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Innovation studies

Competence Centre Programme Estonia Feasibility Study

1 | 2002

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Foreword

What will be the success factors of international competitiveness tomorrow? This question lies at the heart of each country in conditions of a growing global interdependence and competition. Competitiveness is based on the ability to create, transfer and use new and existing knowledge to produce unique products for global markets. In order to be successful, one has to possess attractive resources, as well as the knowledge and skills to use them. Finally, one must be aware of changes on the global market and be flexible towards them.

It is widely understood that research, technological development and innovation (RTDI) are the main factors contributing to any company's competitiveness in the long-term perspective. The higher the level of economic development that is to be achieved, the more important it becomes to develop new technologies. In economic policy, the importance of supporting technological development and guaranteeing an effective national innovation system is ever growing.

According to the Estonian Research and Development Strategy "Knowledge-based Estonia" 2002–2006, the government foresees knowledge-based economic development as the main challenge for the long-term competitiveness of Estonia. The potential opportunities presented in the strategy relate to the preconditions of a knowledge-driven economy: the development of human resources, the strengthening of relationships between industry and science, the promotion of high-tech. development and its integration with more traditional industries, the stimulation of internationalisation, and an intensification of investment into R&D.

Today, one of the key challenges facing the government is the creation of a predictable and conducive environment for innovation, aiming at more intensive innovative activities and strategic investments into Estonia. The strengthening of the decision-making process, with strong linkages between strategic policy planning, short-term resource allocations, and horizontal policy co-ordination research and analysis playing an important role. In co-operation with the Estonian Technology Agency (ESTAG) under the foundation Enterprise Estonia, we have launched the "Innovation studies" series to build a store of knowledge and know-how to support the decision-makers and fuel the national debate. The series is innovation-related analyses, reports and evaluations commissioned by the ministry and ESTAG.

The current feasibility study for the Competence Centre programme analyses the opportunities of the Estonian Innovation System focusing on the weaknesses and strengths of the science-industry relationship. The task of the research was to examine how could tools like competence centres stimulate the knowledge and technology transfer between academia and the private sector in Estonia. The study answers the question, that the establishment of competence centres in Estonia would intensify technological development and innovation, and therefore contribute to the competitiveness of Estonian enterprises and industry through more intensive technological development and innovation.

The research was carried out by an international research consortium Technopolis Group, which has a long-term experience in the development and evaluation of strategies and policy measures for R&D, innovation and technology transfer. The researchers were focusing on the capabilities of different performers in the Estonian Innovation System, their interrelations and their need and capacity for change and development. The study is based on desk research, in-depth structured interviews and workshops. Interviews and workshops were carried out with representatives from companies, R&D institutions, and public sector stakeholders, as well as with local and foreign experts.

The preparation process for the Competence Centre Programme has brought together a wide range of experts from different sectors and levels. The aim of the process is to achieve a common understanding of the opportunities for the science-industry partnership in Estonia. We would like to thank the steering committee members, Raul Malmstein (Ministry of Economic Affairs), Renaldo Mändmets (Ministry of Finance), Jüri Engelbrecht (Estonian Academy of Sciences), Alar Kolk (Estonian Technology Agency), Mihkel Pärnoja (Parliament), Prof. Peep Sürje (Tallinn Technical University), Prof. Hele Everaus (Tartu University), Ilmar Petersen (Elcoteq Tallinn AS), Prof. Ülo Jaaksoo (Cybernetica AS), Andres Sarri (Eesti Talleks AS) and others for their contribution to the process. We hope that consultation between the science, the private and the government sector will also continue during the following phases of the programme preparation, as well as in the implementation phase.

Ministry of Economic Affairs
June 2002

Content

1 Executive Summary

Some important goals of the Estonian Research and Development (R&D) Strategy "Knowledge Based Estonia" 2002–2006, are to reach a better balance between basic research, applied research and development by increasing the share of R&D and to encourage the application of research results in enterprises and in society as a whole, by developing connecting mechanisms between research and entrepreneurship. One of the instruments that can help in achieving these goals is the creation of R&D Competence Centres (CC). Centres of this kind have been successfully introduced in many of countries and can act as important structural and stable bridges between science and industry.

The Estonian Ministry of Economic Affairs (MoE) has asked us to conduct research in Estonia around the following questions:

- what are the main characteristics of the Estonian National Innovation System (NIS);
- what are the main characteristics of science-industry co-operation in Estonia;
- can Competence Centres play a role in developing science-industry co-operation;
- what complementary measures should be taken by the government;
- how can policy measures be designed.

This report attempts to answer the first four questions. We have executed desk research, 61 interviews and 3 workshops as a basis for our analysis.

Our model for analysing the National Innovation System of Estonia is the "Competence Staircase" (figure 2). Companies can be classified according to their different levels of capability. This leads to different needs for external support. These different needs have to be solved by different innovation services. The ultimate goal of a National Innovation System must be to increase the competencies of firms, so that they can "climb" to higher levels the competence staircase, thus improving national development and growth.

Competence Centres can play a role in strengthening the capabilities of companies in the top levels of the competence staircase. In our definition Competence Centres are stable and structured R&D collaborations, performed together by scientific and industrial partners and getting public funding for building intense longer-term science-industry links. R&D Competence Centres exist for at least 5–8 years and act as a framework for a number of industry-related research and development projects (with a prime focus on 1–3 year projects). These projects must be based on a mid-term research plan that has been developed by representatives from universities and/or research institutes on the one hand and industry on the other hand.

Competence Centres are important for a country because they:

- strengthen industrial R&D capabilities in a mid-term perspective;
- create critical masses and sizeable research groups for applied R&D;
- become visible and attractive for foreign partners;
- introduce better research management and change research culture;
- stabilize R&D planning and R&D funding (public and private);
- give younger generations of researchers a perspective.

But are Competence Centres the right solution in the Estonian context? To answer this question we analysed the Estonian Innovation System.

Our **conclusions** with regard to the “top levels” of the Estonian Competence Staircase (figure 2) are for the different elements of the System:

Government

There’s no need for further institutional re-organisations: the EAS (Enterprise Estonia) model is a good one, as is the science/R&D structure. But there is a need for a more pro-active approach towards the business community, more interconnections between services of agencies and stronger mechanisms for monitoring and evaluation.

Innovation and Technology Policy

The technological development of Estonia could be stimulated in a stronger way by linking Innovation and Technology policy, Investment policy, SME[1] policy and EU accession planning.

There is an understandable stress on high tech developments, but this should be complemented by more attention for ”incremental development” within firms on lower levels of the competence staircase using 'appropriate technologies'.

Demand Side (Firms)

There’s a small (about 1/2 the EU average) but growing market for R&D co-operation: around 75% for testing, measurement and other short-term development projects and around 25% for applied R&D co-operation (1–3 years projects).

Factors hampering the growth of this market are the lack of trained engineers, the lack of information about opportunities for co-operation and a lack of trust between businesses and the universities.

Supply Side: Universities

Within the Universities, the general level of science-industry co-operation is higher than we expected, but it is highly personalised and oriented towards short-term projects.

The qualitative level of most Research groups is “satisfactory or good”, as reports on Estonian Science evaluation show. In some cases the size of groups is a problem, in others older equipment or the maturing age structure of the groups.

In the Universities the possibilities for more structured co-operation are hampered because the basic organisational and legal frameworks are still under construction. Even more important are the lack of result oriented planning and the absence of capabilities with regard to project management and commercialisation.

Science-Industry Co-operation

We identified (without having covered all Departments of the Estonian Universities and Research Institutes) 5 or 6 thematic areas which appear at this stage to have enough critical mass to form the core of full Competence Centres (but often boundaries between groups will have to be removed). For most of them, there seems to be also a certain level of Estonian demand, be it private, or public.

> Traditional industries like food and wood and topics like engineering are economically interesting because of their sheer size and development potential. We doubt however that the kind of needs the firms have at this moment can form the basis for their own full Competence Centres. However, in these fields there are a lot of "testing and hands on help" contacts between researchers and firms. If this can be raised to a somewhat more structured and higher level (for example by supporting networks between researchers and industry in these fields) industry could benefit substantially.

[1] *SME stands for Small and Medium sized Enterprise.*

Our answer to the question if there are possibilities to establish Competence Centres is Estonia is: yes. But there are some necessary pre-requisites that are weak or missing.

Our recommendation is to start with a Competence Centre programme in Estonia, which must be build on the following pre-requisites:

- The achievement of common understanding about the goals and the rules of such a programme, by bringing together university and industry people for structured discussions. A clear framework must be built how applications shall be evaluated.
- The programme (criteria, selection of Competence Centres, monitoring) should remain in the hands of the Estonian Technology Agency (ESTAG).
- The common understanding must be made public, and the funding guidelines must get formal protection against changes and the opening of back doors.
- A clear political statement on university investment policy would be very helpful: investments in equipment will only be included when they are directly linked with planned output and planned results.
- PhD posts are a very limited resource controlled by the Ministry of Education. Competence Centres should get enough PhD posts, and PhDs in Competence Centres should get good working conditions and a decent salary.
- Management capabilities have to be strengthened on all levels. ESTAG must play an active role and get the resources to actively promote the programme, its rules and all management issues. The universities have to focus more on research management, by empowering the research performers.

In building the Programme, Estonia can learn from international good practices. A large number of industrialised countries have introduced Competence Centre Programmes. We've studied good practices and have formulated lessons and recommendations. The most important is that:

- Competence Centres must be based on a strategic mid-term research plan or -programme that is collaboratively developed (including industrial partners).
- Competence Centres must have a project orientation: within the Competence Centre work programme, a number of research (and other) projects must be running, each managed by a project leader.
- Competence Centres must be built around a strong core group with a shared vision. They must be managed by a strong director, who is competent in business planning and commercialisation. Thus Competence Centres must be big enough to be able to afford a director.
- Competence Centres must secure strong involvement of „home university departments" resp. research institutes and of industrial partners.
- „A Competence Centre acts like a small firm" – with boards, a director and a business organisation.
- Universities should provide a lean but effective support structure regarding Intellectual Property Rights, internationalisation, contract forms, best practices etc.
- Competence Centres must exist long enough that the structural effort of such centres pays off. This means regularly public funding from 5–8 years, sometimes even longer, but no never-ending basic funding.
- **All Competence Centre programmes are based on bottom up selection procedures along strict scientific, managerial and industrial quality criteria.**
- Evaluations: there must be regular evaluations including foreign experts. This is a core point and a strict ex ante evaluation is the most important one.

Apart from these "good practice" starting points, there are some recommendations with regard to the specific Estonian context:

- Start with building a Competence Centre programme based on strict criteria about governance, management, planning and monitoring and evaluation.
- Apply these criteria not only to individual Competence Centres but also to the support structures within the Universities. At this moment, they focus too much on their internal "University role" rather than taking an external customer focus.
- Link the actual start of this programme with first SPINNO successes (and ensure strong linkages between both programmes). One of the goals of SPINNO is to improve the legal and organisational frameworks within the Universities with regard to science-industry co-operation. The existence of adequate frameworks is crucial for success of the Competence Centre programme.
- Allocate a considerable sum of money. For example: 5 Competence Centres for the first 5 years will cost the Estonian government 100–125 million EEK (20–25 million EEK per year).
- Fund the best, find ways to help the rest and support and empower smaller "areas of competence". These areas of competence must get full support from the University support structures and must be able to benefit from training schemes, international partner search, etc.

We recommend the Ministry of Economic Affairs and ESTAG to start with concerted planning on the government level, i.e. "technology road mapping" and ensure regular contacts between key industry, key research and key government people.

We also recommend to form stronger strategical and operational linkages between Innovation and Technology Policy, Investment Policy, SME policy and EU accession policy (Single Programming Document).

A Competence Centre Programme for Estonia is important, but Competence Centres are, from the perspective of the technological development of Estonian industry, only the tip of the Iceberg. The market for R&D co-operation will not only grow by solving bottle necks: in the longer-term Estonia can benefit from innovation and technology development in firms that are at present on the lower steps of the competence staircase.

Our **conclusions** about the lower levels of the Estonian staircase are:

Government and Innovation and Technology Policy

There is an understandable stress on high-tech developments, but this should be complemented by more attention for "incremental development" within firms on lower stages of the competence staircase using 'appropriate technologies'.

Demand Side

There's an interesting growing group of "Minimum capability" companies, with growth potential and the ability to use "package solutions" from external advisers.

Factors hampering the growth of this market are the lack of trained engineers, but also basic business issues like poor quality management, lack of marketing skills, lack of training, awareness and information.

Given the fact that most firms cannot invest their own money, there is also a need, in addition to the ESTAG grants, to provide for example guarantees for more "mid-tech" technological developments within firms.

Supply Side

The Universities fill a part of this gap, mostly on an informal basis, by providing testing, measurement and "hands on" development help.

But there is no pro-active SME scheme with firm visits, quick scans, advice and follow up services, combining technological support with business support and marketing support.

There are some gaps in supply of capital: high risk Venture Capital and possibilities for investments in "mid-tech" technological developments.

We **recommend** the following lines of action:
For Estonia there is a lot to gain by setting up a support scheme for firms with at least some engineering capabilities, who are able to absorb "package solutions". Size is in this respect an advantage for Estonia: with 6 high quality advisers (3 for Tallinn and the North-East, 2 for Tartu and the South-East and 1 for the rest of the country) all or most of the target group can be covered. This should be done under the flag of Enterprise Estonia, whether linked to ESTAG or the Regional Development Agency (ERDA). One way or another, these advisers should also act as "eyes and ears" for ESTAG and the ERDA (and for other Agencies), in order to provide the Agencies with continuing information about the needs of the demand side.

This individual approach can be supplemented by more focussed group work, like the Finnish Technology Clinics and the Belgian/Dutch PLATO-groups, in which SMEs work together on strategic business and innovation development. These groups can provide possible links between R&D programmes and the SME programmes.

Much may be gained in Estonia by combining resources and services. This does not only hold true for the Universities and the business community, but also for the government agencies inside and outside EAS. One of the points for attention is the general low level of profitability of most Estonian SMEs. This asks for better possibilities to finance technology development from external sources. A suggestion here is to combine ESTAG and KREDEX financial services to provide guarantees for "mid-tech" technological developments in Minimum capability companies.

2 Introduction

2.1 Guide through the report

The goal of this report is to answer the following questions:

- can R&D Competence Centres play a role in Estonia to realise the goals of the Estonian R&D Strategy "Knowledge Based Estonia";
- if this is the case, how a Competence Centre Programme should be set up in order to fit into the Estonian situation.

We try to answer these questions by first describing the essential building blocks of Science and Technology policy in relation to Competence Centres, taking international good practices into account (Chapter 3). We then give our assessment in Chapter 4 of the Estonian Innovation System, looking at the demand side (industry) and the supply side (government and research).

This assessment, against the background of general principles, enables us to answer in chapter 5 the question, 'What role can Competence Centres play to address the needs within the Estonian Innovation System?'.

In chapter 6 we describe our vision of the way a Competence Centre Programme could be designed to fit into the Estonian situation. Chapter 7 describes what else should be done in our opinion to stimulate Estonian innovation abilities. Finally in chapter 8 we suggest a timetable for government action.

2.2 Our Assignment

Possible EU accession in the foreseeable future has speeded up the process of strategic planning in Estonia: the government has approved an "anchor document": the Pre-Accession Economic Programme, which focuses on the macro-economic framework and structural reforms that need to be taken. Investments in R&D are outlined as a priority under structural reforms to increase the competitiveness of the economy. Public sector investments in R&D are foreseen to increase to 1% of Gross Domestic Product (GDP) in 2006.

Although monetary policies are strict[2] and aimed at tax reductions, the government is willing to invest in knowledge driven economic development where the development of human capital, research and the adaptation of new knowledge and skills are the sources of economic growth.

The widely supported vision on R&D development is already given in 'Knowledge Based Estonia'[3]. This R&D strategy fixes the framework and the quantity of the government support mechanisms up to 2006.

Some important goals are:

- to increase total Estonian expenditures on R&D to the average level of EU countries;
- to reach a better balance between public and private R&D investments by increasing the share of private and foreign R&D financing;
- to reach a better balance between basic research, applied research and development by increasing the share of R&D;
- to encourage the application of research results in enterprises and in society as a whole by developing connecting mechanisms between research and entrepreneurship.

One of the instruments that can help in achieving these goals is the creation of R&D Competence Centres. Centres of this kind have been successfully introduced in many of countries and can act as important structural and stable bridges between Science and Industry.

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2 *Estonian National Development Plan 2001-2004.*
3 *Estonian Research and Development Strategy "Knowledge-based Estonia 2002-2006, 2001.*

2.3 Methodology

The Estonian Ministry of Economic Affairs has asked the Technopolis Group and the Technologie Impulse Gesellschaft Vienna, supported by Leuven University Research and Development, to conduct research in Estonia around the following questions:

- What are the main characteristics of the Estonian National Innovation System?
- What are the main characteristics of science-industry co-operation in Estonia?
- Can Competence Centres play a role in developing science-industry co-operation?
- What complementary measures should be taken by the government?
- How can policy measures be designed?

This report attempts to answer the first four questions and tries to give first answers to the fifth.

The limited timeframe of this assignment prevented us to do an extensive supply and demand side analysis from scratch, so we've build on the information gathered during our SPINNO assignment, supplemented with new information gathered via desk research and a limited amount of field work (61 interviews and 3 workshops).

We have focussed on the *capabilities* of the different actors in Estonia, their interrelations and their need and capacity for change and development.

We abstained from technology audits, as they cost huge amounts of time and resources[4], which was not feasible in the framework of this assignment.

Instead of technology audits we followed a combination of the following methods:

- screening of existing studies,
- assembly of facts and figures,
- 61 in-depth structured interviews and 3 workshops with key players and Estonian and foreign experts.

At the "demand side", we have executed interviews with 23 Estonian firms and foreign companies based in Estonia.

Interviews with R&D performing firms: 4 University spin-offs and 16 other R&D performing firms (8 Tartu/ 8 Tallinn). 8 with established University contacts on a permanent or a regular project basis and 8 without established regular University contacts.

R&D expenditures are not the most relevant criterium, relevant is the existence of distinct R&D activity: the existence of a separate R&D unit and/or R&D personnel.

Selection criteria for interviewed firms

- a good spread over different modern and traditional sectors (generally 2 firms per sector: one firm with more that 100 employees; one firm with 20–100 employees);
- sectors: see table on the next page. Selection based on importance in Estonian economic structure;
- R&D expenditures were not the most relevant criterium, relevant was the existence of distinct R&D activity: the existence of a separate R&D unit and/or R&D personnel[5];
- mixture of firms with and firms without University contacts;
- the people we interview must have decision making power over the R&D performed within their firm;
- inclusion of at least 4 University spin-off companies;
- 50%/50% division between Tallinn region and Tartu region.

With these criteria in hand the Ministry and the ESTAG performed the actual selection of firms for us.
The questions we asked are given in Appendix 12.

4 *For example the OECD-led Technology Audit for Hungary (1993-4) took more than 1 year, included many specialists and did not automatically lead to special programme designs.*

5 *Firms without R&D were excluded from this study, based on our experiences in other projects that the inclusion of non-R&D performing firms doesn't generate any helpful information to the benefit of R&D policy measures. We asked KREDEX and ERDA for information about these firms and used existing studies.*

In addition to this, we addressed experts from business organisations to get a clear picture of the capacities and needs of non-R&D performing companies.

At the "supply side" we executed 25 interviews with the heads of University Departments key researchers with links to R&D performing firms, the proposed managers of the Technology Centres and the University management.

Selection criteria Universities

- representatives from University Departments with regular (not incidental) contacts with industry (mixture of representatives with longer-term framework contracts and short-term contacts);
- representatives from internal support structures (Engineering Centres, Central Management, Innovation Centres) with responsibilities in the field of science-industry co-operation;
- 50%/50% division between Tallinn University and Tartu University.

With these criteria in hand the Ministry and the ESTAG performed the actual selection for us.
The questions we asked are given in Appendix 12.

We've tried to form a picture of what they do, how well they do it, how it is managed/marketed, what plans they have for the future and how they could relate to their customer base.

We also interviewed 11 representatives from government and government agencies, who are directly or indirectly responsible for the institutional, legal, financial and policy frameworks for Innovation policy and R&D policy in Estonia.

As has been indicated already, the overall number of interviews was 61.

Besides talking to a number of policy makers, we interviewed university professors with links to industry (doing applied R&D work, having contracts with firms) and a number of firms doing R&D work. We had interview partners from the most important technological fields.

Field	*Number of interviews: firms*	*Number of interviews: universities*
IT and electronics	7	3
Biotechnology	4	3
Food processing	2	-
Manufacturing (different disciplines)	7	7
Service	1	-
Chemistry	2	4
Physics	-	2
Materials	-	2
Engineering	-	4

	Number of interviews
Representatives of government and government agencies	11
International experts	2

In relation to the "facts and figures", we have gathered existing reports, studies and statistical data.

We originally wanted to focus on assessing the R&D situation within the different sectors/companies that constitute the Estonian Industry: actual R&D expenditures by sector, actual situation on the level of (international) competitiveness in general, and, more specific the role of R&D and innovation in this respect and actual needs experienced within industry regarding R&D support initiatives. We discovered however that facts and figures about these topics are rather limited. Thus we were not able to sketch a very detailed picture of the Estonian capability staircase.

The Community Innovation Survey (CIS), distributed to 4000 firms, will hopefully fill in this gap, the results will be presented in June/July 2002. We will study the results and change or supplement this report if necessary.

Another problem is that the few R&D statistics that are available date from 1999. During our interviews with firms we discovered however that the development of R&D is changing at a fast pace, also due to the high growth rates of the Estonian economy over the past years. This means that the Statistical data are to a large extend outdated.

Nevertheless, we gathered enough information to feel confident about the conclusions and recommendations presented in this report. Especially the interviews gave us a huge amount of valuable information and insights, which was mainly due to the very open and helpful attitude of the respondents.

3 Building Blocks for Advanced S&T Policy Making in the context of Competence Centres

3.1 National Innovation Systems

According to the modern theory on 'National Innovation Systems,' economic performance cannot properly be explained at the level of the individual company, university or agency. To arrive at sustainable economic growth, in which processes of renewal play a key role, a multitude of issues, actors and interactions need to be addressed.

