Balancing the Basic, Applied and Commercial R&D in Higher Education research in Ireland: Building a Flexible and Sustainable National Innovation System in an Open Economy

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September 2009
Version 2.0

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Executive Summary

In response to the call for submissions by the Innovation Task Force, the TSSG has revised an earlier position paper, and made this public on its website[1]. The TSSG is submitting the Executive Summary and the Recommendations from this paper formally to the Innovation Task Force, and would invite the members to read the full position paper.

The track record of the TSSG since 1996 has established a model for the creation of an innovation environment funded from diverse Irish and European research funding sources. The co-location of this full-spectrum of ICT research and innovation with supportive business and entrepreneurial systems expands this core model towards one that may have general applicability to other research domains.

There is a profound tension between the pragmatic model evolved at the TSSG and the established R&D funding models in Ireland. In particular bridging the gap from highly academically focussed research directly to industrial exploitation (e.g. the PRTLI/CSET/SRC model) is a major challenge that arguably has yet to be effectively understood. It would appear that in some limited circumstances this transition is possible for larger multinationals. However, SMEs continue to find the established models unsuitable. The TSSG model has evolved successfully to meet some of these challenges. In particular our model builds many intermediary linkages that can act stepping stones for the overall academic/industrial collaboration to mature. This yields a richer eco-system, part funded by the national agencies, part entrepreneur funded, producing a dynamic innovation culture and experience.

Thus the TSSG has established a viable alternative model through the creative use of its funding portfolio, achieving a balanced critical mass of basic research, applied research and commercialisation, and by pushing the boundaries of expectations (driven by a narrow academic view of what research should be like). This has allowed the ArcLabs/TSSG model to flourish. Thus the model has changed the way we think, and we believe that others interested in integrating research and innovation should be trying to do the same.

The paper argues that central Irish funding policy should recognise the efficacy of this model and promote a more integrated approach to basic, applied and commercialisation activities. In our experience the more enterprise-focused agencies have been most supportive of the developing model itself, in particular Enterprise Ireland (EI) and the Industrial Development Agency (IDA), although the latter has no direct funding vehicles for Irish academia or Irish SMEs. The TSSG also appreciates

[1] http://www.tssg.org/innovation

that the academic funding it has won from SFI and the HEA has been critical to its growth, in particular the capital funding from HEA that has allowed for the development of two buildings in WIT's West Campus in Carriganore. Similarly the capital funding from EI was essential to build WIT's Innovation Centre in ArcLabs, and to fund the NGN Test Centre's equipment.

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1 Introduction

The TSSG is the beneficiary of the increased Irish investment in research in Higher Education Institutions (HEIs) from the mid-1990s to the present day. The TSSG believes that at this stage of the development of Ireland's National Innovation System (NIS) there is an opportunity to broaden the metrics by which we define the performance of research centres, and in so doing to increase the potential linkages between research and innovation in Ireland. There has been some discussion on the need to incorporate metrics in the areas of patents and invention disclosures, but our belief is that a more fundamental restructuring of the research environment needs to take place if we are to create a true flexible and sustainable NIS.

The Telecommunications Software & Systems Group (TSSG) in Waterford Institute of Technology (WIT) has over 13 years of experience in Research & Development (R&D) in telecommunications management and mobile services. In this period the TSSG has won €60M in funding. The TSSG was founded on the philosophy that both research outputs and the stimulation of innovation are the two equally weighted objectives of any active research centre in Information & Communications Technology (ICT). This balance has been achieved in the TSSG, with one third of funding in each of these three different cultures of R&D activity:

- one third supporting traditional academic *basic research* where the focus is on academic quality, journal publications and PhD student progression (main funding from HEA and SFI),
- one third supporting *applied research* targeting industry problems and collaboration with industry (man funding from European EU FP4, FP5 FP6 FP7 framework programmes), and
- one third supporting the *pre-product development* bring research ideas closer to a commercial market (main funding from Enterprise Ireland).

The TSSG have a network of over 150 industrial and academic partners, based mainly in the EU-27, and some of the TSSG outputs have been licensed to industrial partners. The TSSG also has a 14 of spin-in and spinout companies in the past ten years that exploit the knowledge and network of contacts established by the TSSG, these companies employ around 60 additional employees in the South East region. Delivering on this funding has involved engagement in 120 individual projects, with the majority being applied and commercial (as these have shorter time frames, and smaller budgets than the basic research programmes/projects). TSSG research and development activity has been focused on the development of innovative products and solutions in the Internet, telecommunications and mobile services environment. During this period the TSSG has worked closely with a wide variety of European and Irish multinational companies and SMEs.

Our experience with commercialisation and innovation has shown that: (i) to have a commercial impact the TSSG has to engage both with multinational companies and with SMEs; (ii) that the majority of Irish SMEs are micro and small enterprises, very few becoming medium. Potentially, in the larger EU economies more SMEs become medium sized. The small size of the SMEs creates real challenges for engagement with researchers, as we describe in the document below.

