Feedback on Consultation Document around the Successor to Ireland's Strategy for Science, Technology and Innovation

University College Dublin **March 2015**

Executive Summary

In the view of University College Dublin, the forthcoming strategy should include:

- A shared and ambitious vision for excellent research and innovation, linking closely with excellent higher education and delivering value into the economy and society
- A clear implementation pathway that sees all parts of the system delivering in a co-ordinated manner, guided by a high-level body under the Department of the Taoiseach
- Increased investment in research and higher education, consistent with our ambitions as a knowledge economy
- A national plan around talent development through research that enhances national success and reputation both in academic institutions and in enterprise
- A reframing of the current 14 research priority areas into 6, as trialled in the 2014 Innovation Showcase
- A filling of clear gaps in SFI Research Centre provision, such as agri-food and manufacturing, and the development of Centre-level capacity in newer areas of strategic opportunity
- A mechanism to identify and support priority areas for policy research
- Funding schemes to support research for knowledge across all areas on the basis of excellence
- A plan to address the growing set of opportunities that require a combination of expertise from the social sciences and humanities with expertise from the STEM disciplines
- A plan to meet national needs for research infrastructure, including local infrastructure as well as participation in international schemes
- A plan for international collaboration that leverages unique national propositions for major funding wins, and also targets opportunities outside Horizon 2020

UCD is strongly committed to success in research and innovation, to delivering impact nationally and globally and to producing graduates who underpin the well-being of the economy and society. We look forward to further participation in the development of this strategy and to bringing it to life.

About UCD

UCD is Ireland's largest university and Ireland's global university, with over 30,000 students drawn from approximately 124 countries. The role of UCD within Irish higher education is underscored by the fact that the university accounts for over 30% of international students, over 25% of graduate students and almost 28% of doctoral enrolments across the seven Irish universities.

Research and scholarship are at the heart of UCD and epitomise the identity and reputation of the university. The knowledge they generate enables our nationally- and internationally-leading activities in innovation, enriches the education of our students and delivers impact economically, socially, culturally and in the formation of public policy.

UCD has a strong and diverse base of research excellence. Our researchers have won over €1 Billion in external funding since 2004, and our citation impact has grown from a level below world average in 2004 to 59% above world average. UCD's Professor Des Higgins is one of the most highly cited researchers worldwide, with one entry in *Nature*'s prestigious list of the top 10 most highly cited research papers of all time and a second in the top 30. In Agricultural Sciences and in Food Science and Technology, sectors of key importance to the Irish economy, UCD ranks first globally for citation impact among all institutions publishing at scale. Professor Barry Smyth, a thought leader and entrepreneur in data science, is the current SFI Researcher of the Year, and successfully led the Insight Centre for Data Analytics to become the largest research centre in the country. Investment in scientific infrastructure in UCD is exemplified by the €300M UCD O'Brien Centre for Science, the largest investment in science in the history of the Irish state, funded by industry, philanthropy and Government.

UCD research and innovation have delivered sustained and substantial value to industry and other stakeholders. Graduates of our research programmes occupy senior leadership positions in multinationals and successful Irish enterprises, both within and outside Ireland. More than 1,000 companies, both Irish and international, have collaborated with UCD researchers in the last 10 years. We currently have 50 companies located on campus, including spin-outs from our research along with SMEs and multinational companies seeking to locate alongside our researchers to facilitate collaboration. Between 2003 and 2013 Nova UCD, our centre for new ventures and entrepreneurs, incubated 126 companies that have raised over €100 million of equity funding, deliver over €36 million per annum of economic value to Ireland, and by 2016 are projected to have supported over 2,500 jobs. In 2014 UCD was ranked 5th among European universities on the basis of our success in educating venture-backed entrepreneurs, and UCD won two of the four Knowledge Transfer Ireland 2015 awards for success in licensing and spin-outs.

General remarks

We must begin with a shared vision

The first element of the strategy must be a vision and description of the destination. The strategy is not for Government alone, although leadership from Government will be essential for its success. It can only be delivered if business, civic organisations and academic institutions support it and mobilise around it. This will be reflected in an agile and co-ordinated system, where there is common purpose and clarity around the role played by each contributor.

The vision must include our expectations around the value delivered by research to a knowledge economy operating in a competitive global marketplace. This value is delivered through a variety of means, including technological advances, informed policy interventions and the development of human capital at all levels. The vision should also include the wider societal and cultural benefits derived from a broad-based research ecosystem. To these ends, it will engage the social sciences and humanities as well as the sciences and engineering.

Excellence is the essential foundation for all of the benefits of research

Our research and innovation base must be internationally excellent. This is the only position that is truly value-adding for Irish business and attractive to international investors. The fundamental components of excellence must be unambiguously identifiable by relevant international norms. From a broad base of excellence all other impacts are possible once the right supports and structures are in place.

The critical output of our research programmes is people

The central tenet of the 2012 OECD report *Better skills, better jobs, better lives* – that skills are the global currency of the 21st Century – reinforces our view that our national prosperity as an economy and society is dependent on our ability to develop not only more, but better, jobs.

Ireland competes for foreign direct investment (FDI) in a highly competitive global landscape. Connected research, education and talent are three of the main elements of Ireland's value proposition for continued and growing FDI, as set out in IDA's recently announced strategy. We must deliver on each of these elements, and in doing so recognise the interdependency between them.

Talent is critical to our ability to secure FDI and enhance the competitiveness of Irish businesses. A mature system of research and higher education delivers this, not only in the form of research-trained postgraduates, but also through the education of undergraduates in a research-enriched environment. The next strategy must further emphasise the connection between research and human capital development at all levels.

We cannot expect to compete internationally without international levels of investment

Irish Government investment in R&D lags behind that of similar countries, and the gap has increased over recent years. This will have consequences for our ability to compete with those countries for FDI and for the success of our knowledge industries.

We are now seeing early consequences of the reduction in investment. For example, the number of PhD students nationally, including those in certain sectors of strategic importance, is now falling. The effects of this are not yet apparent outside higher education, but will become apparent over time.