The current account of how research and innovation link to the economy stresses the interdependence of different parts of the economy. It says that:

- For the National Innovation System to perform well, the institutional building blocks that make up a society – companies, universities, and so on – have all to work well. Therefore interventions which focus on only one point will not improve performance.
- Actors in the National Innovation System have 'bounded rationality'. That is, they do not know everything and they can therefore make sub-optimal decisions.
- Partly as a result of this, the **links** between different actors are very important because they allow the system to communicate and to learn. Most learning take place in networks.

If the rationality of economic actors has limits, then **learning** and **networking** become keys to successful performance.

The ideal National Innovation System is able to deliver a comprehensive and complementary set of service packages that deal with the needs of different company types. The interplay between institutions is such that the system stimulates companies to "climb the competence staircase" (see figures 1 and 2).

This theoretical model (multi-actor focus, networking focus and the ultimate goal of climbing the competence staircase) has been the framework for our analysis of the Estonian National Innovation System.

3.2 Competence Centres

3.2.1 The role of Competence Centres in National Innovation Systems

The reasons why Competence Centres have become so popular in a number of countries are closely linked to the National Innovation Systems thinking. Especially the notion of tacit knowledge, the existence of feedback loops and the apparent weaknesses of any linear model of innovation led to concepts where organised R&D co-operation between different actors – namely science and industry – can take place.

Within a National Innovation System, Competence Centres have a number of functions, all beyond the old automatisms, which were seen as sufficient in the linear model thinking. Such perceived automatisms were e.g. that results from science would find via patents, publications or people automatically their way to firms. This view is now seen as wrong and therefore a number of specialised instruments have to be in place to enhance the links between the actors in a given Innovation System. Especially the following functions of Competence Centres are of great importance in this respect:

- strengthen industrial R&D capabilities in a mid term perspective – by fostering mid-term co-operations in the form of strategically important R&D programmes;
- create critical masses and sizeable research groups for applied R&D – by giving incentives for co-operation between research groups, between firms and between the academic and the industrial world;
- become visible and attractive for foreign partners – by reaching size and attractiveness for cross-border co-operations and partnerships;
- introduce better research management and change research culture – by laying a strong focus on good management, reporting and evaluation procedures;
- stabilize R&D planning and R&D funding (public and private) – by imposing longer term commitments;
- give the younger generation of researchers a perspective – by giving good young researchers the possibility to work on topics of high scientific and industrial relevance.

Effective Competence Centres promote innovation and economic development by playing a role in increasing the capabilities and the network linkages of actors in the National Innovation System. Hence, one could state that Competence Centres contribute to reinforcing the R&D capabilities of a given NIS by focusing on further developing existing technological trajectories. As such, they play a complementary role vis-à-vis for instance spin off initiatives that might result in more radical innovations. Embracing this viewpoint does imply that a Competence Centre programme can only be part of an inter-linking set of policy measures. It needs the support of other measures (like the SPINNO programme in Estonia) and other measures can benefit from the improved capabilities of the actors within a Competence Centre programme.

The term 'Competence Centre' is widely used and even includes specialised affiliates of big firms (see typology in Appendix 1). But in the context of Research and Technology Policy the term is normally preserved for stable and structured R&D collaborations, performed together by scientific and industrial partners and getting public funding for building intense longer-term science-industry links. R&D Competence Centres exist for at least 5–8 years and act as a framework for a number of industry related research and development projects (with a prime focus on 1–3 year projects). These projects must be based on a mid-term research plan that has been developed by representatives from Universities and/or Research Institutes on the one hand and industry on the other hand. Both parties must also be involved in the governance of a Competence Centre. Goals are to improve competitiveness of industry, but also to strengthen project management capabilities in Universities and to give opportunities to promising (young) people to develop themselves.

3.2.2 International good practices

A large number of industrialised countries has introduced Competence Centre selection and funding schemes, for example the U.S. with the NSF Engineering Research Centres (ERC)[6], Australia with the Co-operative Research Centres (CRC)[7], Sweden with VINNOVA's[8] Competence Centres, Hungary with the KKK programme and Austria with the K plus Competence Centres[9].

Competence Centre goals in all countries define the enhancement of industrial competitiveness via science – industry co-operations as a main challenge. All programmes react on similar, in detail different shortcomings of the innovation systems. All are large programmes already running for a long time or scheduled for a long-term support. Typical missions and goals of CCs are stated in 3.2.1; in the box below the goals of the Austrian K plus programme serve as a typical example.

Goals of the Austrian K plus programme[10]

- improve the long-term co-operation between science and industry;
- stimulate pre-competitive research and multi-firm co-operations;
- improve the transfer of know-how;
- focus and create critical masses;
- use public funding to trigger additional private expenditures;
- define new areas of research through bottom-up approaches;
- ensure internationally competitive quality of K plus centres through a strict selection process and periodic evaluation;
- create examples of best practice in research management.

In Appendix 3 and 4 we describe the Competence Centre programmes in Austria and Sweden. In Appendix 5 and 6 we describe how Norway and Ireland have used technological development as a main driver for growth over the past few decades. There are also two extensive descriptions of schemes implemented in England with regard to Manufacturing Centres and International Technology promotion in Appendix 7 and 8.

6 *http://www.erc-assoc.org/; http://www.eng.nsf.gov/eec/erc.htm*
7 *http://www.dist.gov.au/crc/index.html*
8 *http://www.vinnova.se*
9 *www.kplus.at*
10 *Technologie Impulse Gesellschaft http://www.tig.or.at*

3.2.3 Lessons from good practices

Good practice does clearly not mean „only possible way". The most important thing is to design programmes and find solutions fitting to the needs and prerequisites of a specific Innovation System. Competence Centre funding programmes are in the details quite different because situation and needs of countries are different and so are programme goals. For example while in Sweden and Austria only Competence Centres with a strong industrial partner structure are selected, the Australian programme allows centres with an explicit „public good" mission. Another example can be given for the legal form of such centres: While in the Swedish programme all Competence Centres are parts of their „home" university department and therefore part of the university, in Austria the centres are not part of the Universities due to problems arising from the Austrian University Organisation Act and also due to strategic reasons. Also, within one programme Competence Centres are not totally identical. Some differences between Competence Centres exist because of different framework conditions, different legal and organisational needs stemming from technological fields, but also from cultural diversities, even from strong persons and interests. Here a typical example is the contractual regulation of Intellectual Property Rights.

From the international best practices, we have distilled also some general minimum requirements for R&D Competence Centres:

- They must be based on a *strategic plan:* a mid-term research plan or -programme, collaboratively developed (including industrial partners).
- They must have a *project orientation:* Within the Competence Centre work programme, a number of research (and other) projects are running, each managed by a project leader.
- *Leadership:* Competence Centres must be build around a strong core group with a shared vision. The academic track record of the core persons is of course also an important issue.
- *Leadership again:* Competence Centres must be managed by a strong director, generally employed on a full-time basis, who is competent in business planning and commercialisation. Thus Competence Centres must be big enough to be able to afford a director.
- *Stakeholders:* Competence Centres must secure strong involvement of „home university departments" resp. the research institutes and of industrial partners. The departments / research institutes are not identical with the Competence Centres, but the latter will only flourish if there are good co-operation mechanisms in place and if the scientific partners see themselves as fundaments of the Competence Centre. Therefore good incentive structures have to be designed in advance.
- *Structures:* „A Competence Centre acts like a small firm" – with boards, a director and a business organisation.
- *Management support:* Universities should provide a lean but effective support structure regarding IPR, internationalisation, contract forms, best practices etc. Note that in countries like the U.S., Canada, Australia, Sweden, Austria etc. Competence Centres are something completely different than the university support structures.
- *Openness:* Competence Centres must be open for international co-operations. As they are big ventures they naturally urge for cross border work in different forms. The smaller a country the more open such centres should be.
- *Duration:* They must exist long enough that the structural effort of such centres pays off. This means regularly public funding from 5–8 years, sometimes even longer, but no never-ending basic funding.
- *Good selection process:* This means regularly bottom up selection procedures along strict scientific, managerial and industrial quality criteria.
- *Evaluations:* there must be regular evaluations including foreign experts. This is a core point and again the ex ante evaluation is the most important one.
- *Boundaries:* Competence Centres are not a panacea, there must be a clear division of labour with other programmes. A Competence Centre programme is no SME day to day clinic and it is not a university infrastructure funding instrument.
- Competence Centre programmes need a *governance structure:* the responsible funding agency delivers more than just money.

4 The Estonian Innovation System

4.1 Government: institutional settings

In this section, we discuss the institutional setting in Estonia at the government level, with a focus on the organisations that have to deal with Innovation and Technology Policy. We don't discuss the R&D laws and the application of them (which appear to be in good order).

Our main conclusion with regard to the institutional settings on the national level is that, after the Foundation Reform, they are basically all right. Enterprise Estonia is a good umbrella structure for the different agencies. Of course, given the fact that the reform is very recent, there is still a lot to build up within this new umbrella structure.

Points for attention are:
- The need for the development of a sound system of planning, monitoring and evaluation. A complaint with regard to the old Foundation structure was that there were no instruments to determine the success or failure of the expenditure of public money. In the policy measures that have been launched since the reform, monitoring and evaluation are taken into account. This should be a strong point for further development in every action that is taken.
- The need for development of a structured process of interaction with the business community and the supply side organisations (see also section 4.5).
- The need for developing service packages in which the services of different agencies are combined. These combinations should not only be made between EAS agencies, but also between EAS agencies and external organisations like business organisations and KREDEX (see also section 4.3).

The conclusion that the national institutional framework is basically all right also holds true for the Science System in the country. The university system was reorganised to match European systems and funding systems are no longer institutional. We are quite positive about the R&D law and about the structure of the R&D Council. However, government reduced spend on science between 1998 and 2000 by 3.6%. On the one hand, this did lead to more competition in funding and made funding bodies seek higher quality bids, but on the other hand it led to a strong "funding driven" approach within the Universities, with short-term "money-oriented" planning, instead of mid-term result-oriented planning.

4.2 Government: policy framework issues

What we perceive in Estonia is that Innovation and Technology policy is gradually getting off the ground. But at this stage there are no explicit linkages with other policy areas that are important to stimulate the technological development of the country.

We refer especially to Investment Policy, policy in relation to EU accession and general SME policy.

Example

Ireland is a good example of a country where EU accession was cleverly used to boost the technological development of the country. EU money was used to invest in Technology Centres and modern industrial sites (also science parks). These assets were used to attract R&D intensive foreign direct investments. Other policy measures ensured linkages with the indigenous Irish industry (subcontracting/clustering).
See also Appendix 6.

In Estonia we perceive that:
- Investment Policy is leaving the privatisation stage and has to focus on attracting "greenfield" investments. A strategy is in the making. We have the impression that a strong strategic focus on attracting R&D intensive investments based on connections between Investment policy and Innovation and Technology policy, is not an explicit consideration at the moment.
- However, if this change is missed, it will influence the pace of technological development in the country, because influx of foreign R&D capacity can be realised in a shorter timeframe that the more incremental growth of indigenous R&D capacity. Besides, the latter will benefit strongly from the former.

Foreign Direct Investments

Currently Estonia ranks third after Hungary and the Czech Republic by per capita indicators of Foreign Direct Investments (FDI) inflow. Estonia received an overall sum (FDI) of 1.966 Million US Dollars in the time between 1993 and 1999 (1.154 Mio. USD 1997–1999); FDI per capita between 1993 and 1999 was 1.404 USD, which is nearly twice the average of all accession countries. In the last three years Finland and Sweden stood for 80% of FDI inflows. Most of the outflows went to the other Baltic countries. The share of manufacturing is decreasing; while in 1993–1995 about 45–50% of FDI went to the manufacturing sector, in 1998–2000 it was only 18–25% (obviously finance sector was liberalised in late nineties). Foreign share in 1998 was very high in Paper, Construction, Chemicals and Electronics.

In 2000, the positive balance of direct investments accounted for 4.1 billion EEK. Inflow was 6.8, outflow 2.7 billion EEK. 3.7 billion EEK FDI came in the form of share capital (the rest being loan capital and reinvested earnings) and nearly all of it went into existing firms. Only 48 million EEK was invested in new firms.

Innovation and Technology policy is not directly connected with general SME policy. There are strong arguments to make more explicit connections, especially from the viewpoint that helping firms to climb the competence staircase asks for a set of interrelated service packages (see figure 2).

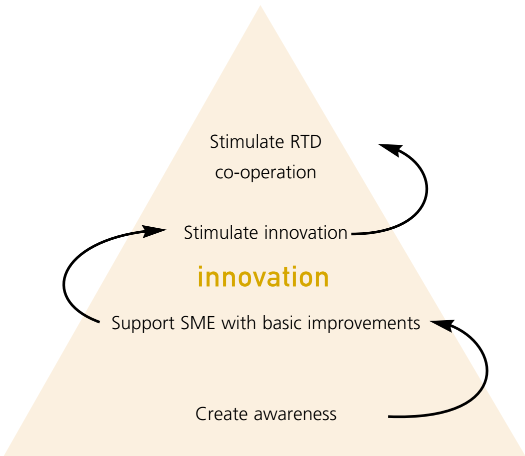

Figure 1: The innovation pyramid

Stimulating R&D co-operation is not an isolated topic, but it is the top of a pyramid, with different services for different kinds of firms (see also the competence staircase). The ultimate goal is that firms climb towards the top of the pyramid (or competence staircase), supported by interrelated policy measures.

Implementing measures for technological development of Estonian businesses based on such a concerted strategy will not be easy, given the strict monetary policy in Estonia. But a lot could be done with EU Structural Funds money (2004 and ahead), for which a Single Programming Document is now being written.

Our impression is that this SPD will be strongly based on a traditional *bottom up* approach, as a result of which a lot of priority areas from different Ministries have to be taken into account. Innovation and Technology policy (the SPD refers to 'Knowledge Based Estonia') will be one of many topics asking for investments. Given the intention that the SPD will be an important planning document and will act as an umbrella over existing strategies and plans, this will not strengthen the focus on technological development. Policy makers should be aware that this limits opportunities for implementing a comprehensive approach to technological development within the next few years.

There is however an opportunity to influence the Single Programming Document on the measurement level in the coming months. See also section 7.2.

4.3 The demand side: the Estonian firms

The concept of 'National Innovation System' has emerged from the wish to compare national styles and patterns in policy making and institutional settings for policy making. However, the very heart of the innovation systems concepts is built up by the existence and functioning of firms – size, sector, technological capabilities, innovation activities and inter-firm relationships. Accordingly, the first and foremost step to understand innovation systems is to get familiar with the firm system. This chapter thus provides an overview of the firm sector in Estonia.

The model

There exists a large number of possible perspectives on the firm sector. Moreover, there is no best-one-way available. Since we focus our analysis at the question whether or not the Estonian innovation system is prepared for a CC programme, we can restrict our analysis to the respective issues. In doing so, we are using the so-called competence **staircase model**, which has both a descriptive as well as a normative dimension. At the descriptive side it allows us to distinct between different levels of technological capability of firms. At the normative side, we use it as a framework for *upgrading* the firm sector as a whole, by enabling firms to climb up the next step(s) in the competence staircase.

Figure 2 provides a picture of the model. It can be read as follows: The different blocks indicate that companies can be classified according to their different levels of capability. This leads to different needs for external support. These different needs have to be solved by different but inter-linked service packages. The ultimate goal is the arrow on the far right: increase the competencies of firms, so that they can climb the competence staircase.

Company Types

Research Performers	■ Research department or equivalent ■ Able to take long run view of technological capabilities
Technological Competents	■ Multiple engineers ■ Some budgetary discretion ■ Able to participate in technology networks
Minimum-Capability Companies'	■ One engineer ■ Able to adopt/adapt packaged solutions ■ May need implementation help
Low-Technology SMEs	■ No meaningful technological capability ■ No perceived need for this ■ May be no actual need

Figure 2: The competence staircase

Empirical findings about the Estonian competence staircase from our research

Based on our interviews, the firm sector in Estonia can be described by the following *stylised facts*. They are arranged according to the above mentioned staircase model.

- The Estonian competence staircase shows a small number of larger R&D performing firms, mainly resulting from successful privatisation, and some high tech SMEs (also spin-offs). Considerable foreign capital is involved at this level.
- The group down the staircase, of medium-sized firms with engineering capabilities, is also comparatively small. Many of the medium-sized businesses in Estonia are production-based outlets of multinationals and do not have their own research, design and testing of products.
- There's relatively large group of low-tech and Minimum capability SMEs and larger traditional firms, some of them outsourcing testing, measurements and other short-term development work, mostly on an informal basis.
- Many firms are subcontractors for foreign firms because of the low costs in Estonia. Whilst this brings in good income in the short-term it is not good longer-term – as costs rise, production will shift elsewhere and unless companies have new, value added products which will sell internationally they will then be in trouble.

The situation on the lower stairs of the competence staircase: unexploited potentials

Most respondents think that this situation is gradually improving, as more SMEs are starting with product development. Though this is a slow process, the group of interesting "Minimum capability companies" is growing. However, upgrading technological capabilities, co-operation, and use of information from outside the company requires a certain level of in-house capability in terms of trained personnel, explicit management capacity, etc., to adopt external resources. These minimum capacities for adoption are often available. However, in the majority of cases these capacities are implicit and thus competed out by short-term daily work.

The most prevailing problem – and at the same time challenge – is thus to transform the companies from implicit to more explicit management and engineering.

Many companies, in particular medium-sized and larger ones, but also a considerable group of smaller firms have unexploited potentials for increasing their productivity. What are the main factors hampering the exploitation of their potentials?

- The lack of trained engineers.
- The lack of awareness and information about development possibilities, lack of market knowledge (also about foreign markets) and marketing and lack of opportunities for networking.
- The lack of service suppliers, in particular consultants, the lack of engineering services and there are hardly any pro-active 'helping hands'.
- Quality management is not up to international standards.
- General low profit levels, limiting the financial possibilities for investment in further development.

These issues are still very much in line with the issues raised in the 1998' PHARE report on Estonian SMEs[11], in which major recommendations for improving the business climate for SMEs focus on access to financing (lack of credit guarantees, high interest rates on loans, the availability of skilled labour and lack of support for export activities.

Gaps to be filled

Estonian Innovation and Technology Policy is focussing strongly on 'high tech' developments, thus addressing the top of the innovation pyramid. 'High-tech' is understandably seen to be the order of the day in national politics and captures the headlines as innovative products reach the market place. In developing economies such as that in Estonia there remains however a less glamorous, but arguably very important need to improve efficiency and profitability through the introduction of established technologies which are new to the business in question – appropriate to their needs and stage of development.

A gap within the Estonian support system is that there is no general business support service with a low user threshold. The only network in place is the county based advisory network connected with the Regional Development Agency. There are two limitations to this network:

- quality and quantity of support varies between counties as there are no minimum quality criteria;
- Tallinn is not yet covered by this network, which leaves out the larger part of the Minimum capability companies.

There are some business associations providing services to members, but there is no pro-active SME scheme with firm visits, quick scans, advice and follow up services, combining technological support with business support and marketing support.

A business support system addressing the needs of Estonian firms should take the following recommendations into account:

- Given the fact that most firms cannot invest their own money, there is also a need, in addition to the ESTAG grants, to provide for example guarantees for more "mid tech" technological developments within firms.
- The introduction of quality standards (e.g. ISO 9000 ff) – a precondition for entering the EU – can be used as a lever for deeper analysis of production, organisation and processes etc. The forthcoming Estonian Quality Award is a first step. However, it should be combined with some sort of "Quick Scan" service, beginning a process of continuous improvement.

[11] *The state of small business in Estonia; PHARE report 1998.*

- Estonian companies, even bigger ones, suffer from managing the market-engineering-technology interface. What they urgently need is assistance in organisational learning, in the definition and development of (core) competencies etc. Education and training are levers to achieve this and are also important with respect to the following needs:
  - as regards to technology transfer, in most companies new knowledge comes in with new equipment. But in many cases, there is a remaining need to train people working with old equipment in order to make better use of the old equipment;
  - cheap labour force is still one of the strengths of Estonia. In many cases labour force is comparatively good trained, but not throughout the whole economy. Investment in (continuous) training could create preconditions for a big leap in productivity and higher value production and thus (foreign) investment in the years to come.

SMEs higher up the Competence Staircase will also benefit from pro-active schemes: A "typical" smaller company we visited encapsulates the hopes – and problems – of Estonia. Spun out of a former Soviet institution and developed by an entrepreneur to a point where they are employing more than 10 people and exporting high tech value added products to important global markets.

This has been done without any substantial external help, inefficient university support and any venture capital or associated management.

The fact that it has survived 10 turbulent years is a testimony to the entrepreneur – but what of the next 10? Without help in developing markets, products and innovation the company will fail – or more likely take the easy option of a take-over from an inward investor who will probably then take innovations out of Estonia and use the company as a cheap manufacturing/assembly base.

The top of the competence staircase: R&D performing companies

First some statistics: The amount of people in industry engaged in R&D is on average relatively low when compared to EU figures. In 1999 only 0.54 researchers and engineers per 1000 workers were employed in Estonian enterprises. The EU average is about 2.5. Given the development over recent years that we perceived when talking to the firms we interviewed, the Estonian figure will undoubtedly be higher by now, but it is likely to be still less than half the EU figure.

Statistics point out that the total Estonian expenditures on R&D are only 1/3 of the EU average and that the bulk of these expenditures have been made by the public sector[12]. Private R&D investments are, according to the Statistics, only 17% of the EU average (situation 1998). Again, if the developments we perceived in the firms we have interviewed is representative for the development of most R&D performing firms in Estonia, this figure will have changed considerably over the last couple of years. But it will still be far below EU average.

1998 data (EST) show that most of private R&D is financed by industry itself: 84% of intramural R&D, 68% of extramural R&D. The rest is mostly financed by foreign funds (which is – at least in most EU countries – also of private nature): 6% of intramural R&D, 30% of extramural R&D. Only 7% of intramural R&D and 2% of extramural R&D is financed by government funds.

The limited level of absorptive capacity of Estonian industry was mentioned in almost every interview. Our impressions about this are two-fold:

- On the one hand, R&D is often carried out without being labeled as R&D ("We invest and learn, but we don't say it's R&D, since our critical know-how is very specific, mostly developed within the company, intangible and tacit."). So the amount of R&D captured by official statistics seems to be underestimated. Our estimation is that 75% of the firms we interviewed perform only Development work. 25% is also engaged in longer term Research projects. This complies with Estonian Statistics.
- On the other hand, the amount of R&D being carried out is lowered by some bottlenecks.