Enterprise Category	Headcount	Turnover OR	Balance sheet total
Medium-sized	< 250	≤ € 50 million	≤ € 43 million
Small	< 50	≤ € 10 million	≤ € 10 million
Micro	< 10	≤ € 2 million	≤ € 2 million

EU Recommendation 2003/361/EC
(http://ec.europa.eu/enterprise/enterprise_policy/sme_definition/index_en.htm)

In the Information and Communications Technologies (ICT) area the main issues for the Irish SME are as follows:

- They tend to be focused on a small number of products (less than 3) delivered by a core engineering team.
- Their core market is often outside of Ireland (mainly the USA, UK or mainland Europe) with limited access to a local market. This creates a major overhead in travel costs and maintenance of their client base.
- The majority of SMEs have no research capacity within their organisations and limited time or budget for staff training and development.
- They have little contact with Higher Education Institutions (HEIs) and in most cases when contact is established there is a disjoint between the *knowledge* available in HEIs and their immediate needs. For instance many academic research groups will produce new models and algorithms for particular problems that would appear to be beneficial to companies in that domain.

To expand on this last point, there is a big difference between the behaviour of multinationals and SMEs, for example the academics often cannot guarantee whether models and algorithms developed in research projects are scalable for use in commercial systems or conformant to relevant industrial standards. This is a major issue for SMEs who need to take and deploy results; this is much less of an issue for multinational companies as these companies generally have a longer development lifecycles, and can afford to invest additional resources in the further development of these solutions. There is a similar mismatch of priorities in the academic emphasis on the production of PhD graduates, as this does not directly benefit SMEs. In general the skill-sets of the graduates are better suited to supporting the specialist niche needs of academia or the larger national and multinational companies with research capacity, than supplying the multifaceted roles required in SMEs. There is also a clear need to integrate product design, development and entrepreneurship into the training and development of postgraduate students. As we will argue below, there is a strong argument that what ICT SMEs need most in terms of recruitment is graduate and masters level staff rather than PhD staff, i.e. levels 8 and 9 rather than level 10 in the *Irish National Qualifications Framework* [NFQ 2009].

The rest of this document explores the model developed in the TSSG, and in its supporting structures of ArcLabs that provides entrepreneur training and also incubation space for small companies. The document then addresses placing this model into a solid academic framework of research and innovation models. This is supplemented with information on how the model links to teaching, how it links to company creation though spin-in and spin-out companies, how the angel and venture capital environment is crucial for the survival of these companies. Finally the conclusions are drawn and some recommendations for Irish funding policy are detailed.

2 TSSG model for supporting Research & Innovation

The ArcLabs/TSSG model is based on creating an integrated environment where entrepreneurs, business start-ups and research centres are co-located in a single environment supporting idea and knowledge sharing, leading to the directly transfer of know-how and IP from the research environment to the business development environment. It also facilitates the transfer of entrepreneurship from the business environment into the research environment.

ArcLabs is connected to the international business and research community through the TSSG's links created through the European Framework Programmes (FP5, FP6 and FP7), international research collaborations supported by HEA and SFI research programmes and awards, and through the establishment of strategic partnerships between the TSSG and leading international industrial players, many of these being funded by Enterprise Ireland (EI) commercialisation programmes.

Support to the broader ICT community (particularly SMEs) is provided through the Enterprise Ireland sponsored Industry-Led Research Programme (ILRP) cluster programme. The TSSG has more than 20 companies (80% SME) in its ILRP IP Multimedia Subsystem (IMS[2]) cluster IMS-ARCS. The role of the TSSG is to support these companies in the development of next generation mobile and telecommunications solutions for the global market. The new deployment of an integrated telecommunications testbed at ArcLabs now enables mobile and telecommunications companies to rapidly deploy and test their product ideas during development prior to launch. This focus has helped develop a clustering of new mobile services High Potential Start-Ups (HPSUs) in ArcLabs, initially based on TSSG spin-out companies but now including the attraction of similar companies from outside the region to locate in ArcLabs.

ArcLabs is developing as a one-stop shop for SMEs providing a suite of business development, training and innovation support services. These services are provided through co-operation between the various internal academic schools (e.g. Business, Science, Engineering). In the ICT domain the TSSG has worked closely with EI to provide knowledge Intellectual Property (IP) transfer and training support to SMEs through the various EI funding schemes such as Commercialisation Funds, Innovation Partnerships, Innovation Vouchers and the ICT Audit Scheme.

One example of how the TSSG is trying to support Irish industry, as well as its own research projects, has been through it's promoting of a Next Generation Network Testbed. The TSSG campaigned for funding for this major investment (over €2M), since the early 2000s, and eventually won the primary funding from EI in the 2008 equipment grant. The TSSG has matched this funding with funding from other sources (including the SFI PI Cluster AMCNS) to build a flexible commercial-grade telecommunications IMS system (based on Ericsson equipment and a matching open source deployment). This is exactly the type of equipment that most fixed and mobile operators in the world will be migrating to over the next 5 years, moving voice services to be over IP (i.e. embracing Internet technologies in the core network), and

[2] IMS is a core part of Fixed Mobile Convergence (FMC) in telecommunications standardised by 3GPP and ETSI TISPAN.

combining fixed and mobile core networks into an integrated IMS core. Thus it makes sense for our academic research on managing networks to be linked to this new emerging industry standard (the TSSG are members of ETSI, one of the two main standards bodies involved in IMS), and for our support of Irish industry to include exposure to these technologies, and the ability to test 3rd party software to make sure that new services are compatible. The testbed was fully commissioned this summer, and the TSSG already has one basic research programme (SFI SRC FAME), one applied research project (Genesis X - an EU Eureka/CELTIC project, funded via EI), and a number of Irish companies interested in using the testbed. A major launch event is planned for November 2009 in the Digital Hub in Dublin. This is a unique capability in Europe, and displays the TSSG's mission to bridge academic and industrial interests in concrete ways, most specifically in the telecommunications domain.