It is not possible simply to stretch or to shift existing levels of research investment to deliver all necessary elements of a mature research system – one that fuels our knowledge economy and delivers the talent to it. Additional investment is required.

Creating an ambitious strategy and building confidence overseas that Ireland is a place for R&D investment will drive a significant proportion of this investment from industry sources. However, the conditions will have to be created to build this confidence, including increased state investment in publicly-funded R&D, a strong pipeline of talented graduates and an integrated approach across the national system to building our reputation.

The decline in higher education funding over recent years and limits placed on the autonomy of universities have a direct effect on our performance and reputation internationally. Our leading higher education institutions are, and will continue to be, the key delivery vehicles for national success in research, fuelling our knowledge economy and providing the talent it demands. The capacity of our academics to deliver on their research potential is limited by the constraints currently experienced by higher education, and these must be addressed.

Research prioritisation is a major component of our strategy, but it is not the totality of our strategy

Research prioritisation was formulated in response to unprecedented economic circumstances in Ireland. It has been implemented effectively and has had a number of successes, but there is no doubt that gaps have emerged during this recent extraordinary period that must be addressed if we are to compete at the level of our ambitions.

We must identify areas where Ireland can lead internationally and prioritise these. However to future-proof our research base, draw out the best of our talent and ideas, and underpin an excellent higher education system, it is crucial for our long-term competitiveness that we maintain a strong and diverse portfolio of research in all its forms across the sciences, social sciences, humanities and engineering. This approach is a feature of the most productive research and innovation systems internationally.

We already have much of the basis for our strategy

Although there are well-publicised areas of difference as we approach the development of the new strategy, we already have much of the basis for a strategy that will serve the country very well. We still have many results from the investment in our research base before the recent retrenchment, both in human capital and in some outstanding infrastructure. The years of that investment also saw a maturing of national ambition in research. Our leading research groups know how to deliver internationally renowned research, because they have been doing so for many years. We have an outstanding enterprise base within the country and strong European and global networks, and our researchers are delivering very substantial value to these. We have research centres of international scale and standing. These are all positives on which we can build. Many of the component pieces of a complete research landscape have been assembled, and it is now for us to visualise the remainder of the landscape and to put in place the system that will change Ireland's performance from innovation follower to innovation leader.

1. Investment in STI and key goals/targets

What should Ireland's ambition be in STI?

Ireland should be one of Europe's innovation leaders, matching or exceeding the performance of other advanced small nations such as Finland and Denmark.

Our education system, our policy system and all areas of national endeavour should understand and foster our shared objective of excellence in science, technology and innovation.

We should seek to lead internationally in areas selected for their particular importance to Ireland, and also to respond with agility to new opportunities that arise globally or nationally.

We should be renowned for the connectedness of our research and innovation systems, with strong links across disciplines, among industry and academic partners and across international boundaries.

We should stand out among our peers as the nation which delivers most effectively in translating the benefits and outputs of research excellence into enterprise and economic growth.

We should be a destination of choice for ambitious national and international talent and for companies seeking to succeed on the basis of this talent.

Ireland is currently an innovation follower and lags other small developed countries in R&D intensity. Should we have more ambitious targets for investment?

Ireland needs to substantially reinvest in Science, Technology, and Innovation, even just to sustain our position as an innovation follower. To achieve ambitions of being an innovation leader will require much greater investment than today.

The outstanding performance of Irish researchers in the last 15 years showed that Ireland can have universities in the top 100 globally, and propelled Ireland to being within the top 20 science-performing nations worldwide.

This level of achievement has been instrumental in securing FDI, licensing new technologies, creating new companies, and providing the highly educated workforce needed to grow the economy.

However, despite this backdrop of achievement and other strong research outcomes captured in the consultation document, a number of indicators suggest that research in Ireland is now in a declining position.

This decline can be directly attributed to the fall in national funding for research. The Government's annual budget for research and development (GBAORD) has fallen by more than €200 million since 2008. Comparisons of national levels of research investment show Ireland lagging behind competitor nations, with the gap increasing rather than closing. The gap between investment and ambition has to be addressed.

The time lag between the funding of research and the outputs of that research has partially masked the negative consequences of Ireland's declining R&D expenditure, but this will not continue.

Ireland is competing among many nations following a knowledge-based strategy. Maintaining the status quo in funding will not sustain the status quo in research quality and impact. Further investment from Government and industry, and further success in winning research income from international sources, is needed to hold Ireland's current position and grow in the future.

How can that level of ambition be justified? Where would we target increased funding and how could this be justified?

People have to be at the heart of Ireland's economic recovery. Investing in a research-led higher education sector is crucial to generating the highly educated workforce that Ireland needs.

Ireland has made great use of its comparative advantage in corporate taxation, particularly in attracting FDI. However, this must be combined with other strengths in order to be truly competitive. Ireland must now invest in new ways to attract FDI and to strengthen the operations of companies already here.

The availability of highly educated and skilled people has to be the major differentiator in attracting FDI and providing the talent required to develop and grow indigenous firms.

The education of such a workforce is closely linked with the national research agenda. Research provides a pool of talent with advanced expertise in cutting-edge areas, and the education of undergraduates by research-active academics enriches their development and raises their ambition.

UCD is acutely aware of its responsibility as the largest producer of graduates in the country. Greater autonomy and greater financial security are essential to fulfilling this critical role.

Targets for increased research funding should include a refreshed set of national research priorities, but with a reasonable proportion of funding reserved to support research for knowledge and research for policy.

There remain gaps in SFI Research Centre provision within the priority areas, most notably in agri-food and manufacturing. These are areas of strategic significance to the country, and the provision of SFI Research Centres here should be prioritised.

There are particular opportunities within the priority areas around which industry and academic stakeholders are currently mobilising in pursuit of major international funding for Ireland, based on a unique national proposition. One such area is energy systems integration, and a relatively small amount of national support here has a strong chance of unlocking very substantial international funding.

There are other areas that were not envisaged at the time of Research Prioritisation, but which have since developed to present very promising opportunities that merit a trajectory towards Centre standing. The sharing economy, also called collaborative consumption, is one example.