We interviewed some firms carrying out R&D projects, without involving external support (i.e. by the Universities), based on either a lack of information about what is available or a lack of trust (the comment was made that "all good researchers work already in industry", which is clearly not the case).

Lack of information about possibilities and distrust in the skills of the Universities and R&D-institutes were registered quite often in the interviews with firms and must be a point for attention in the future.

[12] *Knowledge based Estonia.*

Based on our interviews there are four groups of **bottlenecks** that the Estonian R&D performing firms brought forward in relation to the expansion of R&D activity. These are in order of importance:
Group 1: lack of trained researchers[13];
Group 2: lack of information about possibilities for support and co-operation;
Group 3: lack of skills of suppliers or clients; lack of skills in the Universities; Culture Gap with the universities and lack of facilities like laboratories and testing facilities;
Group 4: marketing issues and the lack of availability of capital.

Another problem, a shortage of good sales people, can in particular observed in a rather specific group of companies, which can be considered as particular candidate for a Competence Centre programme: **Science-based small firms**, often created as a spin-off from universities or research institutes. Many science-based firms are trying to refine, produce, and market scientific instruments, which in itself is a highly competitive, low-volume market.

R&D related Human Resources in Industry: We see from (apparently not altogether reliable and outdated) statistics a rising number of researchers starting from a very low level. The interviews we did indicate quite a strong growth over the past three years. Nevertheless, as Appendix 9 shows all industry sectors employ only a small number of researchers each. Even if the real number is higher now, this points towards small R&D groups. So any measure planned – also a Competence Centre programme – has to include incentives for firms to build up stronger R&D groups.

4.4 The supply side: Universities and Research Institutes

The academic research sector in Estonia is dominated by the Universities in Tallinn and Tartu, as well as by Research Institutes, which have their traditions and roots in Soviet times, where universities typically took over the education and training part, while the institutes acted as research facilities. These research institutes were equipped with design and workshop departments, which can be seen as first steps towards technology transfer. On the other hand, regional considerations, let alone linkages to local firms hardly took place.

Our observations about the Estonian academic research system

The following stylised facts about universities and research institutes shall give our impression of the academic sector in Estonia. We point out some weaknesses against the general positive background that the present state of most Departments is "sufficient or good" as can be distilled from international peer reports ("Reports on Estonian Science Evaluation"[14]) and that some are even Excellent.

Scientific publications by Estonian authors in Citation Index databases (SCI, SSCI)

In 2000 there were 635 such publications, steadily rising from 382 in 1995. More than half of them are co-publications with foreign authors (Source: Tiits / Kaarli, Research and Development in Estonia 2000–2001, Tallinn 2001).

Patents filed in Estonia rose from 213 in 1996 steadily to 805 in 2000. The number of Estonian applicants was constant with 12 in both years – and never rose above 20 in the meantime, which is quite low compared with EU figures.

- **Some (but not all) university departments / research groups are quite small** both in terms of personnel[15] as well as in time spent on R&D. A specific problem emerges from the problem, that, in some cases, younger researchers have to have other non-research jobs. These researchers are in a lagging position vis-à-vis their peers abroad in terms of number of publications, conference contribution, etc.

13 Note that this bottleneck is registered as the most pressing need by virtually every innovation study in European countries.
14 Reports on Estonian Science Evaluation, Estonian Higher Education Accreditation Center, Tallinn 2001.
15 To give an example: While research groups in the same field e.g. in Sweden include 50 people, some Estonian institutes must cope with 4 researchers. What can thus be expected from these group of people, which spent half of their time with education and administration?

- Another set of problems emerges from **cultural and behavioural attitudes:** while size of research groups / budgets is a pressing problem, the willingness to merge departments and research groups from bottom-up is rather limited. Accordingly, research policy should address these attitudes by supporting projects that have an element of growth and co-operation, and at the same time avoiding a continuation of business-as-usual research[16]. To bring in new people and new partners should thus be a highly prioritised strategy.
- A third set of problems in the university environment is caused by **outdated equipment**. However, one should restrain from investments into new equipment, unless investment is linked with long-term, goal-oriented research plan including financial statements. In doing so, three prerequisites for up-to-date R&D at universities could be met: (i) investment in infrastructure / equipment, (ii) long-term orientation, and (iii) stimulation of entrepreneurial thinking and behaviour[17]. The lack of certification and accreditation of labs also seems to be quite a bottleneck in some cases.
- We agree with the assessment by international evaluators of the Estonian science system[18] that there is a proliferation of parallel structures, **driven by available sources of financing**. Apparently the perceived short term urgent need for money is preventing a longer term planning horizon. Money is the driving force and the focus is more on building structures and writing plans to apply for government money than on planning for it's own result oriented sake. This problem is amplified by a need for more project management capabilities and a lack of skills in managing co-operation with industry.
- Eventually, universities, considered here as research organisations suffer from **lacks in managerial skills** and, consequently from problems caused by absence of adequate management: output orientation, meeting deadlines, selling the prototypes (in cases where production of prototypes is the intended goal). However, it would be only half way, to lure university researchers into project-based work, unless projects are not integrated into long-term, programme-led work.
- Lack of resources, smallness of groups, outdated equipment, half-time research (besides education and administration) and at best weak links to industry eventually leads into incremental basic research, often based on outdated theories and methods ("Too theoretical, too far away from real life, irrelevant!").

An observation about basic research

Although in our interviews it was often said that basic research programmes were developed in consultation with industry it was difficult to get clear information about how this was working in practice. Left to their own devices, academics will tend to pursue lines of research without an 'end game' in mind. Although this is arguably the objective of basic research, there still needs to be greater focus on the end result, and given the limited resources and absorptive capacity of Estonia, it is in everyone's interests to improve the system in this respect.

- As far as research institutes are concerned, they have undergone dramatic reduc-tions and re-orientations in the last ten years. While well integrated into inter-national networks, their remaining problems lie in their weak links with domestic industry.
- Number of academic Human Resources are a general problem in Estonia (see also below "age curve"). As we can see from Appendix 9 we can see only slowly rising numbers of master graduates. If this development does not get more dynamics, the replacement of retiring researchers can be a serious problem, note the very low numbers in natural sciences, to a certain degree also in engineering. Another concern is the low number of PhD graduates, see also Appendix 9.

„Age dynamics":

One of the obvious problems of Estonia is the ageing scientific workforce. The average age of scientists and engineers has remained about 47 since 1995. In year 2000 there were 500 below 30, 850 between 30-39, 950 between 40-49, 950 between 50 and 59 and 750 over 60. 43% are over 50.

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[16] *A typical strategy to undermine this strategy is to split bigger projects or programmes into a number of individual and isolated small projects. Absence of management resources typically foster such behaviour.*

[17] *We have also heard other strategies, which are worthwhile to mention: Extra money should not be invested in new equipment, but to increase the salary of the researchers in order to prevent them from running a second or third job. These researchers cannot produce enough publications to meet international standards. Accordingly, the need to have second and third jobs, acts as a negative selection.*

[18] *Reports on Estonian Science Evaluation, Estonian Higher Education Accreditation Center, Tallinn 2001.*

4.5 Science-industry co-operation

As has been said, Innovation and Technology Policy is getting off the ground in Estonia and measures are starting to emerge, mainly centred around ESTAG. We saw a lot of positive developments during the course of our survey work, such as the ESTAG development grants, investments in Technology Parks and the new SPINNO programme, which is aimed at improving the basic frameworks for science-industry co-operation and will support spin off developments.

But what is happening in the field? With regard to science-industry co-operation our impression is that there is a lot more happening than is captured by official statistics. Much of this appears to be based on informal, personal contacts and has to do with testing, measurement, prototyping, etc., mostly in short term, small development projects. In this respect, the Universities fill in an important unofficial niche in the Innovation System, because the availability of private centres to carry out testing and measurements is still very limited.

The market for 1–3 year applied research projects is smaller than the market for these short term projects, which is also reflected in the R&D statistics of Estonia[19], that were already summarised in the former section

Combined with the fact that only 25% of R&D expenditures by firms is spend on applied research and the rest on short term development activities this clearly implies a small market.

Another observation, which leads to the conclusion of a small R&D market, comes from the participation of Estonia within the EU Fifth Framework Programme. This participation can be labeled as successful. In total 145 partners participated in projects. At the level of the EU, Estonia together with Slovenia and Cyprus is seen as one of the most successful 'candidate countries' participants (e.g. when compared with Poland – The return for Estonia is estimated at 3:1, while for Poland hardly 1:1 is reached). The majority of partners were universities (n = 61), followed by R&D organizations (n = 51), governmental agencies (n = 10) and companies (n = 23).

It is noticeable however that the number of participating companies is rather limited, especially when it comes down to joining larger consortia programmes. It appears to be difficult for Estonian firms to participate due to limits in terms of company size and R&D capabilities.

Applied research at this moment thus appears to form mainly around large publicly-funded projects, such as the review of power station fuelling, and smaller private projects with a bias towards testing, measurement and short-term "hands on" development work.

But this market is undoubtedly growing, given the growth of R&D expenditures by R&D performing firms over the last few years. Also there is potentially much to be gained by bridging "information gaps" and by creating more trust between Academia and Industry through stronger partnerships.

Nevertheless, the "average" Competence Centre-programmes with a 1–3 year horizon would typically involve 4-8 firms and this will not in the majority of cases be attainable within the borders of Estonia, so the target areas for firms must be at least the Nordic region and/or European.

We nevertheless identified (without having covered all Departments of the Estonian Universities) 5 or 6 thematic areas which appear to have enough critical mass to form the core of full Competence Centres (but often boundaries between groups will have to be removed. For at least 4 of them, there seems to be also a certain level of Estonian demand, be it private, or public.

Traditional industries like food and wood are economically interesting because of their sheer size and development potential. We doubt however that the kind of needs they have at this moment can form the basis for their own Competence Centres. However, in these fields there are a lot of "testing and hands on help" contacts between researchers and firms. If this can be raised to a somewhat more structured and higher level (for example by supporting networks between researchers and industry in these fields) industry could benefit substantially.

19 *Comparing the R&D Statistics (1999) with the information from our interviews, we believe that the statistics underestimate the amount of R&D being carried out in Estonian industry, especially short term development work.*

With regard to the interfaces within the Universities with industry we found a large potential for improvement:

- The system for interfacing with clients and funding agencies is fragmented and to a large extend left to individuals in Departments. There is therefore not very often a common approach or networking of capacity to undertake multi-disciplinary projects and hardly any sharing of contacts. Many researchers are protective of their contacts in fear that others may benefit rather than them.
- Contractual arrangements are still haphazard and do not follow common formats or systems.
- There are no overall project progressing or management systems.
- There is too little Intellectual Property Rights protection and there is a lack of professional indemnity insurances.

All of these issues point to a need for improvement and will need to be addressed (mainly within the framework of the SPINNO programme) before any significant structural change in the use of the university and its resources for applied R&D co-operation may be achieved.

In addition, without formal audits of resources and business planning involving regular assessments of customer needs it is difficult to see how science-industry co-operation can develop other than in an ad hoc way. Much needs to be done in this respect.

The mature age structure of staff in quite some Departments is also a problem, though not easy to solve within a short timeframe.

Our **conclusion** is that there is a small but growing market for applied R&D co-operation in Estonia. The growth could however be faster if the following bottlenecks were addressed:

- *On the demand side:* a lack of information and lack of trust in the Universities.
- *On the supply side:* a lack of mid-term result-oriented planning, a lack of basic science-industry co-operation frameworks, poor administration in terms of contract and project control, a lack of multi-disciplinary networking and sometimes the poor state of equipment or lack of accreditation of laboratories.

Note however that the market will not only grow by solving bottlenecks: in the longer term Estonia can benefit from innovation and technology development in firms that are at present on the lower steps of the competence staircase, as was described in the former section.

4.6 Summary: Conclusions about the Estonian National Innovation System

4.6.1 Demand side

- Small (about 1/2 the EU average) but a growing market for R&D co-operation: around 75% for testing, measurement and other hands on support or short-term development projects, around 25% for real applied R&D co-operation (1–3 years projects).
- Factors hampering the growth of this market are the lack of trained engineers, the lack of information about opportunities for co-operation and a lack of trust between businesses and the Universities.
- There's an interesting growing group of "Minimum capability" companies, with growth potential and the ability to use "package solutions" from external advisers.
- Factors hampering the growth of this market are (again) the lack of trained engineers, but also basil business issues like poor quality management, lack of marketing skills, awareness and information and a need for growth capital.

4.6.2 Supply side

- The technological development of Estonia could be stimulated even more by linking Innovation and Technology policy, Investment policy, SME policy and EU accession planning.
- There's no need for further institutional re-organisations: the Enterprise Estonia model is a good one, as is the science/R&D structure. But there is a need for a more pro-active approach towards the business community, more interconnections between services of agencies and stronger mechanisms for monitoring and evaluation.
- There is an understandable stress on high tech developments, but this should be complemented by more attention for "incremental development" within firms on lower stages of the competence staircase using 'appropriate technologies'.
- Within the Universities, the general level of science-industry co-operation is higher than we expected, but it is highly personalised and oriented towards short-term projects.

- The qualitative and quantitative level of most Research groups is "satisfactory or good", as reports on Estonian Science evaluation show. In some cases older equipment is a problem, in other cases the maturing age structure of the groups.
- In the Universities the possibilities for more structured co-operation are severely hampered because the basic organisational and legal frameworks are still under construction. Even more important are the lack of result oriented planning and the absence of project management and commercialisation skills.
- There is a strong need for a pro-active scheme aimed at the further development of the Minimum capability companies: taking business development, market development and technological development into account. This must be combined with awareness raising and information and networking support. Market support should not be limited to partner search but should also encompass support for first steps to enter markets and greater knowledge about the rules of their chosen markets.
- There should be more possibilities for these firms to access external growth capital (at least in the form of loan or export guarantees).

5 The possible role for Competence Centres in the Estonian context

In this chapter we are talking about two issues. First, based on our findings, we bring forward some normative and some pragmatic arguments, if and why there should be a Competence Centre programme established in Estonia. The general answer is a recommendation for such a policy measure. A closer look nevertheless shows that that while many necessary prerequisites are in place, some of them only in a weak way, while some others are still missing. The second issue deals with such factors that should be established or strengthened before / while starting a Competence Centre programme.

5.1 Competence Centres for Estonia: the right answer?

First we have to ask if such an instrument can fulfil some of the needs of a small countries Innovation System, if they are useful and desirable. On a general level Competence Centres are instruments of choice also for small countries: There is a need to form critical masses in fields where quality is high and needs are identified. International visibility in some fields, both on national and international level, is necessary to gain profile as a high tech business location and also as possible node in international Networks of Excellence[20]. Local industrial cores have to be strengthened and upgraded in an open economic space. Finally efforts must be made to be attractive for young researchers.

The second more detailed question is if specific gaps in the Estonian Innovation System can be filled with a Competence Centre programme. Competence Centres are very popular with policy makers, but they are of course no "must" for all countries. Reasons not to start with Competence Centres include:

- Science-industry co-operations can be in such a good shape that there is no need to intervene with public money.
- There is the possibility of other institutional arrangements for science-industry co-operations like specialised government labs.
- Resources in money or people can be too scarce for such big initiatives.
- Institutions are not ready for such mid-term collaborations.
- Scientific and industrial R&D competencies and portfolios simply do not match.

Some of these five arguments raise concerns in the Estonian situation. We had ample discussions in the interviews and the workshops, namely on the questions of resources available, readiness to start and the issue of matching. So the first two bullet points are easy to answer, the others are of a more complex nature.

"All is in good shape": Even in the richest and biggest industrialised countries only some industrial sectors have ample, long standing co-operation structures with the academic world totally financed by themselves. Estonian firms with their small size and young market economy tradition spend only few on R&D and only a small fraction of it for co-operations with universities. Longer term R&D planning is missing in most cases. On the other hand the universities are in a difficult change process towards more openness and more research management style. The facts are described in Chapter 4; all studies and most interviews show a need for active government involvement because of missing co-operation culture, lack of organised planning procedures in the industrial and the academic world and because of low overall R&D efforts.

"There are other instruments": In Estonia, there are very few, so there is need for a new policy instrument. This holds true not only Competence Centres, but for a lot of elements of the Innovation System:

- Estonian firms generally do not have large in-house R&D departments[21]. So they (will) rely to a certain extent on co-operations. These needs will grow given the fact that R&D becomes more and more important for Estonian firms as they climb up the competence staircase[22].

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20 *In this context the bigger projects of the upcoming EU 6th Framework Programme are a special challenge for smaller countries in Europe. There is a need for active and sizeable research groups who can play a certain role in the foreseen Networks of Excellence and Integrated Projects.*

21 *The size of such a department is not as important as the existence of a group of engineers who systematically perform applied R&D. A minimum level of organised in-house R&D work is the prerequisite for any R&D co-operation.*

22 *Now they are in a phase of exorbitant productivity growth of 10% annually (Hernesniemi, Evaluation of Estonian Innovation System, Helsinki 2000), which is a typical sign for countries with industries entering a more innovation intensive stage (see the stories of Austria or South Corea).*

- There are no meaningful and professional private providers of R&D, neither in real research nor in testing, prototyping, calibration and the like. While private contract research labs are often missing in smaller countries (without causing problems for the Innovation System) the non-existence of the latter is a problem also expressed in a number of interviews with firm managers.
- There is a small government lab sector, which could not reach an overall good profile for co-operation with industry. So university departments and university-based research institutes remain as the most promising partners for co-operations with industry.

"Scarce resources": Resources are scarce in Estonia. This holds true for money spent and for people employed as researchers. A number of points is related to the question of resources:

- Are there starting points and groups large enough to develop Competence Centres? In our interviews we found a considerable number of research groups in universities departments and research institutes big enough to be visible also internationally, namely in Biotech, Biomedicine, Physics, Chemistry and Materials, to a little lesser extent in Information Technology.
- Are there enough young people to work in Competence Centres[23]? This is one of the most critical factors and there is no choice. Estonia has to develop more young people who can work as researchers for and within industry. Competence Centres in all countries serve this function and there are ample possibilities for attractive industry-oriented PhD posts in such centres.
- Where to invest a limited amount of money? Given the Estonian strategy plans[24] public money for a Competence Centre programme should not be the limiting factor. One reason why we propose a double strategy of Competence Centres and other "soft" innovation promotion initiatives (see also chapters 6 and 7), is the proven ability of such programmes to spur R&D spending in the firm sector. As even in the most ambitious plans overall funds will be limited of course, there should be a concentration on few programmes and initiatives with a meaningful size.
- The fact that Estonia is a rather small country is an argument for strengthening existing strengths, for forming critical masses and for including foreign partners. Competence Centres fulfil all these requirements.

"Not ready to go": Are firms and university researchers able to co-operate on a larger and professional scale? Are the sectors of the Estonian Innovation System prepared to build up Competence Centres?

- A limited number of firms build up innovation networks with universities, some few consider hiring PhDs as researchers. But here we find a very critical situation. There is – also due to the lack of reliable statistics[25] – only sketchy information about the state of intramural and extramural industrial R&D efforts. Most of our interview partners nevertheless expressed needs for R&D co-operation and willingness to enter such co-operations.
- Universities are preparing supporting structures for co-operations in applied research. There is a lot of attention from the university management both in Tallinn and Tartu to create such institutions. If they specialise on managerial support (contracts, Intellectual Property Rights, R&D management curricula and training courses etc.) rather than building up parallel R&D performing structures, they will ensure that Competence Centres have a good start. At least it is to be said that attention for R&D management issues is high both in Tartu and Tallinn.
- Many university departments have established co-operation structures with Estonian and foreign firms. In our interviews we got the impression that the ability and willingness to co-operate is there, at least in a number of very good and excellent academic research groups.
- Co-operation culture can be learnt best when co-operating in a well-planned and organised way. Competence Centres need of course certain prerequisites (see section 5.2) but are on the other hand an ideal ground for co-developing such a culture in the triangle firms – academic researchers – programme management.

"No matching of competencies": Are there enough partners on both sides who can co-operate in a meaningful way? From our interviews we saw that in a number of cases (e.g. IT, chemical industry, extraction industry, biotech) there are such matching groups of firms and researchers. So there is rather a number of caveats how to design a Competence Centres programme than a question whether to start such a programme at all.

- Start with a small number of Competence Centres.
- Don't make them to large.
- Allow foreign firms to participate.
- As government, don't be a too active matchmaker! Let firms and academic research groups find themselves under favourable funding and framework conditions.
- At least government should be very clear about its long-term determination to run the programme. So the expectations of the other parties can be stabilized.
- Do not preselect narrow fields. People get lazy when they can be too sure about being funded.

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23 *The average age of scientists and engineers is 47; 43% of them are older than 50! Tiits / Karli, Research and Development in Estonia 2000-2001, Tallinn 2001.*

24 *See Appendix 3 of Knowledge Based Estonia, Tallinn (2002).*

25 *Statistical Office of Estonia, Research and Development 2000, Tallinn (2001).*

So we can not identify core factors within the Estonian Innovation system that do not allow the establishment of a Competence Centre funding programme. We think there is room for such a programme that can help to overcome some but not all shortcomings and gaps. Such a Competence Centre programme shall be very selective. Therefore only few groups shall be funded (and they shall get a considerable sum of money). Other good groups shall get other forms of support (see next chapter: "fund the best and help the rest") and there must be programmes to help the firms on the lower levels of the competence staircase.

5.2 Beyond the good practise: What should be in place before/when implementing a Competence Centre programme in Estonia?

The success of a Competence Centre programme depends also on a number of factors outside the programme and on some prerequisites on the governance level.

- A common understanding about the goals and the rules of such a programme have to be built. The most important point is to bring together university and industry people for structured discussions, without giving them carte blanche for funding. The ongoing moderated discussions in the oil shale sector are one good example.
- A clear framework must be built how the proposals shall be evaluated. Foreign peer review is a must for a country like Estonia.
- The programme (criteria, selection of Competence Centres, monitoring) should remain in the hands of ESTAG and not be handed over to universities or university support structures.
- The common understanding must be made public, and the funding guidelines must get formal protection against frequent changes and the opening of back doors. This includes financial stability (see chapter 6).
- A clear political statement on university investment policy would be very helpful. As a Competence Centre programme in the understanding of all countries referred to in this report gives money for R&D work, not for building houses and only to some extent for laboratory funding, there should be clear which infrastructures are to be funded by whom.
- As we understand PhD posts are a very limited resource controlled by the Ministry of Education. Competence Centres should get enough PhD posts and PhDs in Competence Centres should get good working conditions and a decent salary.
- Management capabilities have to be strengthened on all levels. ESTAG must play an active role (see chapter 6 and 7) and get the resources to actively promote the programme, its rules and all management issues. The universities have to focus more on research management, not bypassing departments and institutes but empowering the research performers.

