA, Exosomes, etc. - effects on cells in culture As a School of Pharmacy & Pharmaceutical Sciences our capabilities for screening drugs libraries, siRNA libraries etc. is limited to manual and 96-well plates. The aim would be to advance this to High Through-out Screening Equipment required would include: ? Perkin Elmer Janus liquid handling workstations; each is housed in a Cat 2 enclosure ? Perkin Elmer / Packard PlateStak Automated Stacker ? Echo Acoustic Dispenser

allowing scale down to ultra-low volume (in nanolitre to microlitre range) Cost would be of the order of €120K Additional lab space would also be necessary [2]. Vi-Cell XR: further enhancing this, but also for all cell culture experiments, automated assessment of cell viability, cell size, cell concentration, cell circularity would be very useful. This would be achieved e.g. using a Beckman Coulter Vi-Cell XR. Cost ~ €63-€65K. [3]. Hypoxia Workstation: the environment around cancer cells is hypoxic but when we perform research on cancer cells we don't have the facilities to mimic this hypoxic environment. Being able to do so would enhance our cancer research. The Optronix HypoxyLab ~ €62K. [4]. qNano for "nanomedicine" Much of our research is on exosomes, microvesicles and other nano-sized entities. A qPnano to measure particle size, particle concentration, particle interactions is badly needed. Approx. €22K. [5]. AECA xCELLigence Dual Plate Real Time Cell Analysis System (RTCA-DP) for real-time evaluation of cell migration, invasion. Typically used for assessing cancer cells in response to drugs, stimuli, exosomes, etc., but would have other purposes for other users. Ballpark figure ~€35-40K. These would very likely be of interest to many other groups in TBSI, as well as externally.

12. The Irish Epilepsy Phenome-Genome Network

The Royal College of Surgeons in Ireland
Gianpiero Cavalleri

The proposal would be for a nationwide biobanking effort for epilepsy and related disorders in Ireland. The biobank would store DNA, RNA and clinical profiles on thousands of patients with epilepsy. The biobank would allow recontact with patients. Participants will be recruited via a network of seven epilepsy tertiary referral centers in Ireland, already coordinated via the National Clinical Care Programme for Epilepsy. Clinical details will be stored in the epilepsy-specific electronic patient record (EPR) developed at Beaumont Hospital and now in use at all seven tertiary referral centers. Full clinical records on over 5,000 patients with epilepsy (>10% of the entire epilepsy population) are already contained in this EPR and the number is increasing rapidly.

The establishment of a biobank of this nature would provide a globally unique resource that could position Ireland at the forefront of precision medicine in epilepsy and related neurological disorders. With the advent of next-generation sequencing, rapid progress is being made in the genetics of epilepsy. There are now some remarkable examples of extreme responses to precise medications, selected based on underlying genotype. Ireland (RCSI specifically) is a leading player in the study of miRNAs as biomarkers and treatment approaches in epilepsy. By establishing a very large cohort from a homogenous island population, directly linked to dense clinical details in electronic format, this resource would provide the platform for increased discovery and critically, the development of precision approaches to the treatment of epilepsy. For example, by sequencing patients in the biobank, you can identify individuals with particular mutations on which treatments can be tested in-vitro via cell and animal models.

13. Human Nutrition using innovative biotechnology

Waterford Institute of Technology
John Nolan

This infrastructure will support scientists with an interest in human nutrition. Area of research will include study of human function with emphasis on eye and brain function. Facilities will need to be analytical (e.g. HPLC sample analysis) and clinical (e.g. clinical trials for Alzheimer's and age-related macular degeneration). This infrastructure will compliment and be an addition to the infrastructure already established at our centre.

14. National Centre for Metabolomics

UCD Institute of Food and Health
Geraldine Quinn

Establish a centre to provide world class metabolomics research and service. Metabolomics is the fastest growing omics technology and has many applications across multiple sectors. Currently many Irish researchers transport samples out of Ireland for analysis leaving only a few scientists with expertise in the field. UCD is a leader in Nutritional metabolomics however, the group has no capacity to run samples for other groups in Ireland. The development of a national facility for metabolomics would enable a major upgrade of UCD facilities and allow access to scientists to a technology currently not available.

15. Music Therapy Research Laboratory

University of Limerick - Irish World Academy of Music and Dance & Faculty of Arts, Humanities & Social Sciences

Niall Keegan / Professor Tom Lodge

There is no creative arts research centre anywhere in the world dedicated to address the mental health issues and complex social consequences that arise from traumatic events. This proposal outlines a plan to develop a creative arts research centre that will be dedicated to the development of evidence-based recovery practices and strategies in mental health. The arts are eloquently positioned to build such a bridge between these two traditions as they offer a way of making scholarship accessible to a much wider audience. As such this proposal is about the creation of a new research infrastructure, an internationally unique research laboratory and centre for music therapy. Such a research laboratory would be a high tech clinical space featuring state-of-the-art musical and technological infrastructures along with a hub for data collation, organisation and dissemination. This is a physical single site facility which will function for an international virtual hub for this research community.

16. Genomics Ireland

Trinity College Dublin
Aiden Corvin

Progress in genome sequencing has being astonishing. Sequencing the first human genome was a multinational project completed after 13 years in 2003: a decade later my local TCD sequencing lab completed 276 human genome equivalents in one year at <0.001% of the cost of the first project. Having this technology means that new organisms are being identified (e.g. bacteria with potential to identify new antibiotics), genome variation can inform the food and agriculture sectors, we reach deeper understanding about human evolution, we are learning more about the biology of disease. IN medicine, this is already informing how patients are diagnosed, how rapidly we can identify infection and make treatment decisions (by sequencing pathogens), informing new drug development and our ability to determine which patients will benefit most (personalized medicine). Genome data is accumulating at a rate that exceeds global analytical expertise and capacity. Nationally we require a secure, infrastructural solution to managing data across the sectors-this could be delivered by the Irish Centre for HIgh End Computing and partners. This would require a dispersed model as the needs of individual sectors, or groups will differ-but having a nationally supported infrastructure would facilitate training, consistent quality standards of data management and be cost effective. The looming alternative is multiple local 'solutions', where quality if difficult to establish and opportunities for added value are lost through incompatibility and poor planning.