Outside the priority areas, the loss of the Basic Research Grants / Research Frontiers Programme, where moderate research grants of around €200k were competed for across all disciplines on the basis of excellence, is acutely felt across our research system. Some of these smaller grants have been very productive, producing significant successes in academic and commercial domains. Reinstating this

provision, which would require a tiny percentage of GBAORD, would have a disproportionately positive effect in unlocking talent and ideas, future-proofing our research base and supporting excellence across higher education.

There should also be a small number of larger grants reserved to back bigger propositions where short-term economic returns are not expected but the long-term impact, of whatever form, could be very substantial.

Research for policy can deliver very significant impact to the economy as well as to society. Specific priorities in policy research should be articulated, and funding mechanisms put in place to support them.

Excellent infrastructure not only enables excellent research and innovation; it also attracts research talent and serves as a showcase for investors. It is now several years since our last systematic investment in national research infrastructure, and this should be addressed.

Pillar 1: Key recommendations

- A shared and ambitious vision for excellent research and innovation, linking closely with excellent higher education and delivering value into the economy and society
- Increased investment in research and higher education, consistent with our ambitions as a knowledge economy
- A national plan around talent development through research that enhances national success and reputation both in academic institutions and in enterprise
- A filling of clear gaps in SFI Research Centre provision, such as agri-food and manufacturing, and the development of Centre-level capacity in newer areas of strategic opportunity
- A mechanism to identify and support priority areas for policy research
- Funding schemes to support research for knowledge across all areas on the basis of excellence
- A plan to meet national needs for research infrastructure, including local infrastructure as well as participation in international schemes

2. Prioritised Approach to Public Research Funding

How can research prioritisation better serve our national objectives of a strong sustainable economy and a better society?

Prioritisation can best serve Ireland's economy and society by being *part of* Ireland's research strategy, and *not the entirety of* Ireland's research strategy.

Our experience and our feedback from industry suggest that the current list of 14 priority areas is too long, and that the set of 6 broader areas trialled in the 2014 Innovation Showcase is more appropriate. Research within a given priority area should cover both basic and applied activities, and should involve the social sciences and humanities working with the STEM disciplines. This reflects the comment of one of our industry partners: "The scale of the research challenges we are seeing is different from a few years ago; they are multifaceted and they often involve behavioural change."

We must identify areas where Ireland can lead internationally and prioritise these. However to future-proof our research base, draw out the best of our talent and ideas, and underpin an excellent higher education system, it is crucial for our long-term competitiveness that we maintain a strong and diverse portfolio of research in all its forms across the sciences, social sciences, humanities and engineering. This approach is a feature of the most productive research and innovation systems internationally.

It is important to note that basic research can deliver significant impact, including economic impact. The Russell Group of top UK universities analysed the financial returns of their research and found that the commercialisation of blue-skies research generated more than twice the average returns from applied research. The report notes that "the vast majority of the value returned over time originated from more fundamental, basic research"[1].

In January 2014, the UK Dept. of Business Innovation and Skills published[2] a benchmarking of global RDI systems, and identified the common traits of the most successful systems. One of the critical factors was a "balance between curiosity driven research ('pure') and needs driven research ('applied')". In December 2014 the UK Government published *Our plan for growth: science and innovation*, which noted that in addition to prioritised research: "… we will invest £3 billion to support individual research projects and our institutions' world class laboratories … to ensure that **excellence is rewarded wherever it is found**" (our highlighting).

In support of this approach, circa 30% (EUR 24 billion) of the total Horizon 2020 budget is allocated to the 'Excellence' pillar, where research is funded on academic merit and is not prescriptive in terms of priority themes or near-term economic impact. To access this funding, researchers are generally expected to have secured earlier funding, typically from their national systems.

In Ireland today there are some internationally excellent research groups at risk of cessation due to falling outside of the current priorities. In areas such as the basic biomedical sciences, previous investments that had enhanced our international profile and built a strong resource base are being eroded. At the same time there are also priority areas that do not have excellent research at scale (e.g. Innovation in Services and Business Processes). Prioritisation alone does not always leverage the

[1] http://www.russellgroup.ac.uk/uploads/RG_ImpactOfResearch2.pdf
[2] Jan 2014 'Insights from international benchmarking of the UK science and innovation system'.

best of Ireland's researchers, and does not always stimulate research in the areas desired by policymakers.

To achieve the objectives of a strong sustainable economy and a better society, Ireland needs a balanced portfolio of excellent research in priority areas and a sufficient proportion of excellent research outside the priority areas.

How best do we identify emerging areas of opportunity and challenge i.e. horizon scanning?

Horizon scanning is a natural activity for research groups, for industry and for Government agencies such as the IDA.

A rolling national process receiving inputs from all relevant national stakeholders and examining international trends would be straightforward to manage. The lack of involvement by the delivery system in industry and higher education in the implementation of Research Prioritisation by the PAG has limited the ability of that process to adapt to a changing environment, and should be addressed.

Complementary to this, a reasonable investment in non-priority research will itself act as a form of horizon scanning. Emerging areas of excellence with impact can then be grown into new priorities where Ireland will therefore already have a base of excellence.

Pillar 2: Key recommendations

- A reframing of the current 14 research priority areas into 6, as trialled in the 2014 Innovation Showcase
- A filling of clear gaps in SFI Research Centre provision, such as agri-food and manufacturing, and the development of Centre-level capacity in newer areas of strategic opportunity
- A mechanism to identify and support priority areas for policy research
- Funding schemes to support research for knowledge across all areas on the basis of excellence
- A plan to address the growing set of opportunities that require a combination of expertise from the social sciences and humanities with expertise from the STEM disciplines

3. Enterprise-level R&D and Innovation Performance

A review of the outcomes of SSTI 2006-2013 shows that targets for the public research base were largely achieved or exceeded. Opportunities exist for further progress in regard to enterprise RD&I activity. How can public policy best support and more effectively optimise the impacts of enterprise RD&I investment - what actions could be taken to:

- **strengthen the number of innovation performers in the multinational sector?**
- **broaden RD&I activity in the indigenous sector and build absorptive capacity?**

Creating an ambitious strategy and building confidence nationally and overseas that Ireland is a place for R&D will drive additional R&D investment from industry sources. However, the conditions will have to be created to build this confidence, including increased state investment in publicly funded R&D, a strong pipeline of talented graduates and an integrated approach across the national system to building our reputation.