A second example of the TSSG's impact is in its engagement in EU Technology Platforms (TPs). These are the major industry-led groups that help define the future research agenda for the EU Framework Programme funding. The TSSG has made sure to be involved in three of these platforms: NESSI (software services, driven by the European solutions provider community), eMobility (mobile telephony and the mobile Internet, driven by the mobile vendors and operators) and NEM (networked electronic media, e.g. networked home audio/video appliances, driven by companies such as Phillips). The TSSG was elected as board members to eMobility and NEM, and made direct contributions to the security agenda of NESSI. This type of impact is all about understanding how the needs of industry sectors, on a Europe-wide scale, fit with the research agendas of research centres. There are few Irish players in such TPs, and this is perhaps a weakness of the Irish National System of Innovation at present.

The second example also raises the important issue of how to align Ireland's research agenda with the EU Framework Programme, the largest open innovation funding programme in the world. It is very positive that EI has provided support to enable Irish academia and industry to re-engage with EU funding, but as yet Irish funding is not strategically linked to EU priorities, or programmes. The TSSG is leading the way in Ireland in terms of EU FP6 and FP7 success in ICT (with 15 funded projects in FP7 ICT calls 1, 2, 3 and 4). Ironically, the TSSG was even criticised (in the past) for this engagement as a distraction from core academic basic research, funded by Irish agencies. Today, this engagement has been recognised as a key success factor of the basic research funding, the two types of funding successes leading to positive new opportunities in a synergistic fashion. Our main argument has always been that by engaging with such a wide range of key European industries, in particular telecommunications vendors and operators, the TSSG has a unique perspective on the real challenges facing the industry, and the opportunities for all types of research to address these challenges.

3 Placing the TSSG Model in a Policy Context

Most post-war research funding is based on an assumed simple linear model of innovation (basic research leads to applied research leads to pre-product development and to commercialisation) perhaps most famously articulated in Vannevar Bush's report to the US President [Bush 1945] that ultimately led to the establishment of the National Science Foundation (NSF). The terminology popularised by Bush became

enshrined in the statistical metrics used to measure research as the OECD formalised the terms in the *Frascati Manual* (originally in 1963 and in subsequent editions) [OECD 1963]. In perhaps the most comprehensive analysis of the origin of the linear model to date Godin [Godin 2006] argues, in a paper entitled "The Linear Model of Innovation: The Historical Construction of an Analytical Framework," that although Bush made important contributions to the debate, particularly on basic and applied research, and is often credited with having established this model, that the linear model of research and innovation had its origins much earlier. Godin traces the development of the linear model through three phases:

- *Basic and Applied Research:* These definitions were initiated with the work of Huxley [Huxley_1934], Bernal [Bernal 1939] and adopted and promoted by Bush. This stage in the development of a linear model saw the establishment of a clear distinction between basic and applied research, with an implication of a linear relationship (ideas flowing from basic to applied).
- *Development:* Godin argues that analytical and statistical factors combined to define a third term, closer to industry, of "development" of new products and processes. This is termed "experimental development" by the OECD [OECD 1963] for example. This added to the linear model so that ideas flow from basic research, through applied research, and on to development. These became the core definitions by which statistical data were gathered all OECD countries.
- *Production and Diffusion:* The final stage in the development of the linear model was when the model was extended to embrace non-R&D activities such as production and diffusion, beyond development. This extension embraced a number of evolving models of innovation, merging a innovation-centric view with a research-centric view into an integrated linear model of research and innovation; the newer OECD/EuroStat metrics, *Oslo Manual*, for innovation [OECD 2005] serve a similar function to the older Frascati [OECD 1963] research and development metrics.

The linear model of research and innovation has been often criticised in the academic literature on research and innovation, e.g. Stokes' concept of Pasteur's Quadrant mixing basic and applied research [Stokes 1997]. Stokes highlights the creativity of the overlap, and its historical validity. However, the demise of the linear model has been exaggerated in the academic literature given that simplistic notions of linearity in research and innovation often still predominate in popular debates and government policy debates. As an interesting aside Calvert analyses how academic researchers and policy makers use the term "basic research", and concludes that its ambiguity is a useful feature that is exploited allowing everyone to interpret it their own way [Calvert 2004], thus a researcher might claim the same piece of research as "basic" to one agency and as "applied" to another, depending on what that agency was promoting.

There are many more modern conceptual frameworks that seek to theoretically acknowledge the more complex nature of the research and innovation process. Popular with economists, and with the Irish policy documents from the mid 1990s onwards, is the theory of National Systems of Innovation (NSI) approach that analysis capabilities across a wide range of related activities at a national level, and sometimes within specific industrial sectors [Lundvall 1992], [Edquist 1997]. Gibbons et al.'s

"Mode 2" science [Gibbons 1997], [Nowotny 2001] is a more socially oriented conception of the contextualisation of science within various societal contexts that potentially impact on the underlying validity of science itself. Leydesdorf and Etzkowitz's "Triple Helix" model linking universities, government and industry is almost a specialised approach of the NSI generality [Leydesdorf 1998]. The message from all of these frameworks is that science cannot exist without its wider context within society, and its place within an innovation system that usually has some economic motivation from the policy makers' perspective.