6 A framework for an Estonian Competence Centre programme

In this chapter we sketch the framework for a Competence Centre programme which in our view matches the needs of Estonia. We limit ourselves at this stage to a general framework: the detailed outline of the policy measure itself will be part of the next phase of this assignment.

6.1 Guiding principles

In this chapter, we propose how the Estonian government could proceed with respect to the establishment of a Competence Centre programme that can contribute to the goals presented in "Knowledge Based Estonia".

There are some guiding principles, which we think are very important in the Estonian context:

- Don't leap too quickly into discussions about content: the Estonian R&D system is still in the making and where rules and principles have to be established, this should be done first (first things first principle).
- This also implies that a lot of effort should go into preparing the ground for good Competence Centre applications: this can be done by the elaboration of very clear and detailed criteria and support for groups applying (training, proposal days, etc.)
- A Competence Centre Programme is not only about the individual centres, but also about transparent and facilitating structures within the Universities: this means umbrella structures for Competence Centres, which should also empower other research groups. These umbrella organisations should provide support on legal matters, contract matters, Intellectual Property Rights, international contacts and training (for example in project management). There should be clear divisions of tasks with other support structures (R&D Departments, Innovation Centres).
- Investments in Competence Centres should go hand in hand with concerted and structural (longer term) planning on the policy level (i.e. by "technology road mapping"). This ensures the involvement of key government, key industry and key research people. This also implies a pro-active role of the funding agency and the need for further development of capabilities connected with this (content knowledge, but also knowledge about process management).
- There should certainly be no investments without assurances on the right capabilities of Competence Centres management: project management, commercialisation, etc.
- Competence Centres are, from the perspective of the technological development of Estonian industry, only the tip of the Iceberg. This means that a Competence Centre programme should ensure that other initiatives (smaller research groups / network initiatives) can benefit from the programme and that there are links with other R&D and innovation measures.

6.2 General recommendations

We propose that the following lines of action should be considered by the Estonian Government:

- Start with building a Competence Centre programme based on strict criteria about governance, management, planning and monitoring and evaluation.
- Link the actual start of this programme with first SPINNO successes (ensure strong linkages between both programmes).
- Apply the criteria not only to individual Competence Centres but also to the support structures within the Universities.
- Fund the best, find ways to help the rest and support "areas of competence".
- Start with concerted planning on the government level, i.e. "technology road mapping" and ensure regular contacts between key industry, key research and key government people.
- Plan interconnections between R&D policy and other policies, especially investment policy.
- Use Structural Funds to fund schemes aimed at other important aspects of Innovation and Technology policy.
- Try to make as many "package deals" as possible, i.e. combine ESTAG and KREDEX services.

These recommendations are described in more detail in the next sections of this chapter and in chapter 7.

6.3 Start building a Competence Centre programme with strict criteria

We recommend that the Estonian Government should install Competence Centres with a specially designed R&D funding programme. Some guidance on rules for the Centres themselves are given in the annexes. But it is very important to do "first things first":

Of utmost importance is to **work on a strict focus on management and governance** of the centres. This consists of a number of issues: When starting the programme there should be strict set of procedural rules and selection criteria that each applicant consortium has to undergo. When granted, the Competence Centre has to stay within a set of governing rules, like the existence of boards, of reporting structures, of sticking to the research programme, etc. The latter also includes an orderly way to amend the plans when such changes become necessary due to external or internal factors.

Within these broad rules the Competence Centres and its owners and most important partners should be free to develop their vision and run their programme. Therefore it is important to press for a strong, full-time manager to run and 'Champion' the Centre, who is also capable in business planning, Intellectual Property Rights and commercialisation issues. The most important scientific and industrial partners of the Centre should sit in a strategic board with quarterly meetings. Partners are all major financial contributors and owners of the Centre. These boards are very important in the Estonian context given the fact that common understanding of research management procedures is one of the bigger gaps in the Estonian R&D infrastructure.

Managerial capabilities: Strengthening R&D management capacities is one of the core issues of every programme. The title of the Australian CRC programme was nicknamed "Changing Research Culture". While we have already touched on the question of strong Centre management, other important management challenges appear on the programme level. Once the cornerstones of the programme are fixed, the funding agency must do a lot of fieldwork: Helping consortia to come forward with good ideas, bringing the new paradigm into industry and universities, providing managerial help etc. As the Austrian and other examples show us, this is not a culture change coming automatically because of good rules and procedures (but good rules are of course a necessary precondition). So the funding agency (ESTAG) must play a very active role.

ESTAG's role would be to cover:
- support for applicants,
- overall control,
- overall programme management,
- budgetary control,
- control and approval of business and operational planning,
- political and financial accountability,
- performance of monitoring and evaluation,
- overall publicity.

Support for consortia who want to make applications could for example be to organise "proposal days" to guide the applicants through the application form and procedures. Documents must be very clear and detailed. During the proposal days the principles of governance, planning and management can be explained in detail and can even take the form of training sessions.

6.4 Competence Centres, a long term commitment for government

6.4.1 Financial issues

Set aside a considerable sum of money. For example: 5 Centres for the first 5 years will cost the Estonian government 100–125 million EEK (20–25 million EEK per year) (see Appendix 1 for further details about this). Let the funding agency make binding mid-term contracts, the first contract at least for three years. Therefore the funding agency must be sure about the financial means of sustaining the programme for this period.

6.4.2 Strategic issues

Estonia has a number of very well designed institutions. This is a good base for mid-term strategies also on the level of funding programmes. Programmes such as SPINNO or the envisaged Competence Centre programme will not show immediate success, but take time to develop. Moreover a lot of pressure will come in the first years, perhaps from universities attempting to bypass funding programme rules. If government allows such slippage, or alters the programme every two years or so to accommodate these pressures it would be better not to have started with such an initiative.

6.5 The actual start must be linked with SPINNO success and the existence of a good supporting structure within the Universities

One of the goals of SPINNO is to improve the legal and organisational frameworks within Universities with regard to science-industry co-operation. The existence of adequate frameworks is a pre-requisite for success of the Competence Centre programme. This does not mean that SPINNO has to be finished before starting the Competence Centre programme, but there must be certainty that the building of the basic frameworks does not lag behind the implementation of the Competence Centre programme.

The second important thing is the existence (or build up) of good support structures within the Universities.

The Engineering Centre in Tallinn Technical University and the Institute of Technology in Tartu University, could provide this support, provided they develop into lean and mean facilitating organisations, complementary to and not overlapping with other support structures like the Innovation Centre (Tallinn) and the R&D Department (Tartu). At this moment, they focus too much on their internal “University role” rather than taking an external customer focus.

The umbrella structure should have a strong industry and peer involvement in governance and management. They should be staffed by individuals with a research and business background who can combine the essential blend of research and academic understanding with sound commercial judgement. This should be subject to ex-ante evaluation as much as the Competence Centres themselves.

The umbrella structures will network closely with ESTAG, each other, the group of competence centres and individual “areas of competence”. Their principal aims will be:

- To network with each other to ensure that wider use of skills and expertise is developed between the two universities and their clients.
- Supply support on project management, financial management, Intellectual Property Rights, proposals and contracts. This will be done in an efficient and business like way.
- Offer training in commercial negotiations, project management and other issues of good practice to support the competence centre staff and those in separate areas of competence.
- To provide feedback on performance to both the competence centres and ESTAG.
- To form international links with businesses and funding agencies in other countries.

6.6 Fund the best, find ways to help the rest

This support should not be limited to the Competence Centres themselves, but should also involve what we have termed "Areas of Competence":

Areas of competence are defined as those individuals/teams/departments which are not of sufficient scale or relevance to be co-funded within the 'Competence Centre' programme. They nonetheless have an important contribution to make to the wider field of technology development in Estonia. This can for example relate to development support for the traditional industries in Estonia (wood, food textiles).

Areas of competence must get full support from the University support structures and must be able to benefit from training schemes, international partner search, etc. They must be able to link in with the Competence Centres, forming important team members for work on selected individual projects. There should also be possibilities for Areas of Competence to use Competence Centre equipment.

7 What else must be done: complementary measures

7.1 Start with concerted planning and ensure regular contacts between key industry, research and government people

In Estonia there is a clear need for a longer term R&D planning horizon, based on concerted foresight excercises by key persons from government, industry and the research community. This will also fill in the need for more regular and structured contacts between these three actors. Information exchange and the building of mutual trust are important side effects of such concerted planning exercises.

The platform which will perform these exercises can coincide with the Steering Group for applied R&D programmes like the Competence Centre programme. The three areas which were singled out in Knowledge Based Estonia (IT, biomedicine, materials technologies) should at least be a part of these planning exercises.

Explanation of Technology Road Mapping

Technology planning is important for many reasons. Globally, economies are facing many competitive problems. Technology roadmapping, a form of technology planning, can help deal with this increasingly competitive environment.

The main benefit of technology roadmapping is that it provides information to make better technology investment decisions by identifying critical technologies and technology gaps and identifying ways to leverage R&D investments. It can also be used as a marketing tool. Technology roadmapping is critical when the technology investment decision is not straightforward. This occurs when it is not clear which alternative to pursue how quickly the technology is needed, or when there is a need to co-ordinate the development of multiple technologies.

Technology roadmapping is an important tool for collaborative technology planning and co-ordination. It is a specific technique for technology planning, which fits within a more general set of planning activities. As a result of technology roadmapping, better investment decisions can be made because there is better information to:

- Identify critical product needs that will drive technology selection and development decisions.
- Determine the technology alternatives that can satisfy critical product needs.
- Select the appropriate technology alternatives.
- Generate and implement a plan to develop and deploy appropriate technology alternatives.

Technology roadmapping is driven by a need, not a solution. The development process of a technology roadmap includes: (1) identification of the "product" that will be the focus of the roadmap; (2) identification of the critical system requirements and their targets; (3) specification of the major technology areas; (4) specification of the technology drivers and their targets; (5) identification of technology alternatives and their time lines; (6) recommendations about the technology alternatives that should be pursued; (7) creation of a technology roadmap report.

7.2 Plan interconnections between R&D policy and other policies

We refer for this to what has been said in section 4.3. It is important that this will be done in the course of 2002, now that strategy building is taking place within Enterprise Estonia. A link between Innovation and Technology policy and Investment policy should come up with ideas how to use R&D-institutes, Competence Centres and Science Parks as “incentives” for R&D-intensive foreign direct investments and should vice-versa come up with (international) standards for the R&D-assets of Estonia and ideas to use Foreign Direct Investments (FDI) to improve these standards.

Attention should also be paid to linking FDI with indigenous industry. A pre-requisite for this, however, is the need to be support quality improvement (i.e. ISO Certification) of Estonian sub-contractors and suppliers. This can be integrated into the SME support scheme described in the next paragraph.

There must also be linkages between SME schemes and R&D programmes. In Finland there are good examples of linking SME related "Technology Clinics" with Technology Road Mapping and with Competence Centre projects. The detailing of the Single Programming Document into concrete measures should be used to:

- Strengthen the further development of high quality industrial parks (including science parks).
- Provide support for cluster/network initiatives aimed at Technology Development (i.e. interesting Areas of Competence, Technology Clinics).
- Co-fund schemes aimed at supporting the development of the Minimum capability companies (see next section).
- Wherever possible, give an extra impulse to the budget proposed for R&D development in Knowledge Based Estonia.

7.3 Set up schemes aimed at Minimum capability companies and cluster initiatives

For Estonia there is a lot to gain by setting up a support scheme for firms with at least some engineering capabilities, who are able to absorp "package solutions". A very good example of such a programme is BUNT (see box). Size is in this respect an advantage for Estonia: with 6 high quality advisers (3 for Tallinn and the North-East, 2 for Tartu and the South-East and 1 for the rest of the country) all or most of the target group can be covered. This should be done under the flag of Enterprise Estonia, whether linked to ESTAG or the Regional Development Agency. One way or another, these advisers should also act as "eyes and ears" for ESTAG and the Regional Development Agency (and other Agencies), in order to provide the Agencies with continuing information about the needs of the demand side. Ideally, professionals of the RDA and ESTAG should take part in the "running around". The advisers should also be able to link with the Estonian business organisations, for targeted information supply and easier access to potential clients.

This individual approach can be supplemented by more focussed group work, like the Finnish Technology Clinics and the Belgian/Dutch PLATO-groups, in which SMEs work together on strategic business and innovation development. These groups can provide possible links between R&D programmes and the SME programmes.

International good practice: the Business Development Using New Technologies (BUNT) History and general characteristics

BUNT was developed in the late 80ies in Norway to overcome two deficiencies in the Norwegian innovation system. (i) Norwegian companies were facing shortcomings in the employment of new technologies and in innovation. (ii) At the same time they could not rely on an adequate supply of consultants in general and of consultants specialised in the respective fields. Consequently, a programme was developed to address both deficiencies, to bridge the gap in the supply of consultants and to promote the diffusion of new technologies. At the times, when the BUNT scheme was designed and implemented, the prevailing approach to innovation support was to a large extent driven by methods and analytical approaches addressing specific aspects of new technologies. The BUNT approach, however, took advantage both from the power of the individual analytical techniques and, and the same time, from comprehensive and pragmatic approaches.

BUNT as a training scheme

As indicated above, the BUNT scheme addressed both the underemployment of new technologies in the Norwegian industry and the deficiency in the provision of specialised consultants. The BUNT scheme consisted of two separate steps. The first step was the training of consultants in a two weeks course. The respective training course comprised three elements: (i) analytical tools, (ii) case studies, and (iii) process guidance in order to use the analytical tools in an organised and oriented way.

Consultants, who participated in these training courses, were labeled as (certified) BUNT-consultants. While the development of the training material was fully financed by the Norwegian Government, participation in the training course had to be covered by the individual consultants. Certified BUNT-consultants had the privilege to act as consultants in the subsequent BUNT consultancy programme, which can be seen as a temporary monopoly. In this regard there was a rather intelligent mix of incentives: The expectation of accessing an exclusive market for those, who previously invested in training from their private pocket.

In practical terms, training, say 100 consultants, can be organised within 6–12 months. As the Austrian experience shows, the BUNT-training programme attracted not only consultants, but also managers from companies, in some cases even government officials. Since the BUNT scheme is conceptually open, the BUNT training infrastructure can be renewed whenever new opportunities emerge.

BUNT as a consultancy approach

The striking feature of the BUNT programme, however, is its methodological approach to assist companies in their attempts to develop and implement new technologies. The starting point for the methodological approach, eventually chosen, is the fact, that most of the analytical / methodological approaches for helping firms to benefit from new technologies are rather specific, covering only some aspects in the complex process of innovation and technology implementation. The BUNT methodology starts from an overall and comprehensive approach of the whole company. It then runs a two-step process, (i) asking for the **issues** to be addressed further, and (ii) the **options** which have to be discussed in order to meet the respective issues. The overall question in any step is always the same: Can new technologies contribute to the performance of the firm[26]?

Since there are always too many issues and, likewise, too many options, methods have to be put in place in order to reduce the number of issues / options to a workable set of urgent and / or important issues / options. Again, methods for creating issues and / or options are called for, in order to achieve a rational process. The principal logic of the BUNT process is completed with this two-step process: Each option, the output from one step, can be considered as an issue, thus an input into a next cycle. Practical experience shows that a rather small number of two-step cycles can complete a consulting cycle. While the first steps are rather diagnostic, the latter are creative and solution-oriented.

In practical terms, a team of two consultants, one with engineering competencies, the other with managerial skills, are perfectly equipped to meet the problems. One week of intensive work with competent members of the companies' management team typically provide a number of solutions,ready for implementation. A rate of public funding of 75% for external costs (i.e. external consultants)has been proven as adequate. If the scheme is successful – after a pilot phase – the level of funding can be lowered to 50%. Internal costs (i.e. management team) are not eligible.

BUNT has been a rather attractive programme from several reasons. The most important ones are its openness for further methodological developments and at its dual target groups, not only companies, but also consultants. Its attractiveness has been demonstrated in several regards: It has been the back bone for the so-called EURO-BUNT, which was developed further by the European Commission, and it has been adopted by a number of other countries: Austria, Spain, Portugal, Poland.

7.4 Try to make as much "package deals" as possible (i.e. ESTAG/KREDEX)

Much may be gained in Estonia by combining resources and services. This does not only hold true for the Universities and the business community, but also for the government agencies inside and outside Enterprise Estonia. One of the points for attention is the general low level of profitability of most Estonian SMEs. This asks for better possibilities to finance technology development from external sources. A suggestion here is to combine ESTAG and KREDEX financial services to provide guarantees for "mid-tech" technological developments in Minimum capability companies.

For more "advanced" investments Venture Capital is an important issue. Currently, the financial markets within Estonia are characterised by a limited amount of available venture capital. This is especially the case for early stage investments, which are characterised by high levels of risks. Several people we interviewed also pointed out the need for a government supported Venture Capital Fund that could provide higher risk seed money, which will not be provided by the private sector.

[26] *The same logic can be employed to ask another question, e.g. the role of education and training or competence building.*

7.5 Set up an research infrastructure renewal programme

Many university infrastructures – regarding both buildings and laboratories – need renewal. A Competence Centre programme funds R&D activities and therefore is not suited purely as an allocation mechanism for pure infrastructural needs. Of course a number of project-related infrastructure costs can be covered by the CC programme (laboratory apparatus, adaptations etc.).

The Ministry of Education should in co-ordination with the Ministry of Economic Affairs prepare a financing scheme for university infrastructures. This should be based on a priority list. Such priority setting must be based on needs and actual / future research projects, both in basic science and applied research. The existence of a Competence Centre, a Centre of Excellence, of considerable private R&D inflows (like R&D contracts) can be a strong indicator for investment.

8 Proposed time-frame

April – August 2002	Detail out rules, principles and set up for the CC programme
April/May 2002	Ensure links with Single Programming Document measures
Summer 2002	First mid-term evaluation of SPINNO
June - September 2002	Communicate rules and principles for umbrella structures to Universities: how shall these structures foster and serve Competence Centres; principles for interaction and financing[27]
September 2002	Call for proposals + trainings + proposal days
December 2002 – February 2003	Review of applications (with experts/peers/maybe jury's)
December 2002	Combine reviews with second mid-term evaluation for SPINNO
During 2002	Ensure links between policy areas and between services of public agencies
Second half of 2002	Preparations for Foresighting / Technology Road Mapping
First half of 2003	Start first round of Competence Centres
First half of 2003	Platform for Foresighting / Technology Road Mapping established
During 2002/2003	Make a start with the SME schemes: pilots, selection of advisors, connections
2004	Start Structural Funds measures
2004	Second round of Competence Centres

[27] *As we say that the support structures themselves are not Competence Centres, it is nevertheless very important to have a clear division of roles between the centres and those structures. A number of deliverables from these support structures to the Centres have to be defined. Also the way of financing has to be defined: As a first indication we would recommend that ESTAG should fund the Centres directly and not via any university or university support structures. In turn the Centres pay for some of the deliverables and services, others can be defined as in kind contributions from the university.*

9 Summary of proposed measures

Elements of Innovation System	*Topic*	*Challenges and bottlenecks*	*Policy Goals*	*Policy measures*	*Policy actors*
Business Sector	Competitiveness industry	Advantage of low costs will decrease	Upgrade organisation, quality management and knowledge management of firms	BUNT-type services (look Ch.7.3)	MoEA, ESTAG, ERDA
		Increase exports			MoEA, Export Agency
		Attract "greenfield" high value FDI			MoEA, ESTAG, Investment Agency
		Innovativeness of firms is too low: Enable firms to climb the Competence Staircase	Low tech SMEs	No action	
			Minimum Capability Firms	- Awareness raising - BUNT-type services - Financial instruments	MoEA, ESTAG, ERDA, KREDEX
			Technological Competents	- Clusters/networking - SPINNO - CC programme - Financial istruments	MoEA, ESTAG, KREDEX
			Research performers	- CC programme - SPINNO - Science Parks - Financial istruments	MoEA, ESTAG, KREDEX
Universities as research performers	Business support infrastructure	This infrastructure is inadequate or immature	Build adequate support mechanisms	SPINNO	ESTAG, MoEA
	Science-industry co-operation	Co-operation is informal and underdeveloped	Support co-operation (well designed frameworks)	SPINNO and CC Programme are crucial	MoEA, ESTAG
	Critical mass	Some Departments do not meet critical mass	Create critical mass and create networks	CC programme and SPINNO can contribute	MoEA, ESTAG, co-ordinate with MoEduc.
	Equipment	Need to update equipment	Link investments with Research Programmes	- CC Programme can contribute - Infrastructures programme	MoEduc., coordinate with MoEA and ESTAG
	Networks	Little interaction with outside world in some departments	Implement Research Management	CC programme can contribute	MoEduc., coordinate with MoEA and ESTAG
Research Institutes	Research Areas	Mismatch with specialisations within Estonian industry	Link Research Planning with Industry	- CC programme can contribute (also by means of Technology Road Mapping) - SPINNO can contribute	MoEA, ESTAG, co-ordinate with MoEduc.
	Market orientation	Limited marketing capabilities			
Higher Education	PhDs	Rigid PhD regime	Create opportunities for more well paid PhD posts	CC programme can contribute	MoEduc., co-ordinate with MoEA and ESTAG
	Trained engineers	Lack of trained engineers and attractiveness engineering curricula			
Government	Institutional and legal frameworks	Legal provisions are adequate	No action		
		R&D Council is well composed, performance has yet to be proven	No action		
		Agencies (ESTAG, KREDEX) are well designed	No action		
	Capacity	Capacity of Agencies is very limited	Increase Capacity		
	Processes	Little accumulation within agencies and ministries of "field knowledge"	Take care of knowledge management and corporate memory		
		Need for a strong proactive approach by government	Key players from industry, government and science must meet on a regular basis	Technology Road Mapping	MoEA, EAS, MoEduc.
Networks	Linkages	Policies and agencies must be linked together more strongly	More concerted planning and concerted actions	Use national planning as a tool and SPD	Ministries, EAS