We in UCD see a growing maturity in industry-academic collaboration, particularly for those already engaged, and the various supports and mechanisms to enable this should be continued. This will strengthen existing relationships and provide opportunities for the development of new collaborations.

In the multinational sector, the IDA has called out talent, education and connected research as key factors of Ireland's value proposition. Higher education is a major contributor to these. With specific regard to connected research, targets and incentives should be promoted for multinationals to develop an R&D capability as part of their Irish mandate.

Absorptive capacity in all industry, but particularly in our indigenous sector, is pivotal to broadening RD&I performers nationally. Personnel exchange between universities and industry is a major enabler here. This should be facilitated through enhanced marketing of supports and expanded programmes, with particular emphasis on ease of access for smaller companies. Different sectors are at different stages in their RD&I maturity. This must be reflected in the design and implementation of a range of supports tailored to those differing needs.

Do we need to enhance the suite of enterprise support programmes to further drive innovation in industry and/or is there scope for consolidation of the existing range of support programmes?

The simplification of existing supports could be beneficial in terms of making RD&I more accessible to enterprise. However, raising awareness and providing guidance may well provide the greatest impact.

Greater support in guiding companies through the range of engagement opportunities should be developed. These supports should be delivered by enterprise agencies acting in concert with higher education and industry bodies.

Mentoring by those that have experience of interaction with the university research base to those that do not (through industry representative bodies or other networks) should be encouraged and incentivised.

Programmes for personnel exchange between industry and higher education also provide opportunities for a step change in organisations' engagement with the RD&I system. Exchanges between higher education and the policy system would also be very useful.

How can we incentivise firms that are R&D active to scale their research efforts?

Our ability to attract and grow R&D activity will require us to demonstrate a connectedness across our system that derives value from all elements, underpinned by strong Government support and the availability of a suitable workforce to undertake challenging R&D roles

UCD is supportive of Government's commitment to ensuring a competitive tax offering for companies that engage in innovative and value creating operations in Ireland. The new 'knowledge development box' must be internationally competitive for Ireland not to lose ground to similar schemes being developed in competitor regions.

Tax systems alone will not be effective unless there is a suitable workforce available to undertake challenging R&D roles. Again this underscores the critical role of the universities in providing the undergraduate and postgraduate talent needed for growth.

Pillar 3: Key recommendations

- A shared and ambitious vision for excellent research and innovation, linking closely with excellent higher education and delivering value into the economy and society
- A clear implementation pathway that sees all parts of the system delivering in a co-ordinated manner, guided by a high-level body under the Department of the Taoiseach
- Increased investment in research and higher education, consistent with our ambitions as a knowledge economy
- A national plan around talent development through research that enhances national success and reputation both in academic institutions and in enterprise

4. International collaboration and engagement

How can we further increase/strengthen the effectiveness of our international collaboration and engagement across all areas of STI investment in pursuit of economic and societal goals?

Ireland is a relatively small nation within a globally connected research ecosystem. Alongside the development of our indigenous research activity, there is great potential benefit in partnering with major global research groups and facilities. Enhanced mechanisms to support international collaboration could increase high-profile and high-impact engagement within the EU and with world leaders such as the USA.

Ireland needs strategic long-term investment in joining and sustaining formal and informal research networks. Programmes such as Horizon 2020 can facilitate this within the EU, and we note also the opportunities in EU programmes outside Horizon 2020 that have not received similar levels of national attention.

There is also significant potential in non-EU partnerships, the development of which would require investment by the state. In particular the USA (the world leader in research and innovation) is one of Ireland's most frequent research collaborators, but there are few funding mechanisms to scale up this activity and take advantage of these valuable relationships. This approach could also be used to bring these partners into H2020 consortia, adding wholly new expertise to the EU research system.

Ireland faces a challenge in building the reputation of its leading universities globally. This is a problem not just for the universities, but for those seeking to secure investment and inward flow of talent on the basis of our national reputation in education. The strategy should consider how national achievements in research and innovation will translate to reputational benefits for our universities. UCD is committed to maintaining and growing its international reputation with support from Government and its agencies.

What additional measures can be taken to maximise the engagement of industry as a partner in this regard?

Ireland must make best use all of the global channels and networks available in order to connect and collaborate with industry internationally. Nationally there is a need to substantially increase industry participation in EU programmes.

The expected role of industry in H2020 is far greater than it was in FP7. The participation of Irish industry is essential not only for the companies themselves, but also for Ireland's total research ecosystem. Measures to support and incentivise industry participation in H2020 should be a priority.

Intersectoral matchmaking across the EU is one of the most challenging aspects of achieving success in H2020 and in EU funding generally. Enhanced support for matchmaking, and innovation in how it is delivered, would be extremely beneficial.

Ireland is home to many multinational corporations who can provide access to their other locations and international partners. The IDA can leverage its international networks to facilitate "research missions", akin to trade missions, targeting specific sectors or regions.

What additional measures could be taken to enhance Ireland's participation in Horizon 2020 and other EU Programmes – industry, academia, SMEs and MNCs?

There is a need for a clear targeted national strategy in EU funding to complement the actions of individual RPOs and individual researchers.

This should bring together a critical mass of researchers with additional supports to enable them to target and win strategic large-scale EU opportunities in H2020 and in non-framework programmes. The setup of the Horizon 2020 High Level Group and the Strategic Research Proposals Group may ultimately lead to this, but has not yet provided such overarching coordination.

The development of the national strategy should incorporate decisions on investing in mechanisms such as ERA-NETs, JTIs, JPIs and Article 185 Initiatives. Careful consultation with industry and academia is needed to identify the right targets. Similarly the membership of major experimental facilities (e.g. ESRF, CERN) should be considered in this process.

The role of NCPs is critical to Ireland's success in EU research, particularly in the face of much higher targets in H2020 than in FP7. There is a need to strengthen the NCP network. Currently the resourcing of these positions is very diverse; there should be consistent full-time roles for this crucial activity with an appropriate balance between strategic planning and operational support.