Whilst the ArcLabs/TSSG model acknowledges these theoretical frameworks its focus remains pragmatic: build a set of overlapping activities that can be categorised as each of the following:

(i) *Basic research* (with an emphasis on academic publications in peer-reviewed journals and the production of PhD students and the establishment of international academic linkages);
(ii) *Applied research* (with an emphasis on addressing industrial problems through prototype development and an impact on standards and industrial forums and the establishment of international industrial linkages);
(iii) *Pre-product development* (with an emphasis on the production of industrial strength prototypes that fit the product roadmaps of key industrial players);
(iv) *Commercialisation, entrepreneurship and technology transfer support* (with an emphasis on building successful spin-out and spin-in companies and of licensing IP to companies).

Then co-locate a critical mass of all of these activities together and allow ideas to flow in all directions by encouraging both formal and informal interrelationships. This effectively creates a mini system of innovation in one location. It is particularly useful when trying to act as a catalyst for the creation of new companies in a geographical region.

4 Flexible Teaching and Training Model

The most commonly evaluated measures of output from high-end research funding in the Irish context continues to be numbers of patents filed, number of PhD candidates graduated and the quality and range for academic citations for publications generated by the funded programmes. Clearly these are important measures of quality – and they are areas where SFI and HEA programmes have had an impact in Ireland. Generating PhD graduates is a particularly complex process, requiring considerable investment, both in the essential equipment and experimental apparatus and also in the research supervision. The impact of PhD graduates in industry tends to be over the medium term (5-7 years). The PhD programme itself will consume 3-4 years at a minimum, with perhaps another 2-3 years for the graduate to acclimatising to industry, acquiring more pragmatic skills and forming a contribution to the mission of the enterprise. Arguably, if it were possible to integrate more of the industrial focus earlier in the PhD process, the graduate could have an impact more quickly, but there would be a risk to the academic integrity of the PhD programme if this became the major influence.

The TSSG, partly in order to meet the requirements of an emphasis on PhD processes in Irish research funding, has shifted away from a primarily MSc (research) set of programmes, typical of Computer Science and Engineering departments in universities in Ireland up to the mid-1990s. The TSSG graduated 30 masters research students between 1996 and 2004. The shift in emphasis has been towards a PhD-led set of programmes, supported by HEA PRTLI (Cycles 3 and 4) and SFI (PI Cluster, Research Frontiers, Strategic Research Cluster and President's Young Research Award) funding. The TSSG has graduated 4 PhD students and plans to graduate a further 3-5 each year for the next 5 years (20 students are currently enrolled). To balance this shift away from Level 9 towards Level 10 the TSSG has helped develop and deliver a new MSc (taught) programme, at Level 9, as described below.

For ICT domains, the length of the PhD cycle is a problem. The scale of innovation emerging globally, the business and technical opportunities that arise, and the relentless Moore's Law driven breakthroughs are on a much shorter time scale. Additionally, the types of skills required to leverage these opportunities tends to be more "breadth-first" that "depth first" in orientation. Skilled Software Engineers in particular need to master a range of disciplines to a sufficient degree in order to be capable of producing industry-ready output. A PhD track may equip them with outstanding specific skills in a targeted domain. However unless they can apply this domain knowledge in a robust, repeatable process, supported by the full range of current best practice, then the output may not be usable.

For ICT Level 9 (Masters and Graduate Diploma) education has a strong role to play in this context, particularly via taught MSc programmes. These programmes, delivered intensively over one year full time or two years part time, can have a very rapid impact – particularly where the students are immersed in a innovation culture. Curriculum can be highly tuned to emerging technologies, and delivery can take advantage of faculty at the Institutions, the research community and industry practitioners. Participants can be professionals returning from industry to for a skills update, recent graduates targeting a specific domain, or research students preparing for a longer-term research assignment. These three categories produce a lively mix and a very skilled pool from which innovative enterprises can draw. At TSSG we have developed just such a programme.

The WIT MSc (taught) in Communications Software continues to produce high quality graduates equipped with a core technology competency and research focus derived from the work of the TSSG. The teaching team delivering the MSc are Computing, Mathematics and Physics faculty closely associated with TSSG research programmes. There is a particularly strong commitment from TSSG research staff (mainly post doctoral research fellows) in engaging with students involved in the mini-dissertation component of the programme. Many of these dissertations are directly aligned with individual TSSG research projects. This programme has graduated 37 MSc students and 9 Graduate Diploma students in four cohorts since the first intake in 2005. It represents the highest number of graduate enrolments for any postgraduate

programme in the School of Science at WIT and represents a solid foundation for future growth, development and diversification of the postgraduate offerings.

The diversification of the original content of the programme has already commenced. The original focus of the programme - on Communications Software - has been broadened to incorporate general Distributed Systems and Multimedia disciplines. Modules from in the former discipline have already been piloted and a full validation of both of these new streams in ongoing. The diversification has directly led to the strong growth in the number of students participating in the programme in part-time (2 year) mode. These students are working in the local high-technology industry and are released by their employers for two morning sessions per week to attend lectures. For the 2007/8 students graduating in this category accounted for 40% of the participants - and this is increased to 60% in the 2008/09 academic year. Thus the programme can be viewed as having an important impact on the professional development of knowledge workers in the region, significantly enhancing the skill base, productivity and competency of their parent organisations.