Appendix 1 | Thumb rules for Estonian Competence Centres

- **Size:** think of 10 researchers or more, because of the general need for „critical masses", but they can be nevertheless smaller than in bigger countries with a full-grown industrial R&D structure. There should be a number of PhD students and wherever possible a number of people from industry and different scientific partners working either as „in kind contributions" or on paid contract basis. In our interviews we found a number of research groups big enough to be the starting point for such Centres. Add a director, a secretary and perhaps one or two supporting people, the latter depending on the existence of organised university innovation support (e.g. possible need of Intellectual Property Rights management) and on the technological field the CC is in (e.g. laboratory needing a technician). If Competence Centres are smaller they are not visible. If they are much bigger, there is no thematic focus anymore, given the potential of the Estonian R&D system. In budgets – see also below – this means (including some infrastructure investments) an annual budget of about 6–10 million EEK per Centre.
- **Duration:** this must be 5 years or more; 5 years being the absolute minimum. About 7 years is existing best practice in most countries: Still, there is a clear end date. The time-span is long enough to develop a strategic view and realise a work programme based on it. In about 7 years two generations of PhDs with industrial co-operation experience can be educated. A considerable number of projects can be realised in such a time-span and the Centre can build up strong international links. Of course, the R&D projects performed in the Centre have a shorter horizon; most of them will have a 1–3 year horizon, depending on the technological field and industry needs. All Competence Centre programmes have mid-term Centre evaluations and hand out binding funding contracts not for the full 7 (in the Swedish case even 10) years' time-span, but they normally grant the first 2–4 years.
- **Link Competence Centres to university departments:** However the legal form and the financial organisation of a Centre are solved, they should not be totally separated from university departments. In all countries where Competence Centres are running the link to the „home" scientific groups is a strong one.
- **R&D projects as core of a Centres' portfolio:** In all Competence Centres programmes it is about performing research and development. Most CC programmes have a focus on pre-competitive, nevertheless applied research. The portfolio for Estonian Centres of course has to meet the demand of the industrial partners – and most of those partners will be Estonian. It is important in the first place that the R&D performed is real R&D: useful, but at the same time a little more far reaching than what the firms do as internal R&D. Besides, such a set of „single-firm" and „multi-firm" projects (i.e. either one or more firms taking part in a project within the Centre structure) other activities are possible and often necessary. Such activities can encompass basic research projects, technology transfer activities, testing services and – very important in the Estonian context – Human Resource Development, ranging from training courses to PhD programmes. Note that the core activity of a Competence Centre is a collaboratively planned co-operative research programme, which in itself is formed by a number of interrelated R&D projects. A Centre without project orientation is not result-oriented and misses the point.
- **Clear thematic R&D focus:** A Competence Centre must have a clear thematic focus. The focus can be technology-centred (e.g. a Centre for Broadband IT solutions) or problem-centred (e.g. a Centre for Clinical Healthcare). Interdisciplinary is a very good thing and shall be fostered, as long as it is a useful one and is justified by the thematic focus. The R&D focus should enhance (international) visibility and also the quality of the Centre. The funding of „we solve all kind of problems" centres would be a bad idea. In our Estonia assignment we found a considerable number of research groups focussed enough to build cores of Centres.
- **A physical Centre or network-like centres?** Both models exist and it depends on the goals of the programmes which way to go. In Australia the CRC Centres are rather network-like, some including 5-6 academic partners thousands of kilometres away from each other. In Sweden and Austria the Competence Centres are generally real centres with one physical core where most of the researchers stay most of the time. This does not mean that a Competence Centre programme must fund the building of houses. Office and lab space is normally not the scarcest resource. Another Austrian programme, the Networks of Competence (K-net) try to link together groups from all the country in rather loose networks. Given the fact that most of the research in Estonia takes place on two sites (TU and TTU) this question is not seen as a very important one. Note: If a meaningful TU-TTU co-operation comes forward, this is rather an argument to fund them than not to do it. On the other hand funding organisations should generally abstain to force partners to co-operate against their explicit will. This only leads to „Beutegemeinschaften" (hunting groups for funding) and if the managers of the funding programme turn their back to them they instantly fall apart and into their old habits.
- **Co-financing as funding principle:** Competence Centres are always financed in a public – private partnership and always include some contribution from the scientific home institutions and often also from regional governments. The financing models are different, see table.

Country, % of CC budget	*Australia*	*Austria*	*Sweden*
Funding agency	20-30	Max. 35	33
Regional actors	10-25	Max. 20	
Scientific Institutions	15-30	Min. 5	33
Industry	25-40	Min. 40	Min. 33

The financing structure should always take into account the possibilities of the actors to contribute and also the goals of the programme. The scientific actors and in many programmes also industry can bring in parts of their share as „in kind contributions", i.e. rooms, machinery hours, materials and people. Of course it must be evaluated ex ante whether such contributions are useful for the R&D work of the Centre. For Estonia we propose (as a very preliminary idea!) based on our international experiences and the interviews made) the following share: Industry partners should contribute about 20-25% of a Competence Centre R&D budget and pay nearly market costs for testing and other day to day business. The contributions for the R&D budgets can come partly (in Austria e.g. up to 50% of industrial share) in form of in kind contributions. The rest should be in cash and if industry is not ready to pay something meaningful it is better to run other programmes than a Competence Centre funding initiative. Scientific partners should contribute about 15% of the budgets, mostly in In-kind contributions. This leaves about 60% of the budgets to be funded by the agency running the Competence Centre programme. As this is much money, European sources should be tapped, namely the Structural Funds.

- **There should not be too many centres:** Countries bigger than Estonia have of course a considerable number of such centres: Sweden 28, Australia > 60, Austria 18, etc. All these countries have other similar programmes running. For Estonia it is much better to have a small number to start (in Austria the K plus programme started with 5 centres). These centres, selected in a strict procedure with quality criteria and international experts, shall get considerable funding over a number of years. In our proposal government would have to fund 60% of annual centre budgets, each having 8 million EEK. This means that 5 Centres would „cost" the government 20–25 million EEK annually.

Typology of Competence Centres: Some remarks

Nearly all countries running Competence Centre programmes have chosen a number of common characteristics: Implementing open calls for proposals, applying strict selection criteria and a selection procedure including foreign expertise, considerable size of centre and funding involved, industry co-financing, project and programme orientation, a management approach, a thematic focus and last but not least a long term perspective. A commonly defined programme structure is the core of a Competence Centre. Typically, each project has a project leader and a number of researchers working full- or part-time on such projects. The project leader reports regularly to the Centre director who in turn informs the governing board about progress and results. A typical project should run for 1–3 years and have a minimum of 2 people involved in the research work.

While most of the Competence Centre programmes mentioned in this report are science – industry co-operations where the two sides meet as "equal" partners, there are also funding initiatives like the Austrian K-ind Industrial Competence Centre programme, where inner-industrial competencies are strengthened with public money. Such industry consortia like clusters can use part of the funding for (looser) co-operations with universities.

The term Competence Centre is of course widely used. Within big Multinationals (MNE) we also find Competence Centres. In this context the term means a specialised plant, where one or some specific and high-value products / parts are produced for a whole continent, sometimes for the global needs of the MNE. This is not a Competence Centre in our context, neither is a normal university department or research institute without the characteristics explained in this report. Also supporting structures within universities are not within the definition of a Competence Centre.

Appendix 2 | Issues raised in the Workshops on 28 February in Tallinn

Incentives for young people: to study, to be a Post Doc, to come back to Estonia

- One of the biggest problems of Estonia is the R&D age curve. Competence Centres can help to make Natural and Technical Sciences more attractive for students. They can pay decent wages for researchers, offer good jobs with an industrial perspective and Competence Centres can be marketed as cornerstones for future development. Especially PhD students and Post Docs should find a favourable surrounding in a Centre.
- The general age curve problem will not be solved by a CC programme. Here broader measures must be considered to make Natural and Technical Sciences a good career opportunity. If firms do more R&D (e.g. because of co-operation with Competence Centres), there will also be more perspectives.

Incentives for university researchers to work in a Competence Centre

- Incentives are needed for those researchers who will stay in university departments but shall co-operate with the Centre. Some first ideas and arguments include: No (total) separation (also of laboratories) between Centres and departments. Common public relations. Possibility of part-time contracts and other possibilities „to stay on two legs". Think also of a bright future for students of researchers and international visibility. The Intellectual Property Rights structure is also relevant in this case: provide extra financial rewards. And one of the main pre-requisites is: University Management must support this and there must be a provision of support on contract matters, etc., so that researchers are able to concentrate on their research work.

Infrastructure

- Some Competence Centre programmes fund only personnel costs, others like the Austrian programme also funds some infrastructure.
- Infrastructure includes two possible definitions: The one including buildings, the other „only" laboratory equipment, office furniture, computers, some machinery, office/lab rent and the like. While nothing speaks against funding such infrastructure costs up to a certain percentage of the overall CC budgets, we don't recommend to fund buildings. No CC programme known to us does this and there are other possible solutions. One Estonian example is Tartu Biocentre. It is better to view the CC ideas and university wishes for new buildings separately.

Relation between programme level and project level

- Within a CC a number of projects form the core of the CCs work programme. These projects are about (applied) research and development. They have to be interlinked, i.e. parts of the overall work programme designed in the proposal. Of course if the world changes, namely if strategy of participating industrial partners is altered, the projects can and should be adapted or even changed. This change process has to be done in an orderly and well-documented way by the board.
- Each project has a project leader and a number of researchers working full- or part-time on such projects. He / she reports regularly to the CC director who in tun informs the governing board about progress and results. A typical project should run for 1–3 years and have a minimum of 2 people involved in the research work. So projects are „the core of a CC."

How to combine top down and bottom up approaches when selecting CCs; the role of international peer

- Most CC programmes are thematically open (Sweden, Austria, Australia ...). This means that there are no top down thematic preselections. All consortia of applicants have to fulfil a number of minimum criteria (size, duration, thematic focus, partner structure etc.). They write a proposal following guidelines. These proposals are evaluated by economic and scientific peers. The majority of the peers shall come from abroad, and the smaller a country the more important this issue becomes. Those peers give ratings. Due to such ratings there will be excellent, good, fair and bad proposals. The final ranking can be made by he funding organisation with help of some high level neutral experts.
- Preselecting can lead to laziness and disobey of rules. All 18 Austrian K plus CCs are within the six thematic priority areas of the Austrian Research Council; the latter being defined in 2001 when the K plus programme was running for some years.

Legal issues of CCs

- General legal provisions: Generally universities have a very liberal legal framework, allowing them to create and hold companies and to allocate their funding. One Estonian constraint is the strict PhD planning regime of Ministry of Education. Here the ministry grants only a small number of PhD posts combined with a humble salary-like payment. The allocation of PhD posts is based on past PhD output of different scientific disciplines. Other potential PhD's have to pay for the right to study. If CCs are to be created, you should make sure that CCs can offer PhD posts on attractive terms for young researchers: There should be enough such posts and there should be a salary for PhDs allowing them to make a living.

Appendix 3 | The Austrian K plus Competence Centre Programme[28]

National Innovation System of Austria[29]

- **R&DI spending:** According to the latest estimate by Statistik Austria, in 2001, altogether 3.92 billion € will be spent on research and experimental development (R&D; in our context R&DI) in Austria. About 40% of these expenditures are funded by governmental institutions (federal government, provinces, other public institutions: 40,3%) and also by the "domestic" commercial economy (40,1%). 19,3% are funded by foreign entities, which are mostly commercial as well. 0.8% come from other sources. In comparison to 2000, the total of Austrian research expenditures increases by around 6.4% thus reaching 1.83% of GDP. That means also: Public R&DI Spending is 0.72% of GDP. Within the public funding, the ratio Federal: Regional is about 5,5:1. The overall ratio Private: Public is about 3:2.
- **Unusually great role of foreign firms:** After a review of the official R&DI statistics, Austria has by far the highest share of foreign-financed R&DI in the OECD area. Since the records on the sources of R&DI financing have changed since the last R&DI survey in 1993, there is no directly comparable value that allows for an unequivocal interpretation. According to Statistik Austria it primarily concerns financing of R&DI activities executed domestically by foreign (owned) businesses. While the returns from EU R&D programmes went up in the second half of the 90's, they only make a small contribution to the absolute level of this value.
- **Relative position:** All in all, Austria was able to catch up to the EU average in its own catching-up process (1998 Austria: 1.81%; EU: 1.81%). In comparison to the average of the OECD states (1998: 2.18%) Austria is still clearly behind. This is particularly due to the weighting of the USA and Japan within the OECD. In its declaration of 11 July 2000, the Austrian Federal Government affirmed its goal to increase the R&DI quota to 2.5% of GDP by the year 2005.
- **Human resources:** The total results of the 1998 survey by Statistik Austria on the R&DI personnel corresponded to 31.308 full-time equivalents for R&DI. Out of these, 27.7% were active in the higher education sector (1993: 29.2%), 6.7% in the government (1993: 8.6%), 0.5% in the private non-profit sector (1993: 0.4%), 6.0% in the co-operative area and in the area of civil engineers (1993: 5.5%) as well as 59.2% in the area of company-internal research (1993: 56.3%). In total, 65.1% of R&DI employees work in the business sector (1993: 61.8%).

More details regarding the Austrian R&DI policy can be found on Cordis Homepage:
http://trendchart.cordis.lu/Reports/Documents/Austria_CR_Dec2000.pdf.pdf

Research Funding Structure

- **Federal Ministry for Education, Science and Culture (BMBWK)** is responsible for universities and basic science. This includes besides the university sector the Austrian Academy of Sciences (OeAW) with it's research institutes, the College sector ("Fachhochschulen") and a number of other scientific institutions. BMBWK is also responsible for international scientific co-operation, namely Austrian participation in the EU Framework Programmes. See: www.bmbwk.gv.at
- **Federal Ministry for Transport, Innovation and Technology (BMVIT)** is responsible for applied research, research centres and technology funding. The most important applied research centres like ARCS (Seibersdorf) are linked to this ministry; and notably the bigger R&D funding organisations like FWF, FFF or TIG. See: www.bmvit.gv.at
- **Federal Ministry for Economy and Labour (BMWA)** is responsible for aspects of technology transfer, which includes programme funding and institutional arrangements. See: www.bmwa.gv.at
- **Other federal ministries** are active in R&DI funding in their sectoral fields, like the Federal Ministry for Agriculture, Forestry and Environment.
- **FWF (Austrian Science Fund)**, since 1967, is responsible for basic research funding in all scientific fields. It is comparable to other national research councils like DFG in Germany. FWF funds persons via personal grants, projects via project grants and larger scientific co-operation programmes. FWF acts autonomously. See: www.fwf.ac.at
- **FFF (Industrial Research Promotion Fund)**, since 1967, is responsible for single firm applied R&D funding. FFF is the most important source for innovation funding in Austria. Firms (small and large) can apply for project grants on a yearly basis. FWF acts autonomously. FFF is also responsible for running the Innovation and Technology Fund (ITF), an instrument for top down thematic programmes.
See: www.fff.co.at
- **ERP-Fund**, since 1962, is responsible for industrial innovation investments; also acting autonomously. See: www.erp-fonds.gv.at

28 Author: Michael Stampfer, TIG, original text written for EU project MAP.
29 Austrian Science and Technology Report 2001.

- **Innovationsagentur** is responsible for technology transfer and IPR matters. They run programmes to assist New Technology Based Firms and coordinate also funding initiatives in the field of biotechnology. See: www.innovationsagentur.at
- **Technologie Impulse Gesellschaft**; TIG responsible for K plus; www.tig.or.at TIG runs a number of co-operation programmes and can be seen as the Austrian equivalent of ESTAG.
- **Other agencies** cover specific fields; e.g. Austrian Patent Office.
- **On the 'Länder'** (federal provinces) level, there is a rich array of agencies and funding institutions; most of them went operative in the second half of the nineties.

Specific features of NIS

- No big industrial champions; no multinational enterprise headquarters; few R&DI intensive industrial players; as mentioned most of the bigger enterprises in high tech sectors belong to foreign Multinationals.
- Incremental and process innovations, many innovations in traditional sectors[30] like steel, machinery construction etc., Phenomenon of niche champions; "70% world market share in a field you never heard of".
- Dominance of SMEs, many of them highly innovative - see CIS; some of the fastest growing European SME in Austria.
- Highly skilled workforce based on excellent secondary schools (like "HTL") – but relatively low ratio of people with academic degrees.
- Low/middle position in many rankings and international benchmark studies: balance of patents, balance of High Tech imports / exports, number of researchers per 1000 inhabitants etc.
- Rather small structured academic research structures, broad field of disciplines covered; relative position in the academic world (reviewed papers, citations, patents) rising – but from a rather low level.
- Evolving co-operation culture: More inter-academic co-operations, but also more structured co-operation patterns between science and industry.
- Big structural reforms under way: creation of critical masses; university reform towards more autonomous (and also more responsible) universities; 2005: 2.5% R&DI / GDP ratio as a very ambitious target.
- Austrian paradox: Why are we (that) rich?

Overview on K plus Programme

- Geographical coverage: national.
- Information Source/Reference: www.tig.or.at, www.kplus.at.
- Mission: foster long term, strategic co-operation between science and industry.
- Target group: excellent research groups and innovative firms (large and SME).
- Implementing agency: TIG.

Description of the K plus

- **Start date:** 1998, the programme was developed in the second half of 1997.
- **Expected date of completion:** no defined end of programme; but funding of an individual centre is limited to seven years.
- **Previous measure:** none
- **Reasons for launching** / modifying the new measure:
  - low level of existing science - industry co-operation in Austria,
  - increase of short term R&D planning in industry,
  - lack of critical masses,
  - low international visibility of many R&DI efforts.
- **Roles in programme management** on the policy/programme/project level:
  - In K plus clear division of labour between BMVIT and TIG, the latter responsible for all operative tasks incl. funding; BMVIT responsible for strategic issues.
  - Centres have managements; subsidiarity principle: all that can be managed on centre level, has to be managed on this level.
  - Clear reporting and evaluation structures, planned and agreed before the start of the programme/centres.

[30] *Particularly research-intensive branches are seen at the branch level: broadcasting, TV and communications technology, other vehicle manufacturing, automobiles, business machines, computers and chemistry (including the pharmaceutical industry). The low share of some of these branches – in comparison to the OECD – is a reason for the arrears of Austria's overall economic R&DI quota as compared to the OECD average. In recent years, little has changed in regard to these findings. While some of the research-intensive branches show growth rates higher than the overall economy and thereby averaged gains, these increases are however too small to substantially raise the overall economic research quota.*

- **What is the predominant role of the government?** Strategic planning, provision of overall funds, programme evaluation.

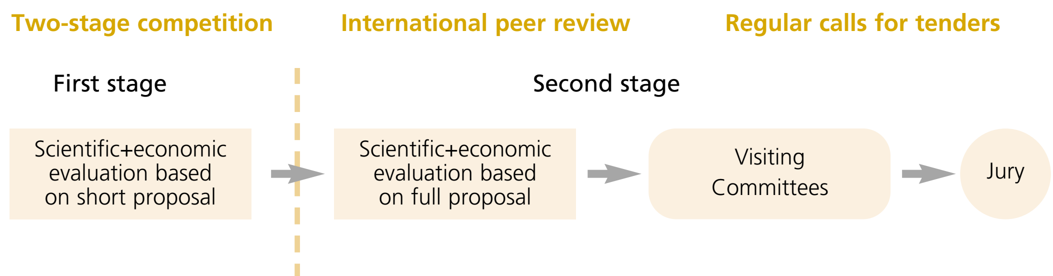
'Catchphrase': K plus funds co-operative competence centres for science – industry collaboration. Within the centres the work is organised in form of R&DI projects, including strategic (basic) research applied multi-firm and single-firm projects. This is accompanied by a number of horizontal measures like Human Resource development. Kplus centres run for seven years.

Preparation of K plus

- **Who was involved in the development of this programme?** K plus was developed within BMVIT (when the later K plus programme management unit was still within the ministry). This group worked for four months preparing the programme and included programme manager and innovation policy experts. They were accompanied by a ministry steering group and industrial + scientific sounding boards. A policy paper was issued end 1997, followed by a short but intensive discussion process.
- **Size of a centre:** 2.5 to 4 million € annual budget. About 40–50 people are working as employees or contract partners in and with the centre.
- **Goals of the programme:** The goals of the programme are of a rather qualitative nature, due to measurement and attribution problems on the programme level.
  - Improve long-term co-operation between science and industry.
  - Stimulate pre-competitive research and multi-firm co-operations.
  - Improve transfer of know-how.
  - Focus and create critical masses.
  - Use public funding to trigger additional private expenditures.
  - Define new areas of research through bottom-up approaches.
  - Ensure internationally competitive quality of K plus centres through a strict selection process and periodic evaluation.
  - Create examples of best practice in research management.
- **Target groups of the programme**
  - University-based and other research groups; Industry (large and SME); no thematic pre-selections. The programme is therefore open also to groups from the sector of contract research. Prerequisites are: minimum of five participating firms, co-operation of good research groups. A typical K plus Centre builds on a network of 5–7 academic research groups.
- **Responsibilities of TIG**
  - Organisation of calls and ex ante - evaluation; contract negotiations; funding of centres; coaching and best practice approaches; reporting and monitoring; organisation of interim and ex post – evaluations
- **Interface between programme and evaluation considered in the design phase?**
  - Yes; goals and core criteria defined in advance.
  - Link between centre evaluation and programme evaluation established.
  - Efforts to show additionalities of programme and centres.

Selection Procedure and ex ante - Proposal Evaluation:

- **Role of TIG:** organises and funds selection procedures, issues calls and relevant information.
- **Call for proposals/Competitive approach:** Regular open calls. There was a limited pilot scheme 1998; where five of six applicants were granted. An open call 1998/99 led to seven more centres out of 19 applicants. The open call 2001 led to 6 new centres out of 16 applicants. Step by step principle proved to be very successful.
- **Procedures:** Two stages (short and full proposal), both covering economic-organisational and scientific-technological aspects.