Additional national overheads provided for EU awards could be used to offset current resourcing constraints in pursuing EU funding. Given the non-exchequer nature of the funding, this would still represent a substantial net benefit to the Irish economy.

Are there research policy or programme developments taking place at EU level where enhanced engagement by Ireland could provide opportunities for research collaboration and ultimate economic or societal benefit?

Membership and active participation in strategic groups such as European Technology Platforms would enable Ireland to directly contribute to the development of strategic research and innovation roadmaps in Europe.

These groups are strongly tied to major EU PPP initiatives such as BBI, but also have substantial influence in the development of the wider H2020 work programmes. Moreover, these groups provide access to very strong consortia in their areas of focus.

Similarly, the strategic and coordinated pursuit of Irish membership in European Institute of Innovation and Technology Knowledge Innovation Communities (KICs) will provide access to extremely strong research partners, and consortia with high funding success rates. The next KICs align with national research priorities in manufacturing and agri-food, and are a great opportunity for Ireland. The benefits of involvement in KICs largely accrue to the industry sector, but the universities can, and have, played a role in positioning an Irish network in KICs.

Existing supports for the development of and participation in EU consortia should be extended to enable Irish academics and industry to participate in these key strategic groups.

Pillar 4: Key recommendations

- A clear implementation pathway that sees all parts of the system delivering in a co-ordinated manner, guided by a high-level body under the Department of the Taoiseach
- Increased investment in research and higher education, consistent with our ambitions as a knowledge economy
- A national plan around talent development through research that enhances national success and reputation both in academic institutions and in enterprise
- A plan for international collaboration that leverages unique national propositions for major funding wins, and also targets opportunities outside Horizon 2020

5. Organisational/ Institutional arrangements to enhance research excellence and deliver jobs

What could we do to further enhance our landscape and institutional arrangements to maximise the impact of research excellence and deliver jobs?

We need a co-ordinated mix of national programmes of scale, support for individual excellence and infrastructure investment.

PRTLI was a very successful investment in the Irish research landscape. There is a need not only for new infrastructural investment, but also specific funding for the operation, maintenance and refresh of the investments already made. Ireland must continuously invest in these national assets or they will fail to keep producing the desired research outputs.

More generally, national funding mechanisms are generally segregated between infrastructure and people. Research programmes often need both but have no means to secure funding for them via one integrated mechanism. This makes comprehensive planning and funding of large-scale research more difficult than necessary.

SFI Research Centres and EI/IDA Technology Centres are a new and highly important feature of the Irish research landscape, and we strongly welcome them. We have seen the benefits that accrue from a networked university system working in partnership with industry. The scale of these activities is substantial by international norms, and their embedding in the universities ensures that they can leverage long-standing national investments in higher education and respond flexibly as opportunities arise or circumstances change. However, these Centres engage a small minority of the available research base. Supports for the rest of the landscape, where excellence and impact can be delivered across the entire spectrum, must be enhanced in the ways outlined in previous sections.

Is there a need for a complementary market focused research centre structure in Ireland and how should that be organised?

The addition of market-focused research centres such as Research and Technology Organisations (RTOs) is potentially of value in specific areas. However, poor implementation of such a model could negatively impact Ireland's research landscape.

There are examples of excellent RTOs internationally, such as the Fraunhofer Centres in Germany. The UK Catapult centres are a smaller version of this model, but have yet to prove that a scaled down Fraunhofer is effective. Given Ireland's size, the implementation of RTOs would necessarily be even further scaled down.

We understand the desire for research at higher TRL (technology readiness levels) and greater near-market activity. RTOs are one possible means of addressing this, in areas where there is a demonstrated demand from industry and where the existing research structures are not demonstrating the capacity to expand to higher TRLs. RTOs could add value to the national landscape in such situations.

However, the risks of deploying RTOs must be considered:

- The set up of the centres will introduce substantial costs without direct return.

- Once established, RTOs may drift down the TRL levels in search of additional revenue, and duplicate the research activity of the universities.
- Universities rely on dynamic talent in their postgraduate and postdoctoral population and have the flexibility to adapt their offering in the face of diverse and changing circumstances. An RTO can accumulate a static staff cohort and may be less flexible in its response if its area of applied focus becomes stale or loses relevance.
- Analyses by the Russell Group, by Stanford University and by others have shown that often the most valuable commercialisation arises directly from research that is low in TRL.

Most crucially, RTOs do not deliver highly educated people into the workforce in the way that university research programmes and undergraduate programmes do. The scientific/technology outputs alone of an RTO may be hard to justify in the absence of training graduates and postgraduates at scale.

If the RTO model is to be pursued in Ireland, it should be in limited circumstances where it is clear that existing research entities do not have the capacity or the desire to operate. Methods of interaction with those entities operating at lower TRLs should be agreed from the start, so that each category benefits from the activities of the other and there is no drift towards duplication of effort. Finally, the RTO operational costs must be made in addition to current research expenditure, or else the growth of RTOs will simply be at the expense of diminishing the rest of Ireland's research and innovation activity.

How can Ireland optimise its strategic advantages of location, scale and environmental quality as a fundamental component of its research infrastructure?

Various research and innovation testbed facilities have been proposed to take advantage of Ireland's unique combination of advantages. Further development of such facilities could act as a focal point for research, innovation and collaboration, and a promotion tool for the enterprise agencies to demonstrate to future investors Ireland's ability to collaborate across industry, academia and Government.

The examples on which we should focus are one where Ireland has:

- an opportunity to bring something unique to the international arena
- genuine research strength and an existing base of national investment
- a supportive and engaged industry sector
- the policy environment (and public sector organisations) that will facilitate successful implementation of a large-scale programme
- an opportunity to attract new industry sector(s) and/or companies in areas of strategic importance nationally.

An example of such a testbed in Ireland that is gathering clear momentum from national and international partners is a demonstration zone for new energy technologies in the area of energy systems integration. The recent successful Horizon 2020 bid by Glen Dimplex, UCD and others is an initial example of how industry-academic collaboration can succeed in this space. A successful testbed would not only attract substantial non-exchequer funding, but would be extremely attractive to multinationals and support growth in Irish business.