17. Clinical Research

Organization and summary confidential

18.Upgrade & Maintenance of the Bioprocessing Pilot-Scale Production Facility (located in the APC Microbiome Institute, UCC) to GMP level

Organization and summary confidential

19. Irish National Centre for Animal Cell Biotechnology

National Institute for Cellular Biotechnology (NICB) (www.nicb.dcu.ie) at DCU
Martin Clynes

A wide range of biomedical research and development projects – spanning basic research, clinical application and industry – require access to excellent core facilities – including specialised laboratories and clean rooms, expert scientific staff, and advanced equipment – in the area of animal cell culture and related technologies associated with the recent explosion in our knowledge of Life processes. Most research projects in this broad area use animal cell culture as a technique, but often the expertise and experience necessary to grow and investigate these cells properly is lacking. For example, cross-contamination of cells is a widespread and often unrecognised problem; unrecognised mycoplasma infection is another. The concept here proposed is a Centre of Excellence in Animal Cell Culture and associated molecular and microscopic technologies which, as well as having its own research programmes, will be accessible for use, for training, and for advice to other researchers in third level institutions, in hospitals and in industry. This would build on and leverage off existing expertise in DCU's National Institute for Cellular Biotechnology (www.nicb.dcu.ie) and its collaborators (including RCSI and NUIM through the 3U Partnership), and a variety of clinical, industrial and

international research partners, and would be complementary to the skillsets developed at NIBRT.
20. MechanoBiological Systems – Transformation of Cells for Tissue Repair
Organization and summary confidential
21. A Centre for the development of new therapeutics and diagnostics based on non-coding RNA
Royal College of Surgeons in Ireland **Professor Raymond Stallings**
In recent past seminal discoveries have been made in the biochemistry underlying diseases, identifying non coding RNAs as new targets for therapeutic intervention. Altogether, this set of discoveries switched the interest of pharmaceutical companies, which focussed for decades on small molecules as drug candidates, to large molecules that resemble or interact with the nucleic acids (RNA). The new centre will take inspiration from these novel RNA and will provide a platform for the design preparation, screening of novel chemical entities as therapeutics and diagnostics. Because of the remarkable difference in chemical nature and behaviour of these compounds a the research centre will have to be integrated by new dedicated facilities. It should be noted that a centre of this type will be unique in Europe and it would therefore attract industrial R&D and collaborative work. For example, preliminary discussions have been run with AstraZeneca, which has recently diverted 50% of their current research from small to large molecules.
22. EuroBioImaging: National Biophotonics and Imaging Platform, Ireland
National BioPhotonics and Imaging Platform Ireland **Professor Martin Leahy**
The proposal entails a major upgrade and reorientation of the PRTLI Cycle 4 National Biophotonics Platform, Ireland (NBIPI - www.nbipireland.ie), distributed across 10 academic institutions nationally, and associated members in 3 EU countries, to consolidate and develop support for individual institutions, SFI Centres and Technology Gateways, EU and national collaborations, industry, and lead Ireland's engagement in ESFRI platforms such as EuroBioImaging and ECRIN. The RI will underpin a range of identified prioritised research areas including Medical Devices, Diagnostics and Therapeutics and provide the critical platform for basic research as well as medical device and pharma industry and discovery labs and the clinical translation and commercialization of Irish diagnostics and therapeutics. The resources will include centralised access and training co-ordination, site based facility engineers and significant investment in enhanced imaging infrastructure including label free imaging techniques for nano, micro and mesoscale imaging and sensing. The RI will be operated on an agreed Open Access Policy and Charging Model, consistent with HEA policy and EU standards ensuring sustainability. In addition, these facilities will support teaching and learning excellence in Science, Technology, Engineering, Arts and Medicine (STEAM) areas, which are a priority to drive innovation and industry of the coming decades.
23. National Centre for Large Animal Prelinical Device Testing, Therapeutics and Translation (NCLA-PDT)
University College Cork **Professor Noel Caplice**
The NCLA-PDT will be a state of the art large animal translational facility with the world class imaging, device and therapeutics testing capability in the key animal model required before translation to clinical trials. The RI would involve high grade refurbishment and expansion of currently available facilities at UCC to an internationally competitive scale,. The existing facility is the only large animal centre with high grade fluoroscopic, CT, ultrasound and endoscopic and endovascular imaging integrated under one roof. The centre already has an international reputation and a track record of translating therapies from the bench to the clinic in Ireland (First in man study to be completed this year with novel therapeutic developed at the centre) and is the only HPRA approved large animal cardiovascular therapeutic and device investigation centre in Ireland. The RI would increase five fold the current throughput capacity of the existing centre allowing it to serve the industry and academic needs of all research institutions and bodies within Ireland. It would provide the necessary scale and international reach currently

absent in Ireland to deliver a missing preclinical large animal device / therapeutics testing capability in the fields of Cardiovascular, Oncology, Rheumatology, Respiratory and Digestive diseases.
24. Advanced Drug Delivery Research Facility
Waterford Institute of Technology **Dr Niall O'Reilly**
The development of the desired RI will require laboratory equipment and facilities which will enable drug delivery development from polymer design and synthesis through formulation, characterisation and in vitro assessment. The equipment necessary for the adequate design of advanced, smart polymer formulations will include computational modelling systems to design the appropriate functionality into the polymers with minimum experimentation and FT-NMR and FT-IR instruments to validate these interactions. Polymer synthesis will require dedicated polymerisation ovens for thermal polymerisation, computer controlled photoreactors for photoinitiated polymers and gamma irradiation chambers for irradiated polymers and sterilisation of the polymers. Formulation characterisation will require high resolution TEM, X-Ray diffraction, zeta sizer/dynamic light scattering, microcalorimetry, solid state nuclear magnetic resonance and size exclusion chromatography instruments. In vitro characterisation equipment will include high resolution mass spectrometry imaging, automated cell culture and processing facilities, cell counters, flow cytometry, and capillary LC/MS. The equipment described above will require dedicated laboratory space in addition to the current facilities at PMBRC and will also require two technical officers to oversee the operation and upkeep of the RI.
25. Advanced Facility for Enzyme Discovery
Waterford Institute of Technology **Dr Niall O'Reilly**
This RI will facilitate the high-throughput enzyme discovery, generation and performance testing of cells/enzymes with high value to the biotechnology/pharmaceutical industry and will be the only enzyme discovery/optimisation/screening platform/service in Europe. The proposed suite will contain an automated cell culturing system. A HTF cell processing and testing system will identify desirable enzymatic activity. The genes responsible will be identified with a next-generation DNA sequencer. Recombinant genes/enzymes will be subjected to automated directed evolution/mutation platform to produce improved enzymes. Enzymes will be purified via automated systems. Liquid chromatography (LC) instrumentation will include: a supercriticial fluid LC for chiral/achiral separations, a bio-separations capillary LC (peptide mapping/enzyme characterisation) and capillary ion chromatograph with corona charged aerosol detection for determination of anions/cations. Chromatographs will be interfaced with mass spectrometry instrumentation including ESI and MALDI sources. This will enable enzyme characterisation via peptide mapping and automated chiral LC-MS screening, evaluating enzyme performance. An automated Flash Chromatography system with mass detector will facilitate small molecule purification following synthesis of novel substrates and standards.
26. Biobank Ireland
Organization and summary confidential
27. Irish Health Research Institute (IHRI)
Organization and summary confidential
28. National Biological Manufacturing Support Facility
Maynooth University **Professor Bernard Mahon**
New biological products will revolutionise the food and medical manufacturing sectors. Mass spectrometry is a key enabling technology to develop such manufacturing. The proposed RI will provide an accessible suite of equipment to facilitate high-throughput and rapid identification, in addition to quantification, of biomolecules including proteins, primary and secondary metabolites and xenobiotics. Specifically, Ireland needs mass spectrometers and ancillary equipment for (i) the identification, and quantitative analysis, of proteins and protein abundance respectively and (ii) dedicated instrumentation for metabolite and small molecule detection and identification.