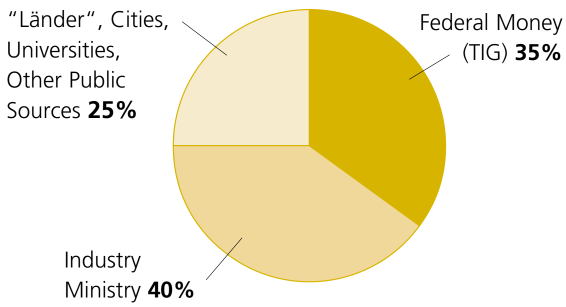


- **Evaluation criteria for proposals**
  - scientific criteria: track record, excellence, coherence, good and ambitious plan; strategic and perspective (about 30 detailed questions).
  - economic: usefulness, impact on firms, macro criteria, management and financial aspects (about 20 detailed questions).
- **Anonymous/Non-anonymous evaluation:** Both; written scientific reviews anonymous; some reviewers form visiting committee and show up. Economic reviewers non-anonymous. Reviewers get a fee.
- **Criteria for selection of evaluation experts:** Six foreign peers are individually chosen per proposal (three for short proposal, three more for full proposal); two Austrian (ERP fund) economic peers. The foreign peers have to fulfil the following criteria: neutrality, scientific excellence in the field covered by the proposal, good knowledge and expertise in science – industry co-operation. Some of the scientific reviewers come from industry laboratories or are academics with a strong industrial background. FWF selects scientific peers; good mix is very important. Dominance of male reviewers.

Contract Negotiations and Funding Principles

- **Funding:** 35% federal funding comes via TIG in cash; up to 20% other public comes mostly in cash and is provided mainly by the regional governments, minimum of 5% in kind by scientific partners; minimum of 40% industrial contribution (by at least five partners; at least half of contributions cash).

Funding Principles



Public funding incl. universities max. 60%

Private funding min. 40% (EU-requirements)

Cash or in-kind contributions

Government no shareholder

- How are **contract negotiations** carried out? All partners should be included in the planning procedures accompanying the formulation of the proposals. After granting a proposal, TIG negotiates the features of the centre with the winners. Centres shall follow some principles, but can also search for individual solution in a number of questions (internal organisation, research planning, IPR ...). There is a standard funding contract between TIG and the centres, but a centre-specific general agreement between all partners (incl. funding organisations). This agreement is the "constitution" of the centre and includes all general rules. On this base bilateral contracts and funding contracts are signed. It takes about 3–4 months to negotiate and sign these agreements.
- How do **consortia** have to look like? At least five firms; a number of research groups; coherence and centre character; shared visions. For examples see www.tig.or.at (‡ go to K plus Centres).
- What **organisational form** of a consortium? Centres start as loose consortium; then they have to form limited liability companies. Reason: state of university law makes it difficult to install such big centres within universities / departments; visibility; accountability. Therefore there is a responsible director, supervising boards and accountancy standards. Besides a "strategic" Board is to be established and unites all important partners.
- Who owns the **results of the work** (IPR)? Based on centre-specific agreements; fair share principles: Scientists shall publish; possibilities for firms and centre to file patents. Examples can be presented.

Monitoring of projects (project means centre)

- **Co-ordination of project monitoring and centre evaluation:** given; mainly the organisational and financial questions and "additional requirements". No direct link to programme evaluation.
- **Which criteria are used for the monitoring of projects?** Organisational and financial criteria; monitoring is identical with quarterly reporting system; additional "PR" annual reports.
- **Which measures are undertaken if a project doesn't work?** Milestone after fourth year (evaluation); number of contractual safeguards up to payback requirements.
- **Who is responsible for the monitoring?** TIG is responsible; internal controlling unit.

Centre evaluation (interim and ex post):

- Centres run for seven years; important mid-term evaluation in fourth year (stop or go); besides: two-year reviews in some cases and ex post centre evaluations.
- **Who carries it out?** External peers (comparable to ex ante scientific peers) and standing group of evaluation experts, commissioned by TIG.
- **How are they organised?** Analysis of reports and visiting committees along written guidelines and questionnaires.
- **Was the evaluation already considered when the programme started?** Principles and overall design was ready before programme started.
- **How much funds for project evaluation?** About 0.5–1% of programme funds for evaluation expertise over programme (incl. ex ante evaluation).

Programme evaluation (ex post)

- **Who carries it out?** External experts on behalf of BMVIT.
- **How are they organised?** Not decided yet.
- **How much funds for programme evaluation?** Not decided yet.
- **How are the results considered for programme redesign?** Not decided yet.

Horizontal Issues

- **Governance:** Strong governance of programme – and corresponding freedom of Centres, clear and transparent rules.
- **Influence of institutional setting on design, incentives:** Programme influenced e.g. by university regulatory framework. K plus is also a notified programme in the framework of EU state aid regulations (within R&D framework).
- **Legal, organisational settings on different levels:** Clear settings.
- **Transferability of core elements in different institutional settings:** Between centres yes, best practice evolving and managed by TIG. Other transfer mechanisms: best practise round table with other national funding organisations; internationally i.a. STRATA MAP.
- **Incentives for cross-border co-operation/opening up of programmes:** Given; 10% of participating enterprises not located in Austria; Incentives for Centres to co-operate internationally. 6th Framework Programme as challenge.
- **Leverage effects, Net macro economic effects:** Important; direct project results and indirect results in firms.
- **Regional effects intended?** Indirectly yes; strengthening of business locations and clusters.
- **SME "friendliness" of the selected MAP:** 1/3 of about 250 participating enterprises are SME.
- **Organisational learning:** Ongoing projects "SOL", best practice workshops, etc.

Appendix 4 | The Swedish VINNOVA Competence Centre Programme[31]

National Innovation System of Sweden

The Swedish National Innovation System, NIS, has a particular two-legs profile, dominated on the one hand by around ten large R&D-intensive multinational industrial groups (manufacturing of transport equipment, telecom products, machinery and pharmaceuticals) and on the other hand by public universities, while the public research institute system outside the higher education sector is very small compared to most other countries. Expenditures on R&D in Sweden have grown during the last decades largely as a result of increases in the business enterprise sector. In 1999 the R&DI spending was SEK 76 billion (c. € 7 billion) or 3,9% of GDP, which is the highest percentage among OECD countries. The business sector accounted for as much as c. 70% and the public sector for 25% of the expenditures.

Although the major part of R&D in Sweden is financed and carried out by the business sector also the public appropriations for R&D as % of GDP are among the highest in the OECD (c. 1% of GDP). The dominating performer of the public funded R&D is the higher education sector, which reflects a policy since long to link research with the educational functions of universities. This dominance of the higher education institutions is a very striking feature in the Swedish NIS. Public grants reach universities through a number of different channels. The dominating channel (c. 50%) is direct grants (general university funds) from the Ministry and Edu- cation and Science. Other channels are from the Swedish Research Council (for basic research), from councils for applied research, from sectorial agencies for mission-oriented research (industry, environment, energy, defence, space etc.) and from public and semi-private research foundations. One striking feature is the relatively modest public funding of R&D with the objective to stimulate economic and industrial development (via for instance VINNOVA) especially compared to the public spending on basic research and the basic grants allocated directly to the universities.

A rather new feature in the research financing system in Sweden is a number of semi-private foundations, which were set up by the liberal government in the mid-90ths with money from dissolved wage earners´ funds. The Foundations for Strategic Research (SSF), for Knowledge and Competence Development (KKS), and for Strategic Environmental Research (MISTRA) are the most important ones. Their creation brought a considerable increase in the R&D funding resources mainly for the HEIs. By now this increase has partly been neutralised due to cuts in the government allocations via for instance the sectoral agencies like NUTEK/VINNOVA.

A group of around 25 semi-public institutes for co-operative research of industrial relevance has been built up and developed since the 1940s in most cases after initiatives from industrial groups or branches. Even if they constitute a very small part of the Swedish NIS these industrial research institutes have a central role within many traditionally strong Swedish industrial sectors (i. e. pulp&paper, production engineering, food and biotechnology, materials technology). The institutes are important partners in many R&D-programmes run by VINNOVA. The system of institutes is currently being investigated.

An issue of some concern in the Swedish policy debate is the fact that although Sweden is a leading research nation and is investing more in research than almost all other countries, it has not been possible to show any significant benefits by the public investments in research for the growth of Swedish industry and economy. It could be argued that the innovation policy in Sweden is still more of a research policy in spite of the creation of a new agency for innovation systems, VINNOVA. The fact that it is the Minister of Education and Science, who is responsible for the overall co-ordination of the governmental R&D-efforts (at the same time as the HEIs under his hat are the only bodies that are allowed as performers of research) is an expression of this focus on research policy rather than on innovation policy for development and economic growth.

Concerning the relative importance of R&DI-programmes in relation to basic subventions and single project funding there is an obvious difference between measures for financing of basic research and of mission-oriented R&D. The Swedish Research Council per definition does not set aside special funding for programmes within stated research areas but applies a strict bottom-up process. On the contrary, VINNOVA like most of the other mission-oriented agencies as well as the research foundations allocate most of their R&D-support within programmes. The degree or strength of coherence within the programmes may differ substantially, in some cases probably the programme heading and a short description of the research area is the only guidance that brings the supported projects together.

[31] *Author: Staffan Hjorth, VINNOVA, original text written for EU project MAP.*

Overview of the Swedish Competence Centres Programme

The focus of the programme is clearly on co-operation science – industry. The dimensions of the programme. The total contributions from the partners are c. € 60 million/year. It is a long-term effort (10 years). Learning loops through step-by-step evaluations. The innovativeness in programme design and management.

- Geographical coverage: National
- Information Source/Reference: www.vinnova.se (see under Activities)
- Target groups:
  - Industry (large companies with R&D-capacities, research and technology based SMEs).
  - Universities (research groups incl. senior staff as well as graduate students; university managements).
  - Research institutes (to some extent).
  - Governmental authorities (to some extent).
- Implementing agency: The programme was initiated and implemented by the Swedish Board for Industrial and Technical Development, NUTEK. The responsibility to manage the programme was taken over by VINNOVA[32] in January 2001. The management of the programme includes co-operation with the Swedish Energy Agency, STEM, who is the governmental partner in five centres.
- Start date: **1995**.
- Expected date of completion: 2006 (is for the current 28 centres). VINNOVA is considering a new call for proposals during 2002 or 2003, probably with a at least slightly modified programme design.
- Previous measure: Interdisciplinary materials research consortia. This was a 10-years programme (1990-2000) containing 11 university-based research consortia for co-operation between research groups from one or several universities. The initiation and selection procedures (two-steps call for proposals) as well as the management of the programme (international peer reviews) gave very valuable experiences. The programme has been very successful in creating excellent and productive research environments.
- Reasons for launching/modifying the new measure:
  - Increasing demands from all parts of Swedish industry to interact with external sources of knowledge and technology, not least universities.
  - Interdisciplinary and industry relevant research within technical universities was sub-critical and fragmentary.
  - Weak incentives for researchers within the academic framework to collaborate with industrial companies.
  - Inspiration and models from National Science Foundation especially the Engineering Research Centres.
  - The basic idea that active involvement from industry in academic research is the best way to achieve efficient transfer of knowledge and technology.
- Roles in programme management in Sweden: Since long there is a policy in Sweden to have a clear share of responsibility between the ministries, which in an international comparison are fairly small, and the central governmental authorities, which often are (or at least have been) rather large. The authorities by this tradition have the full responsibility to develop and use the appropriate measures to implement the decisions taken by the government and the Parliament. The operations of the authorities are regulated by the government primarily through appropriation directions and ordinances and the annual budget allocations. It used to be stated that "minister governance" (direct day-to-day ordering rather than those just indicated) of an authority is not allowed in the Swedish system. Although these principles of decentralization have been gradually "eroded" during the last decade they were still valid when the Competence Centres Programme was initiated in the mid 1990ths. The programme was in all respects a true NUTEK-initiative (see below) and was presented to the government as part of NUTEK´s proposal and request for allocations for the period 1993–96. In its 1993 Research Bill the Government approved NUTEK´s proposal to carry through a broad process in order to initiate and select 30 centre proposals. The government allocated only a small amount of extra funding to NUTEK for this specific purpose. The major funding was raised by the NUTEK management within the ordinary budget by giving the programme top priority.
- What is the predominant role of the government? According to the policy described above its role is mainly policy-making and financing.

32 *VINNOVA is an "independent" governmental agency (see below under section 4 Roles in programme management) under the Ministry of Industry, Employment and Communication. VINNOVA is also reporting to the Minister of Education and Science, who is responsible for the overall co-ordination of the governmental research policy. The mission of VINNOVA is to promote sustainable growth by financing R&D and developing efficient innovation systems. Its main task is to to integrate research and development in technology, transport and working life.*

Overview of the Organisation and Implementation of the Swedish Competence Centres Programme

- About the definition of project level: As we see it there are two project levels in the CC Programme. Project level 1 = Competence Centre level; currently there are 28 centres (= projects). Each Competence Centre is running a research programme containing 5–15 projects (project level 2) often within a number of sub-programmes. As a matter of fact one of the main aims of the programme is to develop managerial skills and competencies within the universities to run this sort of interdisciplinary Centres and research programmes in co-operation with a group of industrial companies. A few of the Centres already from the start concentrated their programme in a limited number of bigger projects, which involve several companies and research groups. There is a clear tendency that by now most of the Centres, underpinned by strong recommendations from the international evaluations, have realized the advantages with this and concentrated their efforts in fewer and bigger projects in order to benefit from the broad range of expertise within the Centre.

Preparation of the Programme

- **Who was involved in the development of the CC Programme?** The governmental agency NUTEK (forerunner to VINNOVA) was in all respects responsible for the initiation and implementation of the programme. The concept was created in 1992 by a commissioned group of programme managers within NUTEK and was based on their experiences and competencies. Extensive interaction with external actors was an integral part of the preparations and launching of the programme, especially through NUTEK´s Industrial and Scientific Advisory Board and regular meetings with the group of presidents of the technical universities.
- **Goals of the programme:** The overall goal is to prove that the technical universities are able to become real resources for Swedish industry and thus to fulfil the tasks that in other countries are managed by public research laboratories/institutes ("the third mission"). The main operational goals in order to strengthen the very important link in the Swedish innovation system between academic research groups and industrial R&D are:
  - To create academic, multidisciplinary Centres of Excellence by actively involving a number of companies in joint research.
  - To promote the introduction and implementation of new technology and to strengthen the technical competence in Swedish industry.
- No quantitative goals for the programme have been formulated.
- **Responsibilities of NUTEK/VINNOVA:** As described above NUTEK had the overall responsibility to design the programme including the guidelines to the applicants/proposers. Of central importance was a new general centre agreement developed by NUTEK, which was used for all centres and signed by all participating partners. NUTEK did not stipulate in the guidelines about the organizational forms for the centres etc. This was a deliberate way to force the universities hosting the centres to realize their responsibility for this issue. Furthermore, NUTEK made it clear in the guidelines that it was the responsibility for the proposers to invite research groups and companies to be involved in the proposed centre. NUTEK did not participate or interfere in this process in order to be able to be credible as a neutral evaluator of the proposals.
- **Interface between programme and evaluation considered in the design phase?** Yes. Early in the design process it was decided to develop the programme and the centres by a step-by-step financing procedure with external ex-post evaluations at the end of each stage. This was clearly stated and agreed upon between the partners already in the agreements for the first start-up phase.

Selection Procedure and Ex-Ante Proposal Evaluation

- In its 1993 Research Bill the Government approved NUTEK´s request to carry through a broad process in order to initiate and select 30 centre proposals. For this selection NUTEK used a two-step procedure:
  - Call for proposals: April 1993.
  - 326 applications for planning grants: September 1993.
  - 61 planning grants allocated: November 1st 1993.
  - 117 final proposals submitted to NUTEK: February 1st 1994.
  - NUTEK´s decision (30 proposals selected): June 1994.
  - Approval and start of centres: During 1995.
- The call for proposals was addressed to universities incl. institutes of technology, and only research groups within academic institutions were allowed to submit proposals. But it was clearly stated from the very beginning that a main selection criterion would be that a number of industrial companies financially supported and actively participated in the centre activities. In the final proposals submitted to NUTEK written commitments from these companies had to be demonstrated.

- Already in the initial call for proposals NUTEK clearly stated that the number of centres could be 30 - at the very most. The response to NUTEK´s initial call for proposals was overwhelming. More than 300 proposals were received. About 60 of these were given planning grants for preparing final proposals. In the second step the competition was open also for other proposers than those 60 who had received a special planning grant. This resulted in almost 120 submitted final proposals. The final decision to select 30 of them was taken in June 1994.
- For the work on assessment of the proposals NUTEK appointed seven expert groups and a central policy group. Members of these groups were more than forty experts from industry, research councils and universities in Sweden and other Scandinavian countries.
- The following five criteria were set up for the selection process:
  - Effect of renewal in the Swedish R&D-system (interdisciplinary approach etc.).
  - Sufficient academic relevance/a firm scientific base.
  - Direct industrial relevance; participation of a number of companies.
  - A sustained (5-10 years) concentration of resources at one university.
  - Attractive partners for international collaboration.
- The individual proposals were reviewed non-anonymously and as strictly as possible on the basis of their merits in relation to the five criteria. No allocations of quotas regarding the number of centres between universities, technological areas or industrial sectors were allowed. Only the final decision was to a certain extent influenced by the ambition to involve various technologies and industrial sectors in the programme. Contract Negotiations and Funding Principles **Public and private project (= Centre) funding:** The funding of a Centre is regulated in a three-partner agreement between a number of companies, a university and VINNOVA or STEM. As a mean the three partners contribute to the research programme with one third each. The requirement of VINNOVA is that the contributions – cash and in kind – of the group of industrial partners should be at least as high as VINNOVA´s up to max. € 0.7 million/year.
- **How are contract negotiations on the project (= Centre) level carried out?** The performing partners in the Centre usually through its Board and Director are commissioned by VINNOVA to prepare a strategic plan and a research programme for the next stage as a basis for negotiations between the companies (existing and new ones), the university and VINNOVA or STEM. The negotiations are finalized at a formal meeting when the commitments to sign the principal agreement are confirmed by all partners. The negotiations, the agreements and the meetings are managed by VINNOVA. The fact that the research collaboration is manifested not only as an ordinary grant but as an agreement between several parties to undertake a joint effort has turned out to have important effects. The negotiations and signing of the agreement have a symbolic value and bring about discussions regarding for example intellectual property rights, rights to use and share results, secrecy, etc. to be concluded before start-up.
- **How do consortia (Centres) have to look like?** The special characteristics of a Competence Centre are summarized in an appendix to the general centre agreement as ten success criteria, which were developed on the basis of the five criteria used in the selection process. A Competence Centre is geographically concentrated, i.e. based at one university. In most cases a Centre implies multidisciplinary collaboration between several departments and faculties within the university. Research groups belonging to other universities or research institutes may take part in order to complement the centre´s profile. A prerequisite is that a number of companies are actively contributing and participating in the Centre. The number of companies in the current centres ranges from 6 to more than 20.
- **What organisational form of a consortium (= Centre)?** A Competence Centre is organised and managed within a university and is in many cases connected to a department that acts as its host and gives it administrative support. Thus a Competence Centre is not a legal entity of its own. The Competence Centre agreement states that a Centre should have its own accounting and be governed by a Board. The chairman and the other members of the Board are appointed by the university in consultation with VINNOVA and the industrial partners. In most Centres the chairman and a majority of the Board members come from industry. The Centre is managed by a Centre Director, who is appointed by and employed at the university.
- **Who owns the results of the work (IPR)?** According to Swedish law lecturers and researchers within the higher education system own their research results and IPR. For inventions made by employees at companies and institutes outside the HEI-system the employer owns the results. The owner of results from a project within a Competence Centre him- or herself controls the results but should according to the general centre agreement grant all industrial partners in the Centre a non-exclusive commercial right of uses to the results. Most centres have signed an incorporeal rights agreement between the university and the industrial partners.

Monitoring of projects (= Centres)

- **Co-ordination of project monitoring and programme evaluation:** The projects (= Centres) are financed stage by stage. A core group of four international experts have taken part in the two evaluations of all Centres that have been carried out so far and they have also made important overall programme-wide observations and recommendations. In this way the co-ordination has been secured.
- **Which criteria are used for the monitoring of projects?** The ten success criteria formulated in 1995 have been a basis for the performance of the Centres and also for the two evaluations of the Centres.
- **Features of the reporting system:** The Centres deliver current reports annually and final reports at the end of each stage in accordance with the agreements and instructions given by VINNOVA.
- **Which measures are undertaken if a project (Centre) doesn't work?** During ongoing stages it is the responsibility of the Board and management of the Centre to report to the partners and to take necessary measures. The report with assessments and recommendations from the international review of a Centre is transferred via VINNOVA to the Centre. The Centre is supposed to use it in its planning for next stage and to take necessary measures according to the recommendations. If a Centre is heavily criticized VINNOVA may decide to withdraw its support (one Centre was closed after the first evaluation) but the ambition is rather to use the evaluations as means to help the Centres to improve their performance.
- **Who is responsible for the monitoring?** The responsibility to monitor a Centre during the ongoing stages is according to the agreements very clearly decentralized to the Board and the Director of the Centre. In doing so the Board, with the 3-year agreement as a basic starting point, has to balance the interests of e. g. the financing partners – the companies, the university and VINNOVA or STEM. In the agreement it is stated that "the board of directors shall in its activities work to promote the common interests of the parties". The Centres are encouraged to take measures in order to self-asses the Centre and to scrutinize its projects. Most of the Centres have by now appointed International Advisory Boards, in many cases after strong recommendations from the international evaluations.

Project (Centre) evaluations (ex post)

- **Who carries it out? How are they organised?** According to the agreements VINNOVA has the responsibility for the evaluations. Up to now the Centres have been evaluated twice. They have been carried out by teams of international experts. The first review, after only 2 years, focussed on the performance and development as a Competence Centre. All Centres were evaluated by the same team of international experts with experience from similar programmes for university-industry research collaboration. The second, mid-term evaluation was carried out during 2000 by teams designed for each Centre. They consisted of two or three international scientific experts and two or three of the "Competence Centre experts" who carried out the first evaluation. The reviews are based on written reports from the Centres and a site visit during 1–2 days at the Centre as a rule including meetings with the university management. The evaluator´s reports are public according to the tradition in the Swedish research community.
- **Was the evaluations already considered when the MAP started?** How much funds for project (Centre) evaluation? Yes, already when the programme was designed and the decision to run it step by step. The funding of the evaluations is raised by VINNOVA i. e. it is not included in the funding of the Centre. The costs for the second evaluation was c. € 0.6 million (c. € 0.022 million/centre) excluding the personnel and other costs for VINNOVA and the Centres for preparing and carrying through the reviews.