How can we further increase/strengthen the effectiveness of our national collaboration and engagement across all areas of STI investment in pursuit of economic and societal goals?

As in most countries, Ireland's research landscape is complex. A broad high-level advisory group is required to provide oversight and co-ordination of all aspects of research policy and funding nationally. Recognising the cross-cutting nature of research, it should sit within the Department of the Taoiseach, along with the office of Chief Scientific Advisor. It should include high-level representation from non-Government stakeholders.

There are multiple funding agencies in Ireland using differing mechanisms to fund research. Without co-ordination their funding can (and does) migrate over time based on individual strategies, leaving unintended gaps within the system. The range of mechanisms can also present a confusing landscape to those seeking to engage with the system.

The advantage of having multiple funders and mechanisms is that they provide diversity, flexibility and agility within the system, and it is important for the long-term health of Irish research that we safeguard these features. There is, however, a clear need for coordination between funders, and also for mechanisms to receive inputs from research performing organisations, enterprise and other stakeholders. The engagement between the Irish Research Council and multiple stakeholders across Government, civic and voluntary organisations, and enterprise is a positive example of how engagement can proceed.

The Prioritisation Action Group is currently the primary high-level mechanism for this coordination, and has seen useful relationships develop between funders. However, it has been entirely focused on that subset of the research system that falls in the priority areas, and it does not involve HEIs, enterprise or other non-Government stakeholders. A high level advisory group within the Department of the Taoiseach, comprising multiple stakeholders, could provide this oversight and coordination for research.

Pillar 5: Key recommendations

- A shared and ambitious vision for excellent research and innovation, linking closely with excellent higher education and delivering value into the economy and society
- A clear implementation pathway that sees all parts of the system delivering in a co-ordinated manner, guided by a high-level body under the Department of the Taoiseach
- Increased investment in research and higher education, consistent with our ambitions as a knowledge economy
- A plan to meet national needs for research infrastructure, including local infrastructure as well as participation in international schemes
- A plan for international collaboration that leverages unique national propositions for major funding wins, and also targets opportunities outside Horizon 2020

6. World class IP regime and dynamic systems to transfer Knowledge and Technology into jobs

The establishment of Knowledge Transfer Ireland has seen an important evolution in our knowledge transfer system but what more can we do to enhance further the transfer of knowledge into jobs?

The Technology Transfer Strengthening Initiative (TTSI) resulted in a massive increase in the quality and quantity of intellectual property transferred from Irish academic institutions into industry. The current funding for TTSI ends in 2016, and there should be a commitment to renew this scheme for a further four years to 2020.

UCD is fully supportive of KTI and views its establishment as a very positive step in supporting the knowledge transfer system in Ireland. UCD itself, through NovaUCD, has long been committed to this space: between 2003 and 2013 it filed 318 patents and incubated 126 companies which have raised over €100 million in equity funding, deliver over €36 million per annum of economic value to Ireland, and by 2016 are projected to have supported over 2,500 jobs.

At a national level, during TTSI there was a seven-fold increase in the number of technologies licensed by academic institutions to industry – from 12 per year in 2005 to 85 in 2012 – and the number of spin-out companies created each year averaged at 22, an increase of 450%. Continued support for this very effective system is paramount to the HEIs' capability to transfer valuable knowledge into the wider economy and create jobs.

Further enhancement can be achieved by supporting additional business development roles within the universities, to drive greater industry alignment and collaboration from the outset of research programme development. These roles must be closely aligned with the national enterprise agencies. There must be a shared responsibility for helping to deliver on the national agenda of a mature and comprehensive RDI system across academia and business.

In terms of Intellectual Property policy, are there specific interventions or supports of a legislative or non-legislative nature that would improve the business environment and act as an incentive to create and sustain an innovative culture?

The proposed Knowledge Box system or a similar scheme will be needed to maintain Ireland's competitiveness in ensuring that globally mobile enterprise R&D is located in Ireland.

Given that many nations already have such systems in place, or are developing similar, there is a clear need for Ireland's approach to be highly competitive with respect to international comparators. This will likely be a dynamic area for years to come, with various countries adjusting their systems over time. Ireland should therefore closely monitor international developments during the life of the scheme to ensure ongoing competitiveness.

Pillar 6: Key recommendations

- A shared and ambitious vision for excellent research and innovation, linking closely with excellent higher education and delivering value into the economy and society

- A clear implementation pathway that sees all parts of the system delivering in a co-ordinated manner, guided by a high-level body under the Department of the Taoiseach
- Increased investment in research and higher education, consistent with our ambitions as a knowledge economy
- A national plan around talent development through research that enhances national success and reputation both in academic institutions and in enterprise

7. Government-wide goals on innovation in key sectors for job creation and societal benefit

What steps need to be taken to further the translation of investments in STI into the achievement of stated public policy goals? How can the Strategy enable research programmes to optimally support policy development and actions to address key national challenges in areas such as environment, health, etc.

Senior research-focused roles are needed in Government departments and agencies to identify how research can support public policy goals, and to drive the translation of the research into actual systems and public services. This would link to the Chief Scientific Advisor and High Level Advisory Group in the Department of the Taoiseach, proposed in Section 5 above.

For example, the deployment of nationwide electronic patient records would enable a step change in the types of health systems research that could be conducted. It would take senior leadership within the HSE (with a clear research-focused remit) to champion the implementation of the electronic patient records system, and to bring the results of the subsequent health systems research into general clinical practice.

Similar opportunities exist in many major areas of public policy and societal benefit. Research leadership roles should be considered in a wide range of departments and agencies. This needs to be complemented by explicitly identifying targeted policy areas where RD&I activity has the greatest chance of addressing national challenges.

Internationally, the use of a defined percentage of procurement funds for more speculative solutions to defined challenges is not uncommon. This can drive industry and universities to focus research and innovation efforts on specific policy goals, and can represent a remarkable opportunity for innovative SMEs and start-ups whose size and structure are ill-suited to 'standard' public procurement processes.

What are the synergies between Government's goals in building a better society and the goal of creating jobs and economic growth?