Associated instrumentation including confocal microscopy and flow cytometry facilities, along with upgrading the existing facility, would lead to a significant upgrading of our successful industrial collaboration programme. Mass spectrometry (MS) in general, and protein MS in particular are essential technologies for the translation of DNA-based discoveries to reality. Through a programme of strategic investment, acquisition of competitive funding and recruitment of individuals with world-class manufacturing research expertise, Maynooth University has positioned itself to translate the deliverables from a BMSF for industrial and clinical applications. Moreover, through a demonstrable track-record of industrial collaboration in the protein mass spectrometry area and the training of multiple PhD-level graduates, we have the essential expertise to maximise outputs from a BMSF.

Environmental & Agricultural Sciences (19 Ideas)

1. RESOURCE - National Centre of Excellence for Applied Research in Sustainable Technologies supporting the transition to a low carbon economy

Technology Centre for Biorefining and Bioenergy
Bart Bonsall

Biorefining and bioenergy systems recover range of valuable bio-energy, bio-chemical, bio-plastic and bio-fuel products from organic matter. RESOURCE will support commercialisation of a wide range of bioenergy and bio-refining technologies developed under Ireland's lab-scale R&D programmes, facilitating commercial exploitation of Ireland's under-utilised wastes, residues and biomass resources, Economic viability requires technologies to work together in coherent "systems". RESOURCE will create a single national open-access centre, co-locating pilot-scale equipment (currently dispersed across a range of locations precluding effective integration) with support facilities and technical expertise to (a) offer process design, engineering expertise and technology scale-up de-risking bio-energy and bio-refining technologies, (b) integrating individual technologies into functional "systems" supporting process optimisation and commercial validation; and (c) facilitating demonstration and deployment of environmental technology systems in a wide range of commercial applications, sourcing risk finance from EU programmes. RESOURCE will leverage funding sourced from established R&D programmes, a range of existing R&D outputs together with an established network of commercial, RPO and EU partners to expedite commercialisation and optimise impact. The combination of skilled researchers, engineering expertise, scale-up facilities and access to risk capital will be a very powerful national asset attracting capital investment, creating employment, and supporting transition to a low-carbon economy.

2. SMART Sustainable Land Management Research Centre

Waterford Institute of Technology
Dr. Nick Mc Carthy

The ever increasing intensification of land-use, be it for agriculture, forestry or horticulture, coupled with stringent EU agri-food and environmental policies, necessitates innovative thinking and alternative strategies for maintaining high quality sustainable productivity, while protecting the environment and encouraging biodiversity. This proposed RI envisages meeting these challenges via the establishment of a world class sustainable Land Management Research Centre which will create novel solutions and maximise productivity and competitiveness. It will also help to engage some of the larger industries in this area who want to collaborate in research but have expressed reservations about using state associated research bodies due to issues of sensitivity and IP. The proposed RI will be subdivided into two synergistic research facilities. Firstly, a 100 acre working research farm will facilitate studies into areas such as animal fertility and health, novel animal feed additives, sustainable land management practices and novel bio-pesticides. Secondly, a state-of the-art land management research facility will house a suite of laboratories equipped with next generation DNA sequencers, chromatographic and spectroscopic instrumentation and an animal feed pilot plant. This will be underpinned by the parallel development of SMART technology and sensors to aid in intensive monitoring and management of agri-food and forestry practices and to assist in compliance with strict EU guidelines in maintaining the integrity of the biodiversity and ecology of the land used. The Centre will focus on enhancing land management opportunities in agriculture, forestry and horticulture.

3. Sustainability Action and Technology Demonstration Centre

Institute of Technology, Sligo
Dr. John Bartlett

A working site where integrated multi-disciplinary sustainability actions and technology can be tested and demonstrated to the public and to economic and social actors, to support the achievement of national sustainability and development objectives.

4. Research Infrastructure for Agriculture and Food Science Education, Research and Innovation

University College Dublin
Professor Alex Evans

The proposed RI will contribute to Ireland's position as a world leader in agricultural and food science. The infrastructure will prepare future generations of workers and leaders for their roles in