Thus ArcLabs/TSSG places as much emphasis on the creation of a suitable pool of MSc (taught) students, and of the entrepreneurial training and support for new companies, as it does in the creation of PhD graduates. The emphasis on MSc (taught) programmes, that can respond to local industry needs flexibly, is a suitable balance for the PhD emphasis in the basic research programmes.

5 The TSSG Commercialisation Model

The figure below provides an overview of the TSSG model of commercialising research and creating economic value for Ireland through spin-in spin-out companies:

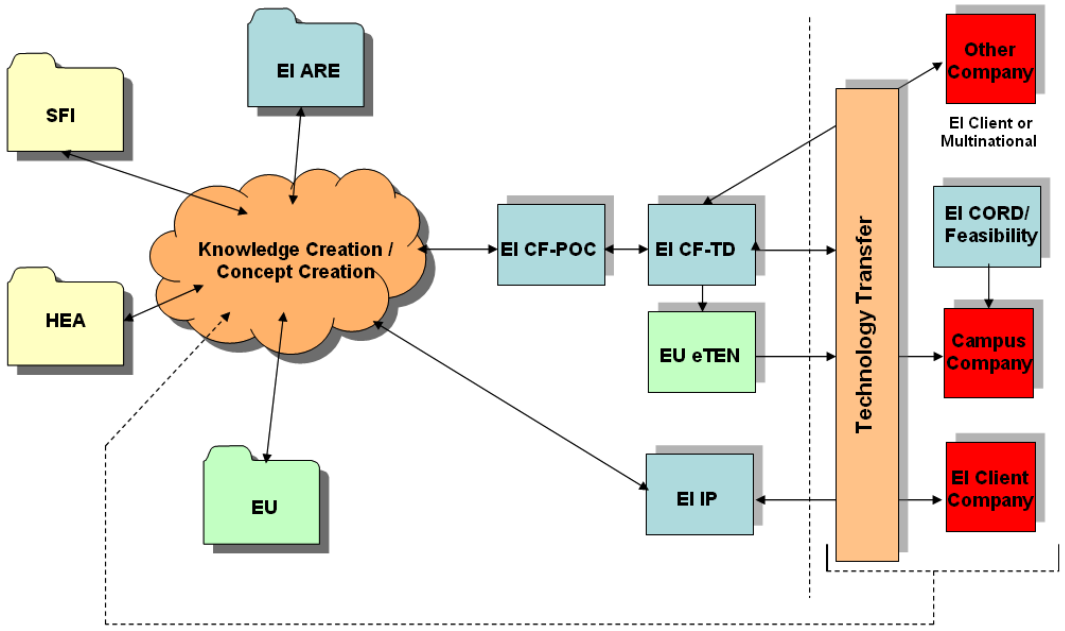

Figure 1: TSSG Model of Commercialisation

This shows the key funding mechanisms and the process used by the TSSG to commercialise its research. Research is at the centre of the process and SFI, HEA, EI ARE and EU programmes provide the funding for research and knowledge creation in the TSSG. The process of commercialisation starts when this knowledge is transformed into concepts that have commercial potential, through TSSG interaction with industry and the market environment. These concepts can then be developed-out by the TSSG applying for Proof of Concept funding (EI CF-PoC) from Enterprise Ireland. A PoC project provides the initial seed funding to enable the TSSG investigate the critical aspects of the technology underpinning the concept and to undertake some initial market validation. The outputs of the POC are: the validation of the concept, an assessment of the commercial potential of the project, and also the direction further commercialisation should take. Subject to a positive outcome from the POC the next stage in the commercialisation process is to apply for Enterprise Ireland technology development funding (EI CF-TD). The purpose of the technology development is to develop the core technology that will form the basis of a spin-out company (Campus Company).

The CF-TD also provides the environment in which to undertake much of the early market oriented commercialisation work. The TSSG uses a best practice entrepreneurial model, a summary of which is presented below, to analyse the market and industry environment for the technology and to undertake these aspects of the commercialisation of the technology.

Marco Market - What market category does this technology belong in? - What is the market size of the segment the technology is targeting? - What is the growth rate of the market?	**Macro Industry** - Who are the main competitors? - What is the industry structure? - How attractive is the industry to enter?
Micro Market - Who is the target customer for the technology? - What are their requirements? - What is their compelling reason to buy – what value does this create for them?	**Micro Industry** - What patent protection can be developed? - How will the company create a sustainable competitive advantage?

The team uses this model to refine the development of the technology throughout the CF-TD project to ensure that it is relevant to the market environment and that it can be commercialised. In parallel the team may apply for EU funding (for example EU IST eTEN funding in the past) to help with the trans-European validation of the technology and the market.

The output of this process is a technology can then be transferred into a spin-out company along with substantial entrepreneurial outputs – business plan, customer and market analysis, industry analysis and initial partnerships to create a route to market

for the technology. A central element of the TSSG model is to setup a process where the CF-TD team, which is in effect a mixed skill mini company start-up team, is directly in contact with its target customers and partners throughout the course of the CF-TD project. The TSSG's model of ensuring that its commercialisation teams are extremely active in the industrial environment greatly increases the likelihood of a real commercialisation output of the CF-TD project. Commercialisation teams have gone as far as the set up a Campus Company and win initial commercial deals for the technology, towards the later stages of CF-TDs. The reason for going so far with the commercialisation within the environment of the TSSG is to create the best possible foundation from which to launch a campus company – and the critical milestone here is progressing the commercialisation to a sufficient point to enable the raising of initial finance (e.g. angel or venture finance) to launch the company.