Education and employment are strongly correlated with other major societal factors such as health and social inclusion. The state's direct investment in higher education is also an indirect, but high-impact, investment in the health and wellbeing of society.

The 2014 OECD report *Education at a Glance* showed very strong links between higher education and higher levels of social outcomes, including self-reported health status, volunteering, interpersonal trust, and participation in the political system.

The WHO report *Employment Conditions and Health Inequalities* noted that "inequalities in health derived from employment are closely linked to other kinds of social inequalities including inequalities in wealth, political participation, and education."

The rate of unemployment of university graduates in Ireland has consistently been half the rate of unemployment for individuals with a secondary level education only. Investing in education is fundamentally an investment in Irish society, in terms of health, wellbeing, prosperity, and social and political engagement.

How can we address national challenges and also provide economic opportunities through development of new products, processes, systems?

The national research landscape is already configured to prioritise research in areas of national challenge and opportunity, and there is substantial innovation, technology transfer and commercialisation activity to develop this research into new products, processes, and systems.

The integration of industry and university activities and personnel is pivotal to this. As an example, UCD presently houses 50 companies, from multinationals to SMEs, on campus. These companies avail of the supports and proximity provided through NovaUCD and NexusUCD to access research capability and personnel across many technical and business sectors, adding value to their products, processes and services. This proximity also engages the companies with the student population and the next generation of employees. A vibrant cluster of new and emerging companies is a key consideration for international companies seeking to establish an RD&I base. The connections between these clusters and the policy system can add to the compelling case for investing in Ireland.

The selection of the 'right' research priorities and the capability to adopt new emerging areas is fundamental to the success of this overall RD&I system. Effective and ongoing consultation with all RDI stakeholders in selecting and revising research priorities is key to this.

How can we address local and national challenges that are also regional and global challenges - how can Ireland through its research turn national challenges into global opportunities in areas such as sustainable land use, urban and rural development, and vulnerabilities to global trends and changes?

The selection of research priorities, the evaluation of impact in research proposals, and a renewed focus on stimulating international collaboration with industry and academia are essential to addressing national challenges and then bringing them to a world stage.

The selection and ongoing revision of research priorities should give greater weight to national challenges that also have a wide global relevance.

The assessment of research impact should not focus exclusively on short-term local economic gain, but should also give full consideration to the global significance of the research. International collaboration with industry and academia will greatly enhance both the quality of the research outcomes and the ability to the relevance of resulting technologies to overseas markets.

The deployment of research testbeds of international significance can substantially contribute to this. For example, the demonstration zone for energy systems integration is gathering clear momentum from national and international partners. The recent successful Horizon 2020 bid by Glen Dimplex, UCD and others is an example of how industry-academic collaboration can succeed in this space. A successful testbed would not only attract substantial non-exchequer funding, but would be extremely attractive to multinationals and support growth in Irish business.

How can Ireland harness the opportunities presented by the major developments on observation systems, including the analysis and use of Earth Observation data by a wide array of sectors and users?

Membership of relevant major international facilities would provide Irish researchers with access to infrastructure and an international community that could enhance the impact and breadth of research. Furthermore Ireland's substantial investment in data analytics will always derive great benefit from access to new and diverse data sets, such as earth observation data.

This can produce research excellence and economic relevance. For example, Parameter Space Ltd, a new UCD spin-out company, has won funding from the European Space Agency (ESA) to develop software to exploit the unprecedented volume of data captured by ESA's Gaia satellite.

Pillar 7: Key recommendations

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- Increased investment in research and higher education, consistent with our ambitions as a knowledge economy
- A national plan around talent development through research that enhances national success and reputation both in academic institutions and in enterprise
- A mechanism to identify and support priority areas for policy research
- Funding schemes to support research for knowledge across all areas on the basis of excellence
- A plan to meet national needs for research infrastructure, including local infrastructure as well as participation in international schemes
- A plan for international collaboration that leverages unique national propositions for major funding wins, and also targets opportunities outside Horizon 2020

8. Research for knowledge and the development of human capital

What more can we do to best harness the potential of our knowledge base for sustainable economic and social well-being?

There needs to be greater investment in research and innovation nationally, greater investment in higher education to produce excellent graduates and postgraduates, and a rebalancing of research to better meet the broad needs of a knowledge economy and a secure society into the longer term.

The deep connection between research and education needs to be recognised within the new strategy. The availability of competitive funding leverages the strength of our research base within higher education to develop further indigenous talent and attract the best of international talent. This talent strengthens Irish higher education and Irish enterprise, acts as a magnet for FDI and underpins a diverse and informed society. Developing, attracting and retaining this talent is the best way to sustain national well-being.

Excellent research in the humanities and social sciences is of particular importance in supporting sustainable social well-being. The strategy should encourage interaction between the research system and all aspects of civic society, as well as with enterprise.

What additional steps can Government take to ensure the development of human capital across the population to ensure the success of the new Strategy?

Student to staff ratios in Ireland's university sector have fallen out of line with international norms. Cuts to staffing levels at a time of rising student numbers are undermining both research and education.

There needs to be an investment in new university posts to match rising student numbers, and to provide sufficient research capacity within the system. The fall in university rankings shows the strain in the system, and that reputational loss itself hinders our ability to attract international talent, both faculty and students. Universities with high ranking and recognition are attractors of international students, researchers and academics. All of these international cohorts can add value to Ireland's human capital.

Universities are vital to the development of human capital, but this is as part of a continuum from primary and secondary schools to tertiary education and beyond. The role of universities is not limited to research and higher education. They support the primary and secondary systems through their support of programmes such as the BT Young Scientist and Technology Exhibition, and more generally by providing role models in researchers whose passion for their subject can inspire the next generation.

At undergraduate level, education delivered in a research intensive environment enables students to learn from international leaders on topics at the cutting edge of their disciplines. This benefit is even further amplified at postgraduate level. At UCD we also strive for broader training for postgraduate and postdoctoral researchers, to ensure that they possess a range of transferable skills to enable them to better adapt to the changing demands of employment over time.

How can we ensure that the requisite links between research and scholarship are maintained across all RPOs?