the agriculture and food sector, it will produce new knowledge and stimulate innovation leading to new products and ways of producing healthy, sustainable food for Ireland and the world. A new generation of leaders will be required, who are conversant with a whole range of new technologies and a more competitive, innovative outlook, to lead the Irish agriculture and food industries. UCD is well positioned to develop these leaders and to undertake the research and innovation that will be required to develop, adapt and implement the new production and processing technologies that will be required. An important aspect of this is collaboration among a wide range of disciplines including basic science, computer science, engineering, health and veterinary science, mathematics, social science, and business. However existing facilities were developed in the 1970s at time when the educational and research needs of the industry were very different from today. The focus of this RI investment is to develop a new infrastructure that will support, the education of the next generation of leaders for the agriculture and food industries, and research into the development, adaptation and implementation of the new and innovative technologies.
5. Centre for Irish Marine Omics Research (CIMOR)
National University of Ireland, Galway (NUIG) **Professor Peter Croot**
The overarching research objective of the Centre for Irish Marine Omics Research (CIMOR) is to establish a world class facility focused on the application of state of the art 'omic' based technologies for marine research within Ireland. Presently there is no national facility for marine 'Omics' in which metabolomics, metagenomics, proteomics and transcriptomics work can be performed in combination with an 'in-house' bioinformatics pipeline and many if not all of these functions are lacking in Ireland and are sourced from elsewhere. CIMOR would provide the infrastructure to sustain a critical mass of basic research on marine biology, chemistry and biotechnology with potential for supporting SMEs that seek to commercialise applications arising from this work. CIMOR will strengthen Ireland's marine research capabilities by providing the necessary shipboard and laboratory facilities for obtaining uncontaminated samples from the marine environment. The work of CIMOR would provide significant benefits to basic research on marine productivity and climate change but importantly is of direct relevance to the aquaculture and fisheries industries. Given the extent of the untapped resources available in the marine environment in Ireland, and the EU's current focus on Blue growth, the establishment of CIMOR is a logical step in maximising this potential.
6. The National Crop Phenotyping Facility
TEAGASC-CELUP **Dan Milbourne**
We propose the development of a "National Crop Phenotyping Facility", based largely at the Teagasc's Oak Park Crops Science campus. The facility will support conventional and biotechnology-based genetic improvement (breeding) of tillage, forage and horticultural crops important to the Irish agrifood industry by providing precision phenotypic data capture across a full range of experimental scales, from single plants to field-scale plot trials. The facility will be based around a cutting edge-glasshouse and controlled environment (CE) complex offering complete control over water, nutrient, light, temperature, humidity and atmospheric gas levels. State-of the art digital imaging apparatus will allow automated data capture of a wide array of plant physiological characteristics on individual plants/small plots using approaches including IR, NDVI, fluorescent imaging and NMR. For field-scale evaluations, Oak Park's field trialling capabilities will be significantly extended. Recent acquisitions such as GPS driven planting technology, a single row plot drill, and a high volume rain boom will be augmented by digital imaging platforms capable of capturing physiological data at field scale level, including drone mounted camera equipment for IR/NDVI and other imaging approaches, in addition to root and rhizosphere monitoring enabled by mobile LIDAR and ground penetrating radar (GPR) equipment.
7. PastureLab: a new infrastructure for Animal and Grassland Research
Teagasc (AGRIP) **Dr Michael O'Donovan**
Increasing world population will raise demand by humans for protein and energy, which will require an increase in animal production from non-human feed sources such as grazed-pasture. Ireland's milk and meat production systems are based on the efficient production and utilisation of grazed pasture. Consumers consider pasture-based systems to produce nutritionally superior milk and meat products which are also more environmentally sustainable and animal welfare friendly. Food Harvest 2020 set ambitious targets to increase milk production and meat output value by

2020. If these increases are to be produced profitability at farm level, then they must be produced from grazed-pasture. The profitability of ruminant farming in Ireland is closely linked to pasture utilisation. Pasture utilisation on the best Irish farms is approximately 10 tonnes dry matter (DM) per hectare (ha); this requires to be increased to 15 tonnes DM/ha. The goal of PastureLab is to develop the technologies required to achieve this increase in pasture utilisation. PastureLab will facilitate the identification of plants: (i) that will motivate high feed intake, (ii) maximise nutrient use efficiency, (iii) minimise environmental load, (iv) that produce high quality milk and meat, (v) and are animal welfare friendly.
8. National DNA Sequencing Centre at Teagasc
Teagasc-Food **Paul Cotter**
Advances in DNA sequencing technologies have revolutionised numerous fields of research and access to these technologies is of key importance to the continued success of Irish research (in research institutions and industry). Illumina and Ion share 95% of the 'Next-generation' DNA sequencing market. The principles/advantages/disadvantages associated with their respective instruments differ and so there are benefits associated with having access to both technologies. Furthermore, Illumina and Ion platforms differ in their output from relatively low (Ion-PGM, Illumina-MiSeq) to medium (Ion-Proton; Illumina-NextSeq) to high (Illumina-HiSeq). Teagasc Food Research Centre hosts the largest DNA sequencing centre (MiSeq, PGM and Proton) in Ireland and its highly experienced staff have provided DNA sequencing services for many Irish institutes and companies since its inception in 2009. The expansion of this sequencing centre to become the National DNA Sequencing Centre, through the purchase of an Illumina NextSeq and HiSeq, would ensure that the countries DNA sequencing needs for the foreseeable future would be catered for.
9. Advanced Soil and Environmental Research Centre
Teagasc CELUP **Karl Richards**
Consumption of agricultural products is predicted to rise by up to 70%, at the same time there is an increasing need to protect the environment and reduce greenhouse gas emissions. These will be further compounded through the impacts of climate change which is predicted to reduce agricultural production. These potential conflicting priorities need to be integrated through sustainable intensification. Soils are the basis for all agricultural production and environmental protection. Maximising production and environmental benefits of agriculture requires soils to be considered in a new light. The Advanced Soil and Environmental Research Centre will combine new techniques in chemistry, stable isotopes, sensor development, molecular biology and agronomy to maximise soil functions. The facility will enable the testing and optimisation of new techniques for maximising agronomic and environmental goods and services. The infrastructure will enable the identification of carbon sequestration potential in soils to off-set agricultural greenhouse gas emissions under contrasting climate scenarios. The infrastructure will provide national and international researchers with advanced stable isotope and molecular biology facilities for the investigating 1. Soil biological and nutrient availability 2. Greenhouse gas emissions and 3. Carbon sequestration. The infrastructure will uniquely provide advanced soil research facilities for the sustainable intensification of the EU agricultural sector under a changing climate.
10. Food Processing Innovation Laboratory
Dairy Processing Technology Centre, (DPTC), University of Limerick **Professor Dick FitzGerald, Padraig McPhillips**
The Food Processing Innovation Laboratory will provide a dedicated, state-of-the-art facility for small scale food processing research. This suite would contain lab & small-scale processing equipment relevant to research activities specifically associated with innovative food processing. The suite to include (a) fully automated processing equipment and (b) associated analytical capability relating to: thermal treatments (pasteurisation to UHT) of foods, high pressure homogenisation, continuous and discontinuous separations including continuous centrifugal separations and decanter separators, membrane processing incorporating micro filtration, ultrafiltration, nano filtration, reverse osmosis and electrodialysis and small-scale process chromatography, a range of jacketed stainless steel storage tanks/reaction vessels, an aseptic packaging system, and a jacketed cooker/mixer unit. Ireland is a world leader in dairy innovation. The development of innovative high value-added food products and more efficient processes is required to maximise the long-term growth opportunities created by the anticipated increase of