Raising the finance to get the company going post CF-TD is a critical milestone in the commercialisation process and this is covered in further detail in the next section. To support this process the initial Campus Company start-up team needs to be put together, along with a business plan and some initial proof that the technology meets a real need in the market environment. A high priority is to progress to an initial customer launch of the technology, i.e. the establishment of a key reference site. Once the team is in place and the start-up funding found the technology can be licensed into the spin-out company from the TSSG (WIT). The details of the license agreement are unique to each project but the TSSG's goal is to make this process as simple as possible in order to ensure the maximum opportunities for commercial success.

The Campus companies that the TSSG form are HPSUs (High Potential Start-ups) that trade internationally. Once trading they can then apply for a number of additional Enterprise Ireland programmes including feasibility funding and matched equity investment (the Innovation fund). The campus company will also be offered space in the ArcLabs incubation environment. The benefit of this is being located close to the TSSG and with other start-up companies. Also once spun-out the Campus Company can avail of further TSSG support including knowledge transfer and programmes such as Innovation Partnerships – which enables the TSSG to put together and R&D programme for the company and continue to help them build out their technology.

A key goal of the TSSG is to support the development of a high-tech cluster of companies in the region. In total the TSSG has created 14 campus companies since its inception – 9 of which have been created in the last 4 years – 3 of which have since been dissolved. In total we estimate that the TSSG has created over 200 jobs in the South-East region to date, 60 directly in these companies, and obviously the potential for one or more of the TSSG cluster companies to grow and create a substantial number of additional jobs over the medium term is very high.

The TSSG also has a model to attract companies into the region – both multinational and start-up Entrepreneurs from Ireland and abroad. In particular the TSSG has used its general commercialisation model outlined above, its knowledge base, skills and competencies and the EI Innovation Partners fund to both to undertake technology and knowledge transfer to companies. These are termed spin-ins, in that they have the ideas themselves, but are attracted to the TSSG by our general capabilities. Sometimes this has led to a new company being established here in Waterford,

sometimes to the establishment of the software development part of the company here, and sometimes to other forms of collaboration and engagement.

Therefore the TSSG has created a substantial output with modest state investments to date. Although the Enterprise Ireland programmes we use provide a mechanism to enable commercialisation - they have their weaknesses and can be improved. Arguably basic research (HEA and SFI) steals the limelight in terms of Irish policy for research in Higher Education Institutions (HEIs). Despite the fact that the TSSG has brought in a third of its funding to date from Enterprise Ireland, this level of activity has never had the same status. It has taken around 50 projects to bring in €16 Million from EI, whilst it took 4 big recurrent projects from the HEA and SFI (HEA M-Zones, SFI AMCNS, HEA FutureComm, SFI FAME) to bring in the same funding. If the commercialisation is to be treated as being as important by Higher Education Institutions, this non-parity of status has to be addressed in the policy, and this may require the increase in the size and scope of the projects funded.

6 Expanding the TSSG Model

The ArcLabs/TSSG model has proved to be highly successful and can be expanded further. The following changes are required to support the further development of this programme.

- There is no simple linear connection from basic research through innovation to economic wealth (linear models are too simplistic). The ideas that generate wealth are as likely to come internally from a team working on implementing something as from a research laboratory. To allow ideas to exist, and to be exploited, the emphasis needs to be placed on the creation of a community of researchers, innovators, entrepreneurs and consumers, constantly communicating about what is possible and what is needed.

- The segregation of research in to basic and applied is meaningless in an innovation environment (the Bush/Frascati analysis has outlived its utility). The creation of a research and innovation continuum from basic to applied to pre-product is required.

- The co-location of enterprise and research within a single building or set of buildings is essential. Presently space is funded by different agencies (HEA, EI, Dept of Ed.) with little flexibility in the use of the buildings.

- Irish research academic research funding programmes are currently more suited to the hiring of students and postdoctoral fellows (pure academics). These are core academic members of any research group in the country. However the ArcLabs/TSSG model requires a large mix of staff including many engineers with industrial experience, product designers and business development engineers. It is extremely difficult to find funding for such people (European Framework programme and EI are the main source of funds for TSSG; and here we had many discussions in the past with EI about the validity of hiring such staff). Baseline funding is required to support these activities and to provide some level of security to staff that is hired to support these roles.

- Research performance evaluation by the funding agencies is still based on traditional mainly academic metrics such as the number of PhD students and of high impact peer-reviewed journal papers. There is increased interest in patents and IP (Intellectual Property). However the type of on-going support that SMEs require, such as training and product development support are not measured (and are thus not credited in the evaluation of projects). Thus the real impact of any research centre in Ireland's capability to innovate is not yet measured.

- There is a real danger that that EI, for example, will not count our successes in creating spin-ins or spin-outs that do not directly involve EI. This means that there will be no one with a metric for our successes commercially, or that we will invent our own that cannot be compared with any other research centre who might use different metrics. We need to move above the agency-specific views of success, to a bigger picture measurement of how Ireland's National System of Innovation is growing, in capability, in richness, and so on. So the TSSG's role might sometimes be as a catalyst rather than as the original source of an innovation. That too is a very valuable role.

- Third level institutes need to move from a facility-based model to service-delivery model. The development of a one-stop shop is particularly important to SMEs. This means that there might need to be a rebalancing of funding from EI towards supporting the capability development aspects of the Innovation Centres in the Institutes of technology.