Programme evaluations (ex post)

- **Who carries it out? How are they organised?** The two evaluation rounds of all Centres, managed by VINNOVA, which have been accomplished up to now (see above) have also included overall assessments and recommendations to VINNOVA, to the universities and to the Centres, concerning the whole programme. This has been possible thanks to the fact that the core group of four international experts with experience from similar programmes participated in the reviews of all Centres.
- **Were the evaluations already considered when the MAP started?** How much funds for programme evaluations? Yes and no. It was from the start announced and agreed that there would be evaluations carried out. But the systematic approach was at that time not elaborated. When the programme was designed and launched the focus was very much on the individual Centres. The principle agreement, the success criteria, the financing principles etc. all contribute to a programme framework. The costs up to now for the programme evaluation has been very modest.

- **How are the results considered for programme redesign?** The overall conclusions and recommendations made by the core evaluation team as a part of the first evaluation were very valuable tools to improve the performance of the whole programme. Some issues have been more focussed, for instance:
  - The placement of the Competence Centres in the university organization.
  - Industrial involvement in the strategic issues.
  - Strength and balance in the interaction industry – academia.
  - Involvement of senior academic staff in the centres.
  - Centre Leadership and the important role of the Centre Director.

The most obvious impact and result of the first evaluation was that NUTEK was recommended to initiate a leadership-training programme for the Centre Directors. By now a comprehensive and very appreciated leadership programme with focus on exchange of experiences between the Centre Directors has been finished.

Horizontal Questions

- Governance: VINNOVA governs the programme in co-operation with the Swedish Energy Agency, STEM. Instead of appointing a steering or advisory programme board VINNOVA has a continuous dialogue with all Centre Directors including annual meetings with all Centres (the annual Competence Centres Day) and with all Directors. The management within VINNOVA is organized as a matrix project with a small central management group for co-ordination and policy issues, legal matters etc. and c. 15 programme managers within the different technology areas, which have the day-to-day contacts with the Centres. Each Competence Centre is governed by its Board and Centre Director. He/she is also reporting to the president of the university, which hosts the Centre.
- nfluence of institutional setting on design, incentives: The Competence Centres are intended to become internationally competitive Centres of Excellence by actively involving a number of companies. A central ambition when the programme was designed was to create incentives for both the academic and industrial partners to take active part. One example; NUTEK argued strongly from the very beginning that a majority of the Board members including the chairman should come from industry. The outcome is that the participation of these persons on the Boards is very active and constructive. The reason for this is surely that they find it worthwhile to spend their time on the Boards as their contributions really influences and steers the Centre and the research programme. When the programme was launched, NUTEK stated that the Centres should be "affiliated to" the universities, i.e. at the interface between academia and industry. In the course of time this view has slightly changed and now the Centres are regarded rather as a part of the university structure. The motive is to attain a stronger impact and closer interaction with th university.

Legal, organisational settings on different levels

- The fact that the Competence Centres not are incorporated or legal entities of their own of course has both pros and cons. and to a large extent affects their behaviour. An obvious advantage is that the "not invented here-attitude" within the university is hampered. Most Centres have found pragmatic ways to handle the cons. The fact that researchers within universities according to Swedish law own their results and inventions has caused certain problems and a lot of discussions. The programme has contributed to trigger the ongoing policy debate in Sweden regarding this issue.
- **Compatibility of core elements across programmes:** The basic idea that all partners, not least from industry, have to take active part and to contribute to the co-operation effort in order to gain something is a leading principle in most of VINNOVA´s programmes.
- **Transferability of core elements in different institutional settings:** The general centre agreement developed by NUTEK/VINNOVA has proved to serve as a model for similar university-industry co-operation efforts in Sweden.
- **Incentives for cross-border co-operation/opening up of programmes:** If you refer to **national** borders: The programme is open for participation of foreign companies, also companies, which do not have activities in Sweden. This has been a rule almost since the programme started. A prerequisite is the approval of all industrial partners in the Centre. Most of the Centres are taking active part in comprehensive international projects for instance within the EU framework programme. The active participation in the Centres of a number of multinational industrial companies often with worldwide coverage is a special advantage.
- **Leverage effects, Net macro economic effects:** The funding from VINNOVA of the Centres is c. 30% of the total. It is still too early after five years to expect measurable macro economic effects.
- **Regional effects intended?** Not explicitly but one of the programme aims is to enhance the research profiles of the various universities around Sweden. The nation-wide competition between proposals from different universities when the Centres were selected contributed to make this obvious.

- **SME “friendliness” of the CC Programme?** 20% of the c. 250 participating industrial partners in the Centres are SMEs with less than 250 employees and not belonging to large industrial groups. They are technology- and research-based, high-tech companies. No special measures have been taken to make the programme SME-friendly. A prerequisite is that the company has R&D-capacities (skilled personnel, equipment etc.) otherwise the company will not be able to benefit by the collaboration.
- **Organisational learning:** The two international evaluations performed so far, and especially the first one, which focussed on management issues, have been systematically used to develop the Centres and the programme. Most obvious is the Centre leadership project, which has strongly contributed to the organizational learning within the programme. Many Centres have arranged leadership and management training days in order to develop their organization.
- It is noteworthy that all Centres have changed their internal organization one or several times. Some Centres have made considerable changes after five years of activities based on the experiences gained. The key issue is to organize the Centre in a way that you maximize the interaction between persons from industry and academia and especially the active involvement from the companies. The interaction with other companies within the Centre has proved to be very appreciated by the industrial partners.

Appendix 5 | User-Directed R&D in the Norwegian Research Funding System

The practice of 'user-directed R&D' is not unique to the Norwegian R&D funding system, but the principles are rather clearly articulated there, and have validity beyond the context of funding by a research council.

Norway has gone through a process of rapid economic development since World War II. Starting from a low base as an essentially raw materials based economy, there were successive industrialisation and rationalisation drives in the 1960s and 1970s, in which the state played a strong role. The discovery of oil in the North Sea changed the whole direction of industrial development, creating new industry and transforming the krone into a petro-currency. But it is easy to let the oil developments of the past two to three decades overshadow the fact that Norway had already established a rather different industrialisation trajectory before this, focusing on technological development rather than on science. NTNF, the natural science and technology research council was set up in 1946, with a clear mission to provide the technological basis for development. Its broad mandate covered activities from what we would now call strategic research through to innovation support. Only in 1949 did Norway set up a research council for basic research, NAVF.

Under NTNF's leadership, Norway developed a very big applied research institute sector (given the size of the country), of which the techno-industrial institutes form the largest part. These provided R&D services to industry, but they were also to some extent expected to substitute for industry's lack of internal R&D capabilities. The institute sector has grown and the techno-industrial institutes now operate with very little core funding or operating subsidy from the state – generally under 10% of their turnover. Many of them nonetheless obtain a significant minority of their revenues in the form of state-subsidised projects, which aim to improve the technological performance and capabilities of firms.

Up to the late 1980s, the institutes received money directly from NTNF, in order to perform these subsidised projects for industry. It was, however, becoming clear that the institutes therefore set the research agendas. Until the mid-1980s, many of the techno-industrial institutes were owned by NTNF. In 1986, these were spun off as independent foundations, but the institutes continued to receive programmatic support from NTNF. In 1990, a second step was taken, when NTNF stopped funding whole programmes set up by the research institutes and introduced the principle of 'user-directed R&D'. Two vital administrative changes were made. The first was that programme committees largely made up of user representatives were established inside NTNF, so that users rather than the institutes played a larger role in setting the programme agendas. The second was that subsidy payments no longer went directly to the institutes. Rather, they went to the companies, with an expectation but not an absolute requirement that a significant proportion would be spent with the institutes.

The following principles were set out:

- Contracts for project grants in user-directed programmes shall normally be made with the intended user of the research results.
- The grants should stimulate increased research by the users or companies, with the overall objective of increased value-generation and profitability.
- The role of the institutes is to supply R&D services to the users, and to be financed by the users based on their need for R&D services.
- The institutes must orient their services to market needs, in order to provide the users with the competencies that users need.

From the start, users were expected to pay at least 50% of the cost of projects (in cash and in kind). In more recent years, the expectation has been that users will pay at least 60% - and more, in the case of large companies.

The principle of user-directed R&D was carried forward when NTNF was merged with the other research councils in 1993, forming the Research Council of Norway. A series of evaluations has indicated that this form of funding is successful[33]. A number of countries provide smaller companies with vouchers, which can be used to buy small amounts of effort from research institutes, but the purpose of these schemes is normally to introduce companies to the idea of buying external research services for the first time. The unusual characteristic of the Norwegian approach is that money flows via the companies to the research institutes **in a mainstream industrial R&D subsidy instrument**. Other aspects of the user-directed approach – especially the use of users in the programme committees – are more normal, and will be found in the equivalent agencies in Sweden (Vinnova) and Finland (Tekes), for example.

33 *See Arild Hervik and Sigmund Waagø, Evaluering av brukerstyrt forskning, Oslo and Trondheim: BI and NTNU, 1997; Heidi Wiig Aslesen, Marianne Broch, Per M. Koch and Nils Henrik Solum, User-oriented R&D in the Research Council of Norway, Background Report No 13 in the evaluation of the Research Council of Norway, Oslo: STEP Group, 2001.*

Appendix 6 | Ireland 1950 – 2000: A Case Study of the Interacting Evolution of Industrial and Technology Policy

Fifty years ago, Ireland (like a number of other countries on the European periphery – Norway, Finland, Portugal, Greece) had still barely entered the manufacturing age. Income per head was very low, and the economy was dominated by the primary sectors, especially agriculture and fishing. Ireland pursued an Infant Industry policy from the 1930s to the 1960s, in the expectation that import substituting industrial growth would be encouraged. In the absence of industrial 'motors' such as large export-oriented manufacturers, however, the policy mainly enabled the continued fragmentation of the economy in small, inefficient productive units, leading to high domestic prices and little growth.

From that unpromising start, Irish income per head has moved from being among the lowest in Europe 50 years ago to the EU average today, with much of the gap being closed in the past 20 years. In other words, Ireland in its phase of post-import substituting policy has followed a path of very rapid growth. This has been largely export-oriented; it has also involved very substantial inward investment by Trans National Companies (TNCs), especially US multinationals, and this necessarily means that the fortunes of the Irish economy are increasingly linked to those of the US economy.

At the same time, the Irish growth path has also been characterised by a major transition in the structure of its technology development system. Having been relatively small and located largely in public institutions, technology development activities and capabilities grew rapidly and became substantially rooted within the growing body of industrial enterprises.

Bearing in mind that R&D is only the tip of the technology development iceberg, aspects of this transition are indicated in Exhibit 1. In 1997, R&D expenditure was equivalent to only 0.77 per cent of GDP, and only one third of R&D was performed by business enterprises. The other two-thirds was undertaken in public institutions – nearly 50 per cent in government organisations and about 15 per cent in universities.

Exhibit 1. Structural transition in R&D: Ireland, 1977-1997

	Total R&D expenditure (GERD) as a proportion of GDP (%)	*R&D performed by business enterprises as a proportion of GERD (%)*	*R&D by foreign affiliates as a proportion of all manufacturing R&D (%)*	*Manufacturing R&D as a Proportion of all business enterprise R&D (%)*
1977	0.77	**32.2**		
1981	0.75	**43.6**		
1984	0.77	**49.3**	63.1	95.0
1989	0.84	**58.3**		93.0
1993	1.18	**62.3**	68.0	86.9
1997	1.41	**69.4**		86.8
Ratio				
1997/1977	1.8	**2.15**		

Source: OECD, Main Science and Technology Indicators (various years).

Twenty years later in 1997, the R&D/GDP ratio was almost twice as large, and almost 70 per cent of it was performed by business enterprises. The share performed in Higher education institutions had increased a little to nearly 20 per cent, and the share performed by government organisations had dwindled to 7 per cent.

This structural transition had not occurred despite the large role of inward foreign investment and the technological behaviour of TNCs. It occurred largely because of that inward investment and TNC behaviour. Already in the early 1980s, foreign affiliates of TNCs accounted for nearly two-thirds of all manufacturing R&D (and that manufacturing R&D accounted for almost all business enterprise R&D). By the early 1990s foreign affiliates accounted for a slightly larger proportion of the rapidly growing amount of all manufacturing R&D (and manufacturing R&D still accounted for nearly 90 per cent of all business enterprise R&D).

The Evolution of Industry and Technology policy

The successes of economic and industrial development policy in Ireland make sense against the background of National Innovation Systems thinking. The government undertook multiple actions in parallel in the domains of both 'industrial' and 'technology' policy, and its was the interaction between these two paths of policy which played a large part in enabling the economy to restructure.

Legislative changes began to be made as early as 1958, which were to form the basis for abandoning the Infant Industry approach, though it took time for the policy system to accept the needed change to export-led growth. By the late 1960s, it was clear that the import substitution approach had failed. During the 1970s and 1980s, Ireland invested massively in inward investment, providing subsidised factory premises (via IDA, the Industrial Development Authority, and Shannon Development), training workers (via FÁS, the national training agency) and – above all – by granting extended tax holidays.

Ireland chose to enter the European Common Market (precursor to today's European Union) in 1973, at the same time as the UK. (Given UK entry and the very close links between the UK and Irish economies, Ireland had little effective choice but to join as well.) Tariffs were already coming down, as Infant Industry policies were being abandoned, but joining the Common Market meant that Ireland's remaining tariff barriers had to be dismantled with respect to other member states. It also placed Ireland within Europe's tariff barriers, and this – coupled with Ireland's low wages and English-language advantage – was to prove helpful in the new phase of industrial policy, which focused on inward investment. The accident of timing meant that the inward investment attracted had a high electrical and electronics content (since these were the growth industries of the period) as well as pharmaceuticals and that many of the multinationals attracted were American. (The sizeable number of the Irish-American population was probably also a helpful 'soft' factor.)

While initially the factories attracted to Ireland were very much 'screwdriver plants', these companies and industries became increasingly open both to local supply and – over a longer period – to higher value-added activity in the Irish plant. Supplier development programmes funded by the IDA were one factor in helping embed the foreign firms in the local economy. However, a series of educational and technological policies have played at least as important a part – creating the levels of knowledge and capability needed in both the multinational and the local companies' work forces.

In common with other countries, Ireland expanded its higher education system from the 1960s, though with a strong focus on first degrees. Postgraduate training had little priority in Ireland before the late 1990s. Regional Technical Colleges (now called Institutes of Technology) were established in several of the larger towns in the late 1960s, to supply the crucial craft and technician level skills in technology and business needed for economic development. Unlike the universities, which have a strong liberal arts tradition as well as working in science and technology, the Technical Colleges did not provide arts and humanities training, focusing sharply on 'economically useful' skills. Two of the colleges were later up-rated to universities, as the demand for graduate-level technical and business skills grew, forming Limerick and Dublin City Universities.

Once the beginnings of a multinational electronics industry were in place, the National Microelectronics Research Centre was established at University College, Cork. Leaning heavily on EU funding –, as did most technical research in Ireland at the time – NMRC has grown tenfold from its original 20 staff and provides a useful part of the research and training infrastructure serving the electronics multinationals and – increasingly – the indigenous companies in the same field. NMRC does not, to any meaningful extent, transfer inventions to industry for commercialisation. (Nor, indeed, does any other part of the research system). It does now do comparatively basic research – for example for Intel.

During the 1980s, the amount of EU funding available for university and company research grew dramatically as the Union set up its Framework Programmes. This provided incentives for reorientation of university efforts towards industrially relevant issues. (The Framework Programmes are primarily instruments of industry policy, not science policy).

From the end of the 1980s, a number of 'Programmes in Advanced Technology' (PATs) were set up. These are generally described as 'technology transfer' programmes, but only BioResearch Ireland can be said to fulfil this function in the traditional sense of transferring knowledge from the research sector directly into commercial production. BioResearch has had some successes with biotechnology test kits and similar small-scale innovations. The Advanced Manufacturing Technology PAT has in practice functioned as a problem-solving support service to both local and multinational plant in Ireland, tackling questions such as logistics, choice of manufacturing technology, and so on (see below). In many cases, it has strengthened the position of Irish managers in the multinational plant, helping them achieve and demonstrate high levels of performance in competition with their companies' plant in other countries. Other PATs have provided a mixture of more academically based problem solving and training. In the case of the telecommunications PAT there was little pretence that the programme was other than an extended postgraduate training programme, to satisfy the huge demand for software and telecommunications engineers that arose in the 1990s as these industries took off in Ireland.

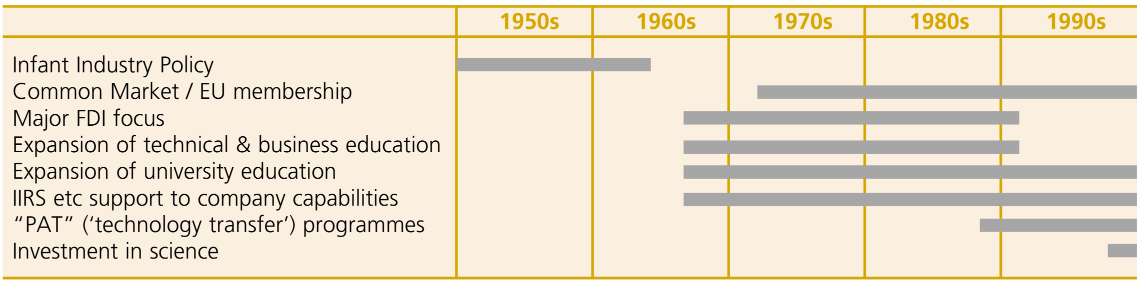
The PATs were set up as joint ventures between the universities and the central state funding authority (at that time called EOLAS – which in today's organisation of the Irish funding system corresponds to part of Enterprise Ireland). A case study of the Advanced Manufacturing Technology (AMT) PAT is attached, which contains more detailed description of the organisation of the PATs, showing how they related institutionally to the universities. In effect, each PAT centre comprised two parts: one part, which conducted university research, partly with the intention of laying the foundations for innovations; the other part aimed to sell services to industry, partly based on the work of the university research part of the PAT. The extent to which this model was practical varied among the PATs. In those (such as AMT and parts of Materials Ireland) tackling current industrial manufacturing problems, the university research aspect was unimportant. These PATs used generic knowledge from their field, most of which was not produced at the university in question, or even in Ireland. Others – notably BioResearch Ireland – were able to use the university side of the PAT to develop marketable innovations, such as diagnostic kits. In another case – the Teltec PAT, which focused on telecommunications – the parts of the industrial support which came from large companies were provided largely in order to increase the PAT's ability to train post-graduate manpower, responding to the acute labour shortage in this area in Ireland.

The single PAT formula, therefore, was in practice exploited in rather different ways in order to meet the needs of different parts of Irish industry. These needs differed both in technology terms, and in terms of the level of sophistication of the users, and therefore the sophistication of the services they required. We see this subtle flexibility as a key success factor in the overall PAT programme. Six identical PATs would have had limited benefits. Six different PATs, each one adjusting to its unique circumstances and the specific needs of its customers, were a lot more useful in promoting economic and technological development.

Common to all the PATs, however, was a funding formula that gave them a very high level of subsidy (80%) in their initial years, then fell over time. The original idea was that they would eventually become self-financing. Partly as a result of our evaluations of three of the PATs, the funding rules were later changed to provide a continuing subsidy at the 20% or so level, recognising that this would be needed to allow the PATs to continue to address areas of market failure.

Irish spending on scientific research was minimal up to the late 1990s. Excluding medicine, the total available for project and postgraduate grants (that is, the equivalent of the US National Science Foundation funding) to the entire university system in 1996 was under £I 5 million. (About US$ 7.5m, or 100m Baht.) From 2000, a £2.2 billion investment programme has been launched to strengthen Ireland's scientific base. Much of the investment is going into IT and biotechnology, which were prioritised in the national Technology Foresight exercise. Investment is focused in a fashion perceived to improve the enterprise environment and to be industrially relevant. While the linkages with industry will often be indirect – not least, through the transfer of manpower over time – this is not 'science for its own sake' but science with an economic purpose. **Exhibit 2** tracks the approximate timing of the events outlined in this short description.

Exhibit 2. Key policy actions in Irish industrial development



Direct foreign investment continues to be a major and valued component of the Irish economy, even if the desired rapid growth in the indigenous sector has now begun. Promoting FDI was, nonetheless, massively expensive. There are few official figures, and a considerable degree of secrecy, about the overall cost to the state per sustained new job as a result of the FDI policy. By 1990, the national debt was as big as Ireland's GDP while unemployment remained in the 10–20% range, which is extremely high by European standards. Personal tax rates were (and are still) high compared with the UK and wages were lower. The main economic payback to development policies has come during the 1990s, as the economy has grown rapidly. GDP per head in Ireland is now higher than in the UK (at purchasing power parities).

The Culliton Committee produced a landmark report in 1992, which marked a shift (which was already well established) in the official view of FDI. While the multinationals would remain significant, it was seen as increasingly important to focus on the development of indigenous industry as the motor for further economic development.

Support for Capability Development in Industry

The policies for technology and science outlined above would have made no sense in the absence of a parallel set of activities dedicated to raising the more routine technical and business skills of industry. In the late 1960s, the Institute for Industrial Research and Standards grew rapidly to some 400 people. It provided not only needed standards and metrology infrastructure and certification but also a growing range of technical services to industry. These included testing, analysis, consultancy, information, advice and formal training. IIRS served both local and multinational companies. The range of services was gradually expanded, and by the late 1980s it included a number of 'soft' programmes (such as quality, technology audits, manufacturing consultancy and human resource development). As European Union structural funds[34] became available from 1989, so it was possible to expand these services and to fund the increased emphasis on technology transfer and services referred to earlier. (It is perhaps noteworthy that the current expansion of science is being funded from national resources, reflecting the much greater relevance of science after a period of economic and industrial catching up).

Exhibit 3 shows the portfolio of company supports provided by the state in Ireland in 1997. It reflects the broad development strategy described above, and encompasses various kinds of start-up supports, business advice, training and mentorship, technology supports and other kinds of support to learning.

The state makes this portfolio accessible through regional offices, where 'client executives' are responsible for monitoring a list of potential customers, for selecting those that want to grow and have apparent potential to do so, and for helping them exploit the support system in order to achieve growth. Different supports cater for companies at different stages of development.