50% in the Irish milk pool by 2020. The Enterprise-Ireland funded Dairy industry-led Dairy Processing Technology Centre (DPTC) brings together a spectrum of companies working collaboratively with academics drawn from a wide variety of disciplines which could access the facility. The challenges faced by the Dairy industry require an interdisciplinary approach if they are to be solved.
11. Food Biomolecule and Food Structure Analysis Centre
UCD Institute of Food and Health **Geraldine Quinn**
To develop a state-of-art technology platforms for the design and characterisation of food structures and formulation matrices to predict food interactions, particularly in adanced, nutritional food and beverage products. This RI would include instrumentation required to characterise food biomolecules and bioactives (e.g. LC- MS, GC-MS, NMR) and characterise their interactions with food ingredients (e.g. particle sizers, image capture and analysis, rheometers, differential scanning calorimeters, LUMIfuge, zeta sizer)
12. Food Processing Centre
UCD Institute of Food and Health **Geraldine Quinn**
Establish a centre to provide world class efficient processing, packaging and preservation technologies for the Food Sector. This would involve a major upgrade of existing facilities and would be a distributed facilities. The upgrade would include increasing the size of the current facility to accommodate existing and new equipment and would allow for the inclusion of emerging technologies both thermal and non-thermal and sustainable unit processes.
13. Metabolic Unit for Human Nutrition Studies
UCD Institute of Food and Health **Geraldine Quinn**
UCD would like to enhance its existing metabolic unit and human intervention suite to facilitate the increased workload in this area. As the requirements of research funding agencies and industry become more focused on the applied outcomes of research the current facilities have reached their maximum use. The requirements of some studies necessitates the research teams to move to facilitates at St Vincent's UH which adds significant pressures on the teams.
14. National Stable Isotope Facility
UCD Institute of Food and Health **Geraldine Quinn**
Establish a centre to provide world class stable isotope research. Currently there is a real deficit in this field in Ireland with no facility for assessment of stable isotopes. The applications range include but are not limited to (1) Whole body metabolic flux studies in humans (2) isotope tracer analysis for food authentication and (3) tracer studies in humans to follow food bioactives.
15. European Smart Agriculture Infrastructure
Dublin Institute of Technology **Brian O'Neill**
Population Growth, Climate Change and rising Water Consumption by 2050 are all drivers that are forcing us to become more efficient in producing food with less inputs and less damaging outputs. (Beecham Report 2015, FAO, IPCC) but to do this the way we practise agriculture must change. Modern ICT, GPS, and communications technologies (the Internet of Things - IoT) provides many potential avenues to address these problems. There are several problem domains including Fleet management, Arable farming, Dairy and livestock farming, Indoor farming – greenhouses and stables, Fish farming, Forestry , Storage monitoring – water tanks, fuel tanks.
16. Veterinary and agriculture biological specimen bank
Teagasc - AGRIP **Dr. Riona Sayers**
The process of animal monitoring is often coupled to the establishment of a specimen bank. A specimen or bio-bank is a long-term archive of suitably preserved biological samples which are

used for the purposes of retrospective analysis for epidemiological (disease investigations) or validation purposes. Analysis of samples can be carried out to (i) verify the success of monitoring programmes, (ii) apply new analytical procedures to historical samples for validation, (iii) continuously evaluate animal health including exotic disease investigations, and (iv) serve as a research tool to analyse temporal trends in animal health. In most cases, samples are collected for immediate analysis and a sub-set of samples is then cryogenically preserved for long-term storage. Specimen banks are a highly valuable resource once samples are logged, preserved, and traceable according to appropriate quality standards. The infrastructure required includes, a suitably-sized stand-alone facility, appropriate freezer storage comprising of an appropriate number of standalone freezer units with samples held at a minimum of -80oC, a linked-IT system with built-in temperature monitoring to ensure samples are archived correctly and are fully traceable, and a liquid nitrogen generation facility to reduce on-going costs of operation. A technician would be required to oversee the facility.
17. Center for Integrated Food Stucture and Flavour Analytics
Organization and summary confidential
18. The Kerry Maritime Blanket Peatland Carbon Observatory
Organization and summary confidential
19. The Next Crop Centre
Maynooth University **Professor Bernard Mahon**
The proposed research infrastructure aims to extend Ireland's ability (i) to develop crop varieties with improved agronomical traits and new biological pest control methods, and (ii) to identify proteins that could be targeted to overcome plant pathogens. Climate change, population growth and demand for land will challenge Ireland's position as a green high quality producer nation. New technologies can be used to meet this challenge. The proposed research infrastructure will bring together a suite of new technologies, and key scientists in a model pioneered in Germany. The response comprises high-throughput phenotyping instruments, such as LemnaTec's Scanalyzer imaging platforms that allow the measurement of different physiological and morphological parameters for a rapid, automated, and reliable phenotypic screening of thousands of different genotypes or conditions. The versatility of these platforms allows testing of the effects of different treatments, pathogens or environmental conditions on a wide range of organisms, such as bacteria, fungi, worms, insects and plants To complement the phenotyping platforms, the bio-imaging facility will also comprise a spinning disc confocal microscope that allows the monitoring and detailed characterization of specific processes at the cellular and molecular levels (e.g. monitoring of host-pathogen interactions, real-time protein movements within the cell). The facility will allow Irish scientists and national agencies to assist farmers and consumers to be prepared for major agri-food disruption and will position Irish agri-food producers at an advantage in the future.