We in UCD are very clear on the central and mutually-reinforcing links between our research, scholarship, innovation and education at all levels.

We recognise, however, that different RPOs within the national system may have a different balance across their portfolio. The strategy should support diversity of provision, with oversight at the system level balanced by appropriate autonomy at institutional level.

In order to achieve a sustainable research capacity, are the outputs of our research system at doctoral and postdoctoral level the right ones in terms of volume, quality and relevant discipline?

The Irish research system needs to move to greater coordination in assessing the pipeline of doctoral and post-doctoral resources, and how those map to longer term needs in academia, industry and the public sector.

There are a number of areas in UCD where the supply of PhD-qualified personnel cannot meet the demand from industry, and the pipeline of graduates needs to be grown to meet these needs. A consequence of the time taken to complete a PhD programme is that the research system cannot rapidly react to short term changes in demand. The joint development of roadmaps for doctoral and postdoctoral supply and demand would enable the research system to track and adapt to changing requirements in terms of volume and relevance. Such a roadmap would, however, only be a rough forecast of the future, and should not represent a substantial limitation on the topics and scale of doctoral and postdoctoral research.

It should be recognised that while a PhD or postdoctoral research topic can (and should) be quite focused, researchers develop advanced skills that are relevant to a much wider array of challenges and careers. Engagement with employers throughout doctoral and postdoctoral programmes can facilitate easier and more productive career transitions.

How can the new Strategy support and strengthen the reforms taking place under the Higher Education Strategy and align with the new National Skills Strategy and develop capacity to enable Ireland to deal with new and emerging challenges across the full breadth of Government strategies?

The National Strategy for Higher Education to 2030 notes that "The capacity of higher education has doubled over the past twenty years and will have to double again over the next twenty." There must be commensurate investment in academic resources to address this massive growth.

This capacity building in education must be structured so that it does not undermine research capacity (i.e. does not simply redirect research time and resources to teaching activity). Particular support should be given to institutions that are building capacity in line with the Higher Education Strategy and the specific needs of the National Skills Strategy.

How can we better leverage our research talent into the economy? How can those individuals active in research (and those seeking to be), both in the public and private sectors, be best supported to perform and progress including through optimum researchers' careers, recognition and mobility mechanisms.

Leveraging research talent into the economy needs a base of research excellence, effective industry-academic collaboration, and training in transferable skills. There needs to be a national plan around talent development through research that enhances national success and reputation both in academic institutions and in enterprise.

Industry and academia need to cooperatively adapt their practices and expectations in order to maximise the transfer of knowledge and people between them. It cannot be one-sided, and a national plan on human capital development will provide the policy context to enable this.

As part of this plan, specific attention must be given to researcher careers and examining systemic restrictions in how researchers are employed by universities. There are examples of international best practice, and UCD supports the deployment of the EU Human Resources Strategy for Researchers (HRS4R) in Ireland.

Career development and international mobility awards, such as Marie Skłodowska Curie Actions, are extremely valuable in human capital development. The range of national funding mechanisms to support the development of researchers preparing for awards such as the ERC should be maintained. They provide a much needed pathway to develop Ireland's research talent.

How can gender equality in publicly funded research activity be further enhanced?

The new strategy is a crucial opportunity to review and revise the policies and programmes that seek to address gender inequality in Ireland's research system.

The Athena SWAN Charter has been extended to Ireland this year, and Irish HEIs have committed to developing gender equality action plans (GEAPs) as part of this process. Public funders that do not already have gender action statements or plans should be required to develop them. Items for potential inclusion in these plans include a commitment to gender balance on decision-making bodies, addressing issues around maternity leave, and the provision of systems to enable the collection and monitoring of gender data, including application and success rates.

There is the potential to secure non-exchequer funding for projects to enable systemic institutional changes, develop knowledge on key components of effective GEAPs and related research initiatives.

Achieving equality in the research system is critical to ensuring excellence and fairness in Irish research institutions, maintaining our national reputation and developing our competitive position globally.

How can the Action Plan for Jobs 2015 objective to increase the number of researchers in enterprise be fulfilled?

Raising awareness of the available supports and undertaking a comprehensive review of the outcomes of the current set of supports will increase participation and identify areas for future improvement. Industry and academia both need to adapt, with the support of Government.

There are many mechanisms to support industry academic collaboration, but it can be difficult to comprehensively and effectively communicate the benefits to potential industry partners. Awareness raising and marketing that specifically targets sectors with low participation in collaborative R&D would be beneficial.

Low participation could also indicate dissatisfaction with the available mechanisms rather than a lack of awareness. This is still a developing area of Ireland's research system and it would be timely for the funders of collaborative research schemes to holistically assess how well they are operating, and how they could be improved or extended.

Industry and academia both need to adapt, with the support of Government. There needs to be greater coordination in the system where universities develop research talent, enterprise identifies areas of demand, and suitable mechanisms are provided to better match and connect them.

Should research and innovation performers be supported to engage citizens more actively in the innovation process to achieve optimal outreach to the public?

Outreach to the public is of central importance in inspiring school students, building a research and innovation culture within an informed citizenry, and in ensuring that the projected outputs of research are well mapped to the needs and expectations of society.

Research and innovation performers are increasingly aware of the need to communicate the impact of our work to stakeholders. As a small and highly networked society, Ireland can lead in developing the appropriate 'impedance match' between the outputs of research and the needs of society.

This will require that those needs be evaluated, including through public consultation, and fed into the design of research programmes.

UCD supports outreach and engagement activities such as the BT Young Scientist and Technology Exhibition, but such activities can be extended to also incorporate 'citizen science' in Irish society more generally.

Pillar 8: Key recommendations

- A shared and ambitious vision for excellent research and innovation, linking closely with excellent higher education and delivering value into the economy and society
- Increased investment in research and higher education, consistent with our ambitions as a knowledge economy
- A national plan around talent development through research that enhances national success and reputation both in academic institutions and in enterprise
- A mechanism to identify and support priority areas for policy research
- Funding schemes to support research for knowledge across all areas on the basis of excellence
- A plan to address the growing set of opportunities that require a combination of expertise from the social sciences and humanities with expertise from the STEM disciplines