- It is impossible for any institute to provide services to SMEs individually due to limited resources. The clustering of SMEs around particular business sectors is important. Creating clusters that incorporate suppliers and consumers, SMEs with multinational companies and academics is vital to the development of an innovation eco-system.

7 Financing of Spin-ins and Spin-out Companies

The TSSG model of supporting and growing SMEs is to utilise market knowledge, funding and pricing to align the technical capabilities of the TSSG with the economic value of the SME's market opportunity. This alignment of economically valuable commercial opportunity with sustainable technical competitive advantage (through TSSG research) is a pillar of the TSSG SME growth model.

It is commonly recognised globally that the early stage Venture Capital (VC) model is not working and needs to be replaced with a funding model more suited to the needs of SMEs with high growth potential.

TSSG has developed a funding model that addresses the deficiencies of the traditional VC model for the SMEs with which it collaborates.

- From a spin-out perspective, TSSG's goal is to provide research and development capabilities to eliminate technical and business model risk from the spin-out company, thus preparing the spin-out companies for mid-stage

venture financing designed to support commercial scaling. This approach will enable the TSSG to attract the highest calibre internal VC financing into Irish Spin-outs.

- From a spin-in perspective, TSSG's goal is to provide highly efficient, high competence research and development to spin-in in exchange for equity. This model enables TSSG to attract the highest calibre entrepreneurs across the world to develop the core IP and organisation competence of their business in Ireland, thus creating high value sustainable employment in Ireland. Ireland essentially becomes the magnet for the best entrepreneurs in the world, similar to the model of Silicon Valley.

To support the spin-in global entrepreneur model, TSSG is establishing relationships with angel networks globally. There are hundreds of angel networks in North America and Europe where successful entrepreneurs finance new start-ups up to approximately €500k. The TSSG's emerging relationships with these angel networks enables TSSG not only to attract these entrepreneurs to Ireland but also the finance provided by the angel investors globally. This international angel investment can be amplified by government investment and research finance to de-risk the technology and business model risk of spin-ins and prepare them for venture scaling finance.

The TSSG model encapsulates the open innovation model by attracting entrepreneurial talent, international finance and associated contact networks into the Irish economy. Around this, TSSG can develop high quality sustainable and defensible work forces that can grow into successful and sustainable indigenous companies that compete on value and not price.

8 Conclusion

The track record of the TSSG since 1996 has established a model for the creation of an innovation environment funded from diverse Irish and European research funding sources. The co-location of this full-spectrum of ICT research and innovation with supportive business and entrepreneurial systems (begun in 2002 with SEEPP/TSSG co-location, and continued in ArcLabs since 2005 where the TSSG is co-located with SEEPP, the Centre for Entrepreneurship and with incubation space for companies) expands this core model towards one that may have general applicability to other research domains.

The success of this pragmatic model runs almost counter to the predominant models of funding in Ireland that seek to bridge from very academically motivated research directly to industrial research interests (e.g. PRTLI/CSET/SRC model) in a linear fashion. Whilst bridging this gap may be possible for larger multinational companies, SMEs cannot bridge this gap and so are more attracted to the ArcLabs/TSSG model that builds linkages that are much closer to their real needs and interests, and places less emphasis on the "original" source of an idea, and more upon the development of key capabilities, that do include the pure academic capabilities, but not to the exclusion of other more practical and pragmatic capabilities (e.g. software development to a professional level by full-time programmers with industry experience).

Only through the creative use of its funding portfolio, and by pushing the boundary of expectations (driven by a narrow academic view of what research should be like), has the ArcLabs/TSSG model been able to flourish. Perhaps it is time that central Irish funding policy recognised the some of the benefits of this alternative model, and helped to promote it directly, rather than by letting it happen on the fringes?

In general the more enterprise-focused agencies have been most supportive of the developing TSSG model itself, in particular Enterprise Ireland (EI) and the Industrial Development Agency (IDA), although the latter has no direct funding vehicles for Irish academia or Irish SMEs. The TSSG also appreciates that the academic funding it has won from SFI and the HEA has been critical to its growth, in particular the capital funding from HEA that has allowed for the development of two buildings in WIT's West Campus in Carriganore. Similarly the capital funding from EI was essential to build WIT's Innovation Centre in ArcLabs, and to fund the NGN Test Centre's equipment. The TSSG plans to continue to develop its model to create innovation in Ireland, leveraging its extensive network of over 150 academic and industrial partners (where we define a partner as a legal entity we are working with on a funded research programme) to benefit the ICT sector in Ireland.

9 Recommendations

1. Innovation has to be core to the research activity and designed into the research process. Thus more research funding programmes should emphasise innovation as well as research. Thus **Ireland should clearly define the research and innovation model that its policies support**, and this model should recognise the complex non-linear nature of research and innovation, where there is never one simple linear path from an academic idea to a commercial exploitation. The model of a **National System of Innovation** is the strongest candidate in the past policy literature produced in Ireland, and is non-linear. This model should be defined in the Irish context, so it is clear what is meant by it.

2. Ireland should fund research into understanding how Ireland's own National System of Innovation actually operates. Some of this funding should be used to bring in external experts, particularly from Scandinavia where there is a strong history of such research, so that we gather appropriate supporting evidence for works and what does not work in Ireland for stimulating innovation. Many current decisions seem to be based on potentially naïve assumptions and simplistic models.