Social Sciences & Humanities (10 Ideas)

1. Irish Social Science Data Archive: New Infrastructure and Services to Support Social Sciences Research

Irish Social Science Data Archive (ISSDA)
John B. Howard

The Irish Social Science Data Archive (ISSDA) is Ireland's centre for quantitative data acquisition, preservation, and dissemination. In operation since 2002, it provides access to selected official statistics on behalf of the CSO as well as data from surveys relating to a broad range of topics that relate to the social well-being of the people of Ireland. ISSDA is a long-time participant in the Council of European Social Science Data Archives (CESSDA) and is a Service Provider within the CESSDA ERIC. ISSDA's focus has been on anonymised microdata, i.e., individual statistical records that have been modified in order to minimise the risk of identification of individuals or organisations to which they relate. ISSDA provides access to these data and preserves them by applying international best practices for data preservation. In this context it leverages expertise and technical infrastructure developed and supported at University College Dublin, including use of the sole digital repository in Ireland designated a "trusted digital repository" by an assessment framework recognised by the European Commission. ISSDA proposes to expand its remit to meet the broader needs of the Irish social sciences researchers. It will further develop infrastructure to integrate with services planned by the CESSDA ERIC; it will expand the scope of data collected to include datasets created by individual researchers and research groups, enabling compliance to funder mandates for Open Access to data and enhancing the visibility and impact of Irish social sciences research.

2. National Portal for Financial Data & Analysis

University College Cork
Ray Donnelly

The Government's Strategy is to grow employment in the International Financial Services (IFS) Sector by 10,000 before 2020, (IFS2020, March 2015). Accordingly, HEIs must provide the additional high quality graduates required by the sector. Over 70% of the research published in leading Accounting & Finance journals is supported by empirical data. A pivotal part of an institution's research infrastructure is good access to the financial databases that provide this data. This document outlines (i) details of the infrastructure required for HEI's to undertake the research necessary to underpin world class teaching in accounting, finance and business and (ii) to support high quality postgraduate programs in same. The RI involves an investment in a portal to access WRDS which provides access to COMPUSTAT; CRSP; IBES; NYSE-TAQ; Bureau van Dijk. The improved access to data will be a game-changer for the quality of Irish Financial research allowing Irish academics to finally compete on a level playing field with their international colleagues. It will enhance the creation of human capital in the financial sector in Ireland. The objective is to create a similar standard of access to financial data for academics in Ireland as IREL has created to journals.

3. National Service Re-Imagination Lab (NSRL)

Waterford Institute of Technology
Patrick Lynch

Although the ESRI forecasts that by 2025, services will account for over 70% of Irish exports and for nearly 80% of GDP, and that service innovation is a National research prioritisation, in aggregate terms, Ireland lags considerably behind other EU and OECD countries in terms of National investment in service innovation research. Indeed, there is an urgent need to accelerate and underpin Ireland's underexplored service innovation prioritisation through the establishment of a large scale demonstrator such as a National Service Innovation Re-Imagination Laboratory (NSRL), which will be a 500msq facility incorporating; Immersive Design Lab, Visualisation Lab and Design Studio. NSRL will provide a platform to investigate, coordinate and leverage multidisciplinary service innovation capabilities within Ireland's innovation ecosystem while equally underscoring and accelerating the pioneering applied research capabilities of RIKON. NSRL will conduct and advance state of the art service innovation research and apply and translate this knowledge and output to support Irish industry, to re-imagine how their services/processes/business models can be delivered using advanced new service innovation

frameworks and technologies. NSRL aims to address stakeholder' end-to-end requirements of service innovation and design research; user centric ideation through to business development and modelling, design and delivery, prototyping, testing and commercialisation.
4. National Centre for Technology in the Interpretation and Genealogy of Meaning (TIGM)
National University of Ireland, Galway **Dr. Edward Herring**
The National Centre for Technology in the Interpretation and Genealogy of Meaning (TIGM) will bring together AHSS and IT specialists working collaboratively to meet methodological challenges of AHSS-led research. The purpose is to enable researchers in the interpretive social sciences and humanities to realise the potential of their work through IT applications and data aggregation, for example, in creating network analyses, engaging in natural language processing, translation and linked data. There is huge potential in this area which is currently under-realised. The focus on the interpretive dimension of research is an innovative and essential, qualitative component of the project. TIGM will facilitate interdisciplinary and multidisciplinary units with teams working on AHSS research projects that use interpretive methodologies, multimodal discourse and narrative analysis, language translation and interpretation – in context, between contexts and over time – encompassing the written and spoken word, as well as visual texts of various kinds. TIGM will stimulate and support a wide variety of AHSS research projects concerned with the complex interpretation of texts (written, spoken, visual), including cross-language and cross-cultural translation and interpretation. It will also support projects that focus on the discovery, documentation and preservation of text-based heritage (e.g., early Irish and minority languages). Uniquely, it will be a space where technology and AHSS researcher work collaboratively on projects that expand the horizons of technology-enriched interpretive research. As such it will be a leader in design and facilitation of research methodologies and programmes that involve multilingual and cross-cultural dimensions.
5. National Driving Research Centre
School of Applied Psychology, University College Cork **Professor John McCarthy**
The School has the only research-dedicated full simulator in Ireland. It supports PhD and other funded research projects and is in demand by Road Safety Authority, colleagues in UCC (Engineering, Computer Science) and groups in other Irish universities. In order to develop it into an internationally outstanding simulator, at the heart of a National Driving Research Centre, the existing simulator needs development and technology needs to be added and integrated that would enable more sensitive analysis of driving behaviour, as well as more sophisticated measurement and localisation of driving-associated brain activity. This would involve significant investment in upgrading the simulator, and adding and integrating enhanced EEG and brief electromagnetic stimulation (tDCS- Transcranial direct current stimulation) technology. This would support research on the influence on driving of, for example, ageing, alzheimer's, and health conditions such as stroke. A similar major upgrade of the portable simulator, by integrating eye-tracking would enable us to opens up a line of work with disabled drivers, training, rehabilitation, clinical interventions for those with post-crash PTSD etc., who may find it difficult to travel to the Driving Research Centre and to deal with the car housing of the full simulator.
6. National Dance Archive of Ireland PLUS
University of Limerick – Faculty of Arts, Humanities & Social Sciences **Gobnait O'Riordan / Professor Tom Lodge**
The National Dance Archive of Ireland (NDAI), established with Arts Council seed funding, is the most comprehensive archive in Ireland devoted to the collection, preservation and promotion of dance. Managed by the Library with close research relationships with the Irish World Academy of Music and Dance, the NDAI chronicles dance in Ireland to provide a research base and to convey an understanding of the processes and practices of creating and performing dance in this country. Digitising the archive, particularly the moving images, together with the proposed research infrastructure will allow exploration of new media tools, strategies, new roles for technology in the performing arts with a particular emphasis on dance but incorporating new ways of combining elements from disparate fields. This will be an ideal environment to analyse and create dance