Policy Institutions: Changing Roles and Structures

The institutional history of Ireland's industrial and innovation policy has involved a series of reorganisations (Exhibit 4). In the 1960s, the Institute for Industrial Research and Standards (IIRS) was the state's main agency in industrial technology, working with standards and various industrial extension services. The National Board for Science and Technology (NBST) worked in parallel with research and science funding. The two were merged in 1988, as it became clear that research and innovation needed to be tackled together in order to affect economic development. The merged organisation was called Eolas ('knowledge' in Gaelic), and offered a wide range of capability- and knowledge-building support to industry, as well as providing the small amount of 'dual support' funding for university research that Ireland invested in those years.

In parallel, the Industrial Development Authority (IDA) was working with foreign investors, offering factory sites, training packages and so on and marketing Ireland as an attractive location (not least, in the context of the long tax holidays offered to inward investors). The IDA also had responsibility for the economic development of indigenous industry, offering factories, grants, loans and various 'soft' supports such as the supplier development programmes, which network inward investors to local suppliers.

The growing realisation in European industrial development policy that innovation was a central process and that it could not be treated in isolation from business meant that by the early 1990s, EOLAS and the IDA's activities were beginning to overlap. For example, EOLAS ran a manufacturing consultancy service offering subsidised help to companies based in Ireland. At the same time, the IDA operated a 'World Class Manufacturing' programme, using foreign consultants to transfer in good manufacturing practice. In 1994, the IDA was split in two. The part of IDA that focused on indigenous industry was merged with EOLAS, to form Forbairt. This therefore became a 'full service' provider of research, innovation and economic development support. Today's IDA – renamed the Industrial Development Agency – handles inward investment and is strongly focused on international activities. A new agency – Forfás – was created to do strategy and evaluation work.

[34] *These are essentially financial transfers from the richer parts of the Union to the poorer regions, and are intended to establish infrastructures and services necessary for economic and industrial development.*

Exhibit 3. Irish government: company support portfolio, 1997

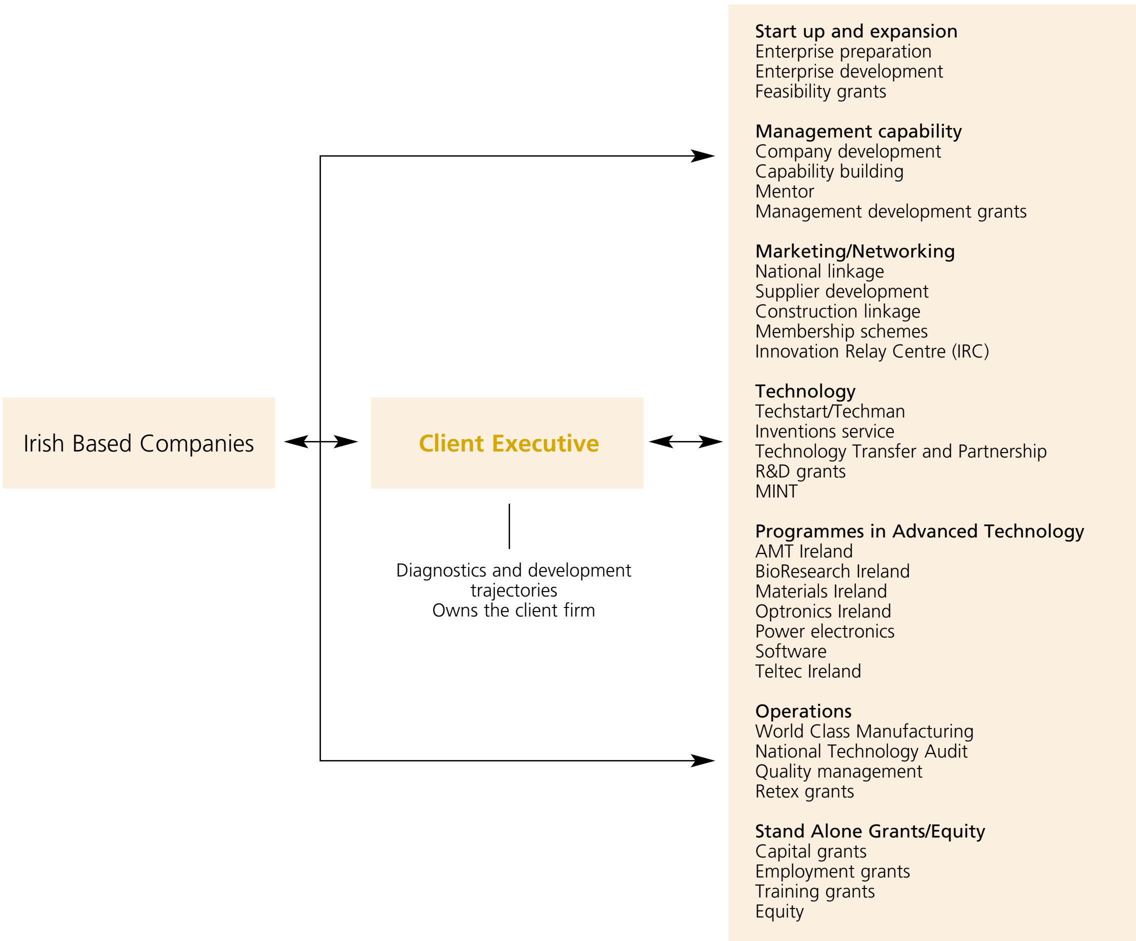
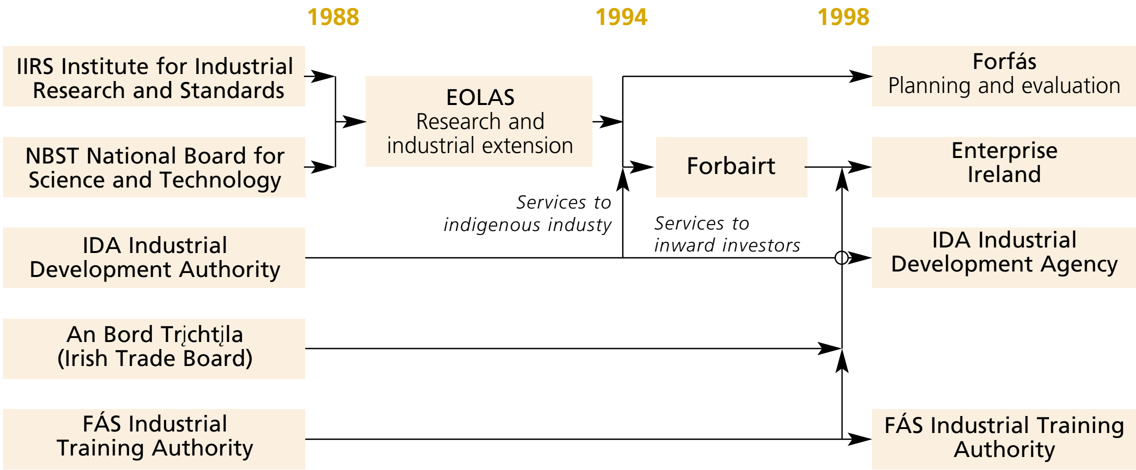


Exhibit 4. The changing structure of Irish business and innovation support institutions



In 1998, Enterprise Ireland was created. This involved merging Forbairt with Bord An Trachtala, the Irish Trade Board, and with the small part of FÁS (the Industrial Training Authority) that had provided in-company training to the employed. The remainder of FÁS continues to do its historical job of addressing structural unemployment by providing training to the unemployed. This was something of a 'tidying up' reform. The architects of the 1994 changes had originally envisaged including the trade board in Forbairt, in order to link company capabilities to international markets, but were frustrated in their aims.

Benchmarking Highlights

The main messages to carry forward from this chapter are quite simple.

- In industrialised countries business enterprises are the core of industrial technology development systems. They themselves constitute the 'supply side' for most of the technology used by industry.
- A large part of the process of technology development does not involve R&D. It is generated in an underlying structure of design and engineering activities.
- Firms draw large proportions of the knowledge inputs to their own technology development from other firms. Those knowledge-centred interactions among firms are a critically important part of the whole system.
- Several of the more technologically advanced industrialising countries, especially in Asia, have moved through a fundamental transition during which this firm-centred structure of innovative activities and capabilities has been built up quite rapidly from a preceding phase when most scientific and technological capabilities were located in public institutes.

In addition, the experience of Ireland provides a country-specific set of benchmarks against which to set the review of Thai experience in subsequent chapters. Key features of the parallel Irish experience are as follows:

- Creating indigenous company capabilities in technology and business at intermediate (technician) levels is a vital prerequisite to enable companies to move on to higher levels of development.
- Willingness to devote resources to company-based programmes is necessary in order to develop technological and business capabilities in industry.
- Multinationals provide an excellent means to transfer in technological and managerial capabilities, provided policies are pursued which actively engage them in the local economy. Nationals working in local MNC plant need support in raising their performance, so as further to embed the company in the local economy and infrastructure.
- Policies which create technological manpower, but which do not then trap those resources in the public sector research system, enable the industrial system to recruit key skills to help build their technology development activities. There have been limited opportunities in postgraduate and research training in Ireland until the recent past.
- Scientific research and training is important once the economy reaches the level of sophistication required to use large amounts of scientific manpower, but may be less necessary at earlier stages of development.
- 'Technology transfer' activities are fundamentally about technological learning in industrial enterprises, not about finding inventions in the research system and trying to commercialise them.
- The institutional structure for delivering support for technological learning and capability development in industry needs to evolve over time to take account of changing circumstances, as well as growing experience in developing and implementing policy.
- Emphasis in the substance and aims of policy also needs to evolve in order to meet differing priority needs at different stages in the process of growth and structural transition.
- Evolution in both policy and policy institutions appears to be effective if mechanisms to implement the specifically 'technological' aspects of policy are integrated with mechanisms dealing with broader business and economic aspects, with the whole 'package' being shaped and guided by changing economic priorities and strategies.

AMT Ireland: an example of technology transfer as part of a Research Centre

AMT Ireland is one of a number of Programmes in Advanced Technology managed by EOLAS - The Irish Science and Technology Agency. The Programmes in Advanced technology (PATs) are funded by the Department of Industry and Commerce with support from EC Structural Funds.

AMT Ireland comprises four AMT Centres and a Core Unit at EOLAS in Dublin. In total, it employs 30 people and has a 1992 budget of almost one and one-third million pounds: £0.4m in fees from industry and just over £0.9m from the state.

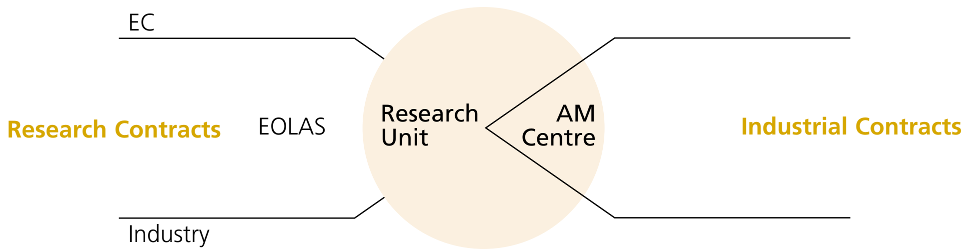
The Core Unit comprises a Director, Administrator, Marketing Manager and the national co-ordinator for Just-in-Time (JIT) Manufacturing practice.

The Centres are respectively at the University of Limerick, Trinity College Dublin (TCD), University College Dublin (UCD) and University College Galway (UCG). Each has a Centre Manager and a number of engineers, engaged in AMT technology transfer projects: consultancy and/or training courses for industry. The Centres have differing technical specialisms.

AMT Ireland is part of a larger constellation of AMT work at the universities involved. Each Centre has an academic Director (or Directors), who is already a Head of Department or Director of a Research Unit in the University. These Directors are responsible for managing research projects at the level of the Centre. They are not paid by the Programme.

Generically, the relationship with the Universities is as shown in **Exhibit 1.1**, though there are some differences of implementation and terminology between sites. AMT Ireland employs a manager in each Centre, responsible to both the Research Unit Director at the University and to the AMT Programme Director at EOLAS.

Exhibit 5. Relationship of AMT Centres to Research Contracts



The Research Unit operates as a conventional applied academic research institution, seeking grants from national and European authorities and from industry. It plays the traditional university role creating technology through research. It undertakes mostly postgraduate and some undergraduate education.

The AMT Centre undertakes industrial consultancy and training work. In principle, the Research Unit is the source of its technical capabilities. Its people may be hired from elsewhere, but at the junior level are most likely to be recent graduates of the Research Unit or associated teaching departments at the University. The Centre's technical expertise should overlap that of the Research Unit. Co-locating the two allows cross-fertilisation of ideas, sharing of resources such as equipment and other benefits of shared scale that would not be available to them separately.

In principle, Research Unit Directors are in a position to manage their research portfolios so as to create the technology which will be used by their AMT Centres. Thus they can secure a route-to-market for the technology developed in the Research Centre as well as underpinning the future generations of service offerings from the AMT Centre. At a 'higher' level, EOLAS is in a position to steer the Programme through the selective award of research grants (such as Strategic Research grants and HEIC grants) to the Research side of the Research Units. However, there is no official mechanism to create a strategy spanning the two entities.

History of AMT

The antecedents of AMT Ireland go back to the government White Paper on Industrial Policy in 1984, which called for the creation of Centres of Excellence in biotechnology and robotics. The IDA subsequently proposed to the Minister of ITC&T that a robotics research facility be established at University College Dublin (UCD). Other universities – notably Limerick – objected that they had relevant expertise and that they should also be included, so the National Board for Science and Technology (NBST, now part of EOLAS) canvassed university and industry opinion and produced a larger proposal for six centres.

Based on market research by Programme management in mid-late 1988, the original idea that collaborative research would be the focus of the Programme's industrial activities was abandoned. The market research showed that industry was largely unwilling or unable to fund substantial AMT research projects at the universities. However, industry required help in machine vision and in four additional technologies for which 'Strategic Initiatives' for technology transfer activities were developed by the AMT Programme, namely:

- Just-in-Time Manufacturing (JIT).
- Production Management Systems (PMS).
- Electronics Manufacturing / Surface Mount Technology (SMT).
- CAD/CAM.

With the exception of CAD/CAM, all the initiatives have since expanded, though delivery still focuses geographically in the areas around the centres where they were originally launched. CAD/CAM has not expanded beyond the original engineer – probably because the technology was sufficiently mature, well packaged and supported by vendors that AMT Ireland added little value to what could already be obtained in the market.

In addition to research and consultancy, AMT Ireland has increasingly delivered training - both as a service in its own right and as a tool for marketing by creating potential customer contacts. The need for AMT training in Ireland was explored by a joint FÁS/AMT study in 1990, although the Programme was already investing substantial efforts in short training courses. 1991 saw 34 courses delivered, generating 26% of the Programme's fee income.

In April 1991, an AMT Association was set up. This uses seminars - many of them involving AMT users 'telling their story' – and mailings to promote awareness of AMT needs. Membership is free, and spans some 290 individuals from 250 different companies. JIT 'user' groups have been established in Dublin and Waterford. However, the Galway-based PMS club has fallen foul of the UCG centre's concern at devoting effort to non-fee-generating activity, and is to be replaced by an electronic conference on PMS.

Organisation and Governance

In the first months, the Programme had to work to agendas wholly defined at Research Unit level. It began national operation in February 1988 with the appointment of a Co-ordinator and (in September 1989) an Administrator at EOLAS, who were to be responsible for strategic planning, programme co-ordination, research unit development, financial control and marketing. Each Centre received state funding to cover a manager and a senior engineer to handle industrial contracts. Additional staff was to be recruited against industrial research income. The Programme was expected over time to raise its level of industrial income to match the state's contribution.

The power of the Core Unit at EOLAS was strengthened during 1989 by creating a programme Steering Committee, comprising officials from EOLAS and the Department. The Department decided that AMT would become a Programme in Advanced Technology (PAT) under the Programme for Industrial Development (1989 - 93) as from January 1990.

The transition to PAT status allowed European Structural Funds to be deployed to cover 75% of the Department's financial support for AMT Ireland.

The transition from a co-ordinated programme guided by a government steering committee to a directed programme appears to have made a decisive difference to the programme's ability to organise and manage itself. Indeed, AMT Ireland management tend to regard the history of the programme as beginning at this point, rather than in 1988.

The Board is non-executive and unpaid. It is charged with the following functions:

- to formulate (and oversee the implementation of) such policy and plans as are required for the efficient and effective management of the PAT in accordance with the general policies…[laid down by the Department of Industry and Commerce];
- to establish, monitor and review performance targets for the PAT in accordance with the objectives and targets… [laid down by the Department of Industry and Commerce];
- to prepare an annual budget for the PAT and to approve purchases of capital equipment;
- to report to the EOLAS Board on the activities of the PAT.

The Programme was further centralised during mid-1990 to mid-1991. Income and expenditure were channelled through EOLAS, which assumed responsibility for invoicing customers and for employing the AMT staff in the AMT Centres. Staff was therefore gradually moved from varying College contracts and pay scales to a common set of EOLAS employment conditions and a standard two-year contract.

Responding to a request from the Department of Industry and Commerce that the programme become increasingly self-financing, the Board resolved in 1991 that the AMT Centres should plan to cover 40% of their current costs from fee income in that year. This proportion was to rise to 60% in 1992 and 80% in 1993. In principle, this would leave the Centres on track to break even in 1994 – the year following the end of the current Structural Funds tranche. These requirements have been relaxed by the Department during the Summer of 1992.

At the instigation of the Board, the most recent structural change is the appointment of a marketing manager to the Core Unit at EOLAS, with a brief to set marketing strategy and lead selling efforts to key accounts.

The Evolving Mission

The goal of the PATs, is "to develop new technology in selected niche areas and transfer it to industry". By correctly targeting niches, the cost-competitiveness of traditional industries would be improved and new technology-based firms could be fostered. It was intended that the PATs (i) would be mission-oriented to obviate the possibility of stagnation and self-perpetuation, (ii) would have well-defined technical goals, (iii) would spin off companies and people over the course of their life span, and (iv) those PATs not succeeding in their objectives would be terminated.

Originally, while the main "driver" for the programme was to be industry, the broad objectives included the strengthening of academic research capabilities at the Research Units. The industrially-oriented work was essentially to be research, primarily undertaken by "graduates employed as full-time research assistants" and managed at each centre by "one senior research engineer to work under the supervision of a nominated key academic". Industry was expected to fund 50% of the cost of "applied or generic research" at the Centres. The state would match this 50% through a range of existing research and R&D funding aid mechanisms.

The programme concept handed down from the NBST was therefore fundamentally concerned with increasing the 'relevance' and long-term benefits for industrial development of automation teaching and research in the university sphere. Industry was expected to be not only a user of advanced manufacturing technology but also a partner in its creation, through collaborative projects and by funding relatively substantial projects at Research Units within the Programme.

In 1990, the Steering Committee expanded the mission statement to: "The Programme will support the Advanced Manufacturing Technology needs of industry in Ireland, having as its main focus the transfer of technology to Irish companies and in particular Irish SME's." They amplified this statement in terms of creating centres of research excellence in the Universities and performing strategic research in the Research Units, as well as offering a technology transfer service.

Today, the mission of AMT Ireland is "to support the Advanced Manufacturing Technology (AMT) needs of industry in Ireland, having as its main focus the transfer of technology to SMEs".

The Programme is a partnership between the Government, the third level colleges and industry to create competitive advantage, through the application of advanced manufacturing technology, for growth-oriented companies. This includes, where appropriate, the commercialisation of technologies resulting from development projects.

The Government provides financial support on the undertaking that the Programme achieves an increasing level of self-financing over the period of the Programme for Industrial Development.

The current objectives (which translate the mission statement into more concrete form) show that the limits of ambition of the Programme have become more modest. They focus on the performance of AMT Ireland as a technology transfer agent:

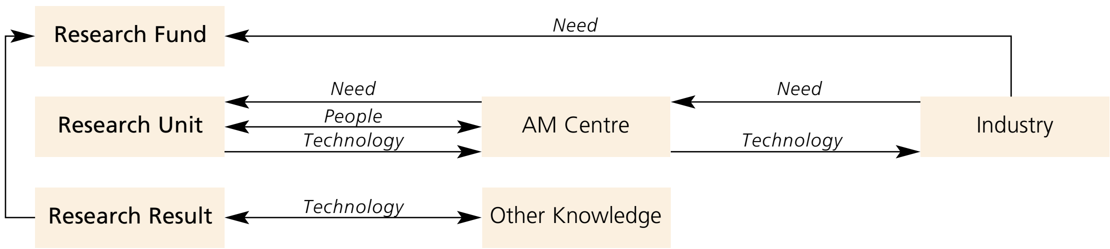
- Undertake technology development and transfer projects with 100 companies to 1993. Typically these would have a minimum value of £1000 and would lead to
  - Quality improvement
  - Cost reduction
  - Expansion of capacity
  - Product development
- Each Centre to conduct a minimum of two training courses per year with a target of 50 attendees per centre.
- Maintain a membership of at least 200 in the AMT Association.
- Centres to become 80% self-sufficient on current account by 1993.
- Each Centre to participate in EOLAS, EC and Fraunhofer research projects via the research side of the unit.
- Develop and maintain effective links with EOLAS, IDA and FÁS.

The evolution of AMT Ireland's goals has therefore involved a successive narrowing of the mission from one which embraces both the Research Unit and the AMT Centre sides of the activities at the four universities to one which focuses mostly on the AMT Centres' activities. This amounts to a recognition that EOLAS and the AMT Ireland can only really control that part of the activity that EOLAS pays for and manages. Unlike, say, BioResearch Ireland whose funding spans both the research and diffusion aspects of the PAT, AMT Ireland has limited formal influence at all over what happens on the research side. This influence is confined to helping define the technology themes to be included in the annual Call for Proposals for the Strategic Research Grant (SRG) scheme.

AMT Ireland and the PAT Model

AMT Ireland clearly does not conform to the current PAT model: it is an 'industrial extension service' rather than a creator of innovations. It undertakes technology transfer but not its creation. Certain of its operating procedures and structures are also different from the PAT norm, reflecting this.
Exhibit 1.2 describes the AMT Programme in systems terms. The traditional academic research system (shaded) is essentially a closed loop. Researchers attract research funds based on their research track record and the judgement of their scientific peers. In the short-medium term, the quality of the science is what matters, not its ultimate usefulness to industry[35]. Industry can, however, influence the course of research by providing funds – a possibility central to the original idea for the AMT Programme as a collaborative or University/Industry research programme.

Exhibit 1.2. A Systems View of Research Units and AMT



Introducing