3. SMEs are the backbone of any economy and therefore Ireland's strategy should be to develop a strong indigenous industry sector in parallel to attracting multinational investment (the current SFI strategy is almost exclusively based on the existing multinationals). This means a radical change in how the big budget projects are designed and evaluated.

4. Ideas for innovation can originate anywhere and we do not have to create all of the knowledge originally in Ireland. We can leverage knowledge that already in the public domain (such as what is already published). Thus it may be a better strategy for a country like Ireland to promote applied research very heavily, as Israel does, rather than to have a very basic-research centric policy, as we currently do. This does not however mean that there should be no basic research funding, a proper balance is what is required, for a healthy National System of Innovation.

5. There is a need for a balanced approach to the allocation of long term research funding (over 3-5 year programmes) to allow research groups such as the TSSG in WIT build strong strategic relationships, engage in knowledge transfer and product development with industry. We feel that EI should therefore fund a Competence Centre (or equivalent) high status programme that is led by HEIs with funding from €5M-€10M over 5 years with strict annual evaluation criteria in terms of industrial impact. The current EI Competence Centre model led by industry is flawed as industry clusters often cannot agree on priorities, or cannot prioritise the Competence Centre to make sure it is delivered - thus a successful HEI has no control of the process that should be designed to support it. This is equally true of the EU Technology Platforms and other so-called industry-led programmes - all are driven by key academics. The trick is to make the proposals industry-

focused, with strict evaluation criteria, but allow suitably industrially oriented academic groups to drive the agenda setting. This should include the possibility for capital investment in buildings. This is the only way to get applied research funding in Ireland to have equal status with basic research funded by SFI and HEA.

6. In terms of national metrics for PhDs it should be formally recognised that there is still a place for masters graduates where there can be greater focus on providing them with the training required by industry and particularly SMEs. The funding programmes for HEIs should be flexible and allow Master or PhD researchers as required by the needs of the programme. Thus our high-level national student targets should not all be about PhDs, and HEIs should receive financial support for MSc (taught) programmes that address clear skills needs for the economy.

7. Any research centre that is exclusively composed of postdoctoral staff will tend to focus on academic criteria and will generally recruit staff members that do not have the required skill sets to innovate, or to directly link up with relevant industrial partners. We think it is very important that Ireland change the assumed staff profile of research centres in HEIs, as the TSSG has done, so that the default is not just to have faculty, postdoctoral researchers, junior research assistants and students. The current assumptions are adequately illustrated by the IUA scales[3], where the maximum salary that a non-PhD holder can attain is around €40k. When recruiting people with good software design and development experience from industry to create a balanced team able to perform professionally on funded projects these assumptions are a serious limitation to flexibility.

8. In ICT, and in software development in particular, the patent model of exploitation does not really work. If you file a patent and try to license it to industry it will have little value. You need to build commercial grade software, get reference customers, and then the real IPR rests in the code base itself (the software that has been developed). Thus the value is linked to the market value of the spin-out company you have established, not to the patent. Therefore Ireland should prioritise the creation of successful (in terms of revenue generation or in terms of raising VC funding) spin-in and spin-out companies as a metric for exploiting ICT IPR rather than patents.

[3] http://www.iua.ie/iua-activities/documents/07scalesdefinitions.pdf

10 References

Bernal, John Desmond [1939] *The social function of science.* US: Cambridge, MA: MIT Press. (Reprint 1973).

Bush, Vannevar [1945] *Science The Endless Frontier.* US Government Printing Office, US: Washington DC. URL http://www.nsf.gov/od/lpa/nsf50/vbush1945.htm.

Calvert, Jane [2004] *The idea of 'basic research' in language and practice.* Minerva, 42(3): pages 251--268.

Edquist, Charles, editor [1997] *Systems of Innovation: Technologies, Institutions and Organizations.* Routledge.

Gibbons, Michael; Limoges, Camille; Nowotny, Helga; Schwartzman, Simon; Scott, Peter; and Trow, Martin [1994] *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies.* London, UK: Sage.

Godin, Benoit [2006] "The linear model of innovation: The historical construction of an analytical framework." *Science, Technology and Human Values*, 31(6): pages 639--667.

Huxley, J. S. [1934] *Scientific research and social needs.* UK: London: Watts and Co.

Leydesdorf, Loet and Etzkowitz, Henry [1998] "The triple helix as a model for innovation studies." *Science and Public Policy*, 25(3):pages 195--203.

Lundvall, Bengt-Ake, editor [1992] *National Innovation Systems: Towards a Theory of Innovation and Interactive Learning.* UK, London: Pinter.

Nowotny, Helga; Scott, Peter; and Gibbons, Michael [2001] *Rethinking Science: Knowledge and the Public in an Age of Uncertainty.* Polity Press.

NFQ [2009] *Irish National Qualifications Framework: Levels and Award Types* Last visited 2009-09-17 URL: http://www.nfq.ie/nfq/en/about_NFQ/framework_levels_award_types.html

OECD [1963] *Proposed Standard Practice for Surveys of Research and Development: The Measurement of Scientific and Technical Activities.* Paris: OECD.

OECD/Eurostat [2005] *Proposed Guidelines for Collecting and Interpreting Technological Innovation Data: Oslo Manual, Third Edition.* Paris and Luxembourg: OECD/Eurostat.

Stokes, Donald E. [1997] *Pasteur's Quadrant: Basic Science and Technological Innovation.* Washington D.C., USA: Brookings Institution Press.