performance in film, video, but could also support other performance genres. The RI will provide hardware and software for: reviewing, analysing, creating, editing and converting audio and video recordings; filming green screen sequences, recording motion capture data or experimenting with projection mapping; and professional editing suites. All of this new knowledge will be fully available for access, reuse and research by Irish and international scholars and practitioners.
7. Centre for Environmental Sustainability (CES)
Organization and summary confidential
8. Digital Arts Research Centre for Time-based Media (DARC TIME)
Maynooth University **Professor Bernard Mahon**
DARC TIME (Digital Arts Research Centre for Time-based Media) is new research infrastructure, taking the form of a mixed use building facility with performance, installation and research space that will enable researchers at Maynooth University across the Arts and Sciences (and, particularly, in the Computer Science, Media Studies, and Music departments) to collaborate with one another on research projects, to train PhD students, and to engage with community arts organizations, libraries, archives, and cultural institutions.
9. Makers Labs: Text, Data & 3D Visualisation in Digital Humanities and Culture
Maynooth University **Professor Bernard Mahon**
The Digital Humanities and Culture Makers Labs at An Foras Feasa, the Maynooth University Research Institute for the Humanities, will be spaces with world-class suites of equipment dedicated to the development of cutting-edge research, innovative practices, approaches and ideas. These will enable researchers to improve their skills and knowledge, foster interdisciplinary collaborations and capitalise on the academic strengths of the institution. They will also provide students with a wide range of technical and methodological skills that go well beyond humanities, thus placing them at the centre of Ireland's digital economy and serving their entrepreneurial ambitions after graduation. An Foras Feasa has already excelled in the fields of text, data and 3D visualisation in Digital Humanities and Culture, and therefore, the proposed research infrastructures will build upon existing expertise on digitally enabled research, also leveraging the commercial exploitation of humanities research and its connection with small and medium-sized enterprises, private sector and the industry. Such research infrastructure will also allow a much greater diversity of projects, thus being better positioned for national and European cutting-edge research and innovation. This proposal is also in line with 'Digital Platforms, Content and Applications' priority area aiming at boosting Ireland's culture and heritage at an International level, also building partnerships with cultural institutions to facilitate access and interdisciplinary research across humanities, social sciences, and technology-based disciplines.
10. Irish Qualitative Data Archive Towards 2020
Maynooth University **Professor Bernard Mahon**
This national research infrastructure seeks to build a truly national archive resource for qualitative data based upon the existing Irish Qualitative Data Archive (IQDA) and the Digital Repository Ireland (DRI). Co-ordinated infrastructure for qualitative, qualitative longitudinal and mixed-method social science data is urgently required. A number of such infrastructures (Growing up in Ireland qualitative modules, Changing Generations, IQDA) have been seed-funded by Government and philanthropy) and there is enormous (but urgent) potential for Ireland to play a leading role in the co-ordination of such infrastructures on a European scale, especially in the context of Ireland's international leadership in systems of data analytics that can make qualitative research more accessible and effective for researchers, policy-makers, educators and learners. We require a co-ordinated approach to the dissemination of official micro-data to ensure future participation in European infrastructures in this area – e.g. Data Without Boundaries project – and to contribute to smarter policy development and evaluation.

E-Infrastructures & E-science (11 Ideas)
1. National High-Performance Computing Facilities
Irish Centre for High-End Computing (ICHEC) **Professor J.-C. Desplat**
ICHEC is seeking funding for a new national High-Performance Computing facility. This infrastructure is required for the continued provision of a truly National Service to Irish researchers. The centrepiece of this RI is a Supercomputer. Its characteristics will be chosen to ensure suitability for a broad section of the Irish research community, as is the case for the current service. The supercomputer is likely to include a large cluster of nodes connected with high performance interconnect and high performance storage. Special purpose partitions will be added to accommodate specialist accelerator technology and large memory. As this will be the source for generating large and valuable datasets, a data archival platform may also be included. This service will see the continuation of the National HPC Service started in 2005 and replace the "Fionn" service started in 2013. A total of 610 researchers from 18 Irish HEIs across a broad range of scientific disciplines (from 10 of the 14 priority areas) have used the National HPC Service on Fionn to date. Our projections show that the next service will be utilised by an even greater number of researchers, and as such request a sufficient budget to provide an additional 20% capacity.
2. DOCTRID Research Institute in Assistive Technologies DRIAT
DOCTRID Assistive Technologies www.assistid.eu **Professor Brian Harvey**
The DOCTRID Research Institute (www.doctrid.ie) was established in 2010 as an international research network in Intellectual Disability by RESPECT Ireland (www.respect.ie) and the universities UCD, DCU, TCD, RCSI and Michigan State University. DOCTRID currently includes all of the universities on the island of Ireland and brings together 17 higher education institutes in Ireland, UK and USA plus disability service providers, and industry partners to undertake multidisciplinary empirical research into intellectual disabilities (ID), autism spectrum disorder (ASD) and dementia, in particular, the impact which Assistive Technologies (AT) can have on improving the lives of individuals with ID or ASD. DOCTRID won a 9million euro EU Marie Curie COFUND 2014-2019 in Assistive Technologies applied to ID and Autism - ASSISTID (www.assistid.eu) which supports 40 Postdoctoral Research Fellows to become leaders in Assistive Technologies and disability service provision. Research to date in this area has been fragmented but there is a growing need for evidence based research in AT to inform policy and service provision in the disability sector. There is a unique opportunity to develop DOCTRID as a dedicated Research Institute in Assistive Technologies (DRIAT) to sustain research into Assistive Technologies and promote this industry in Ireland and throughout Europe through collaborations with established IT companies (IBM, INTEL, Philips, Google etc) building on the success of the EU ASSISTID Award and the DOCTRID international consortium of universities. DOCTRID has created a critical mass of social scientists, psychologists, occupational therapists, special educators, computer scientists, engineers, IT experts, industry partners and disability service providers to undertake multi-disciplinary research to improve the lives of people with ID, Autism and dementia and enhance their care, education and employment. The research and innovation outputs from DRIAT can be applied to a wide range of areas other than ID and ASD including physical disability, stroke and traumatic brain injury patients, and the aging population.
3.Infrastructure for Earth Observation
Ryan Institute, NUI Galway **Professor Colin Brown**
The proposal is to establish a national observation system, including instrumentation for data acquisition, integration, analysis, modelling, visualization, interpretation and dissemination, for areas such as agriculture, forestry, terrestrial and marine ecosystems, energy, natural resources, atmospheric composition and climate change. The infrastructure should include a strong element of e-data science involving near real-time streaming of big data, high performance computing for data mining and predictive modelling. A national infrastructure for observation of Ireland's marine and terrestrial assets will be important to ensure that economic development stays in step with environmental legislation and corrective action, if necessary. A priority should be coastal

infrastructure.
4. Irish Research eLibrary (IReL)
Irish Universities Association **Ned Costello**
IReL was established in 2004 as a national research infrastructure, initially to support research in Science, Technology and Medicine (STM) with an expansion to Humanities and Social Sciences (HSS) disciplines in 2006. IReL is a highly successful shared service and an essential element in Ireland's research infrastructure, delivering access for all seven universities and the Royal College of Surgeons in Ireland (RCSI) to over 30,000 journals as well as databases and e-books. A subset of resources is also available to the Institutes of Technology. IReL is an established shared service, contributing to improved research performance, delivering recognized value to the research community and achieving value for money and efficiencies through the scale of its actions, which would not be possible for institutions acting alone. Separate funding streams have existed for STM and HSS information resources throughout, currently via the Department of Jobs, Enterprise and Innovation (DJEI) and the Higher Education Authority HEA: The funding is top sliced from the core HEA funding based on a proposal from the Council of the Irish Universities Association (IUA)) respectively. Funding cycles have been relatively short-term and purchasing power has contracted, inhibiting the optimal development of the infrastructure. The establishment of a stable and consolidated funding model for IReL as a whole is needed, alongside a review to enable a reorientation and expansion to match evolving priorities and increased research activity under the next Science, Technology and Innovation (STI) strategy.
5. Social Innovation Officina (SIO Living Lab)
Interaction Design Centre **Dr. Cristiano Storni**
The Social Innovation Officina (SIO) is a new RI concerned with timely issues in the area of social innovation, citizens' engagement, and democracy. It can be understood as a Living Lab for citizens to explore, debate and articulate (local) issues together, map matters of concerns, controversies and their stakeholders, experiment with technological solutions in collaboration with the University and SMEs, and create new opportunities to learn, to make, and to do business. It includes an open lab for social innovation (single sited in UL) and an ICT-based system (Virtual) to support the activities of the open lab.
6. Visualisation and Human-Computer Interaction Lab
University College Dublin **Peter Scott**
The recent, and ongoing, explosive growth in big data necessitates the discovery and development of new ways for people to understand, interpret, and interact with such massive and complex information. Effective 'visualisation' is key to this. The 'Allosphere' in University California Santa Barbara is a leading example of a visualisation research infrastructure, and consists of a 3-story cube containing a spherical surface that is used as a visualisation surface for twenty-six high-resolution projectors. A state of the art Visualisation and Human-Computer Interaction facility would not only enable Ireland to be at the forefront of this emerging area of research and development, but would also provide an incredible asset for the visualisation, analysis and understanding of big data in a wide array of research areas of academic and industrial relevance. The visualisation aspect of this proposed infrastructure will be similar to current leading facilities in the US, but will be unique globally by also enabling non-visual forms of interaction such as airflow, sound and touch feedback, together with rapid physical prototyping facilities, e.g. high quality 3D printing. Such a comprehensive suite would be not only an asset for Ireland and the EU, but also for global research in this field.
7. The Digital Repository of Ireland (DRI) for Born-digital data – major upgrade and reorientation.
Digital Repository of Ireland **Dr. Sandra Collins / Dr Natalie Harrower**

We propose the upgrade and reorientation of the existing e-infrastructure - the Digital Repository of Ireland or DRI. Currently the DRI provides digital preservation, data discovery and data curation for Humanities and Social Sciences data, with an emphasis on text, audio, video, and image formats. Born-digital content, particularly large-scale web, social media and email content, is outside the current scope of the DRI, requiring complex data models and novel data curation practices, and posing particular challenges for digital preservation because of its ephemeral, heterogeneous and linked content. Particular scientific and engineering challenges include developing solutions for bit rot, obsolescence, emulation, format shifting and authentic rendering. We propose the DRI be upgraded and expanded to provide digital preservation, data discovery and data curation services for Born-digital data, including social media, internet, and email archiving. This would: - fill a significant gap in digital preservation that is not being approached by any Irish institution. - deliver a trusted digital repository for preserving and providing access to born-digital content, and offer the services of this platform to state and private organisations. - provide a national testbed for experimentation with stable born-digital content, and validation and showcasing of data analytic tools.
8. National Health Data Repository
National University of Ireland, Galway **Dr. Edward Herring**
A major barrier to understanding health-related attitudes and behaviours and how these relate to physical health and disease is the lack of data infrastructure available nationally to facilitate large scale epidemiological studies. Comparably sized countries in Europe (including Norway, Scotland, Denmark, and Sweden) are world leaders in this area, and having similar database infrastructure in Ireland would represent one of the single most important advances in terms of societal benefit. The proposed National Health Data Repository would address this urgent need and provide a crucial resource for research in psychology, health care and health management.
9. National Research Data Management & Visualisation (NRDMV)
University of Limerick – Faculty of Arts, Humanities & Social Sciences **Gobnait O'Riordan / Professor Tom Lodge**
The National Research Data Management & Visualisation (NRDMV) research infrastructure will allow for the effective management of research data on a national level and provide new and exciting ways of visualising this data. This RI will combine distributed data management services and structures from across all Irish research institutions into a virtual environment for data management. A single simple interface will allow users easy access to the data of Irish research and will allow the data to be disseminated and archived. The interface will also allow users to download the data but will also allow them to perform a range of visualisations. More complicated and innovative data visualisations will be conducted in the NRDMV Visualisation Labs housed within the Glucksman Library at the University of Limerick which will be open to all researchers from research institutions and industry. The Labs will provide uniquely powerful tools for problem solving and unlocking data with a wide variety of large-scale displays that present different sizes, aspect ratios, configurations and capabilities. The variance in digital canvases will encourage creativity in how we visualise the world of data and digital media.
10. A trusted repository for research data for all domains: major upgrade and reorientation for the Digital Repository of Ireland (DRI).
Organization and summary confidential
11. National Research Repository (NRR)
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technopolis |group| The Netherlands
Spuistraat 283
1012 VR Amsterdam
The Netherlands
T +31 20 535 2244
E info.nl@technopolis-group.com
www.technopolis-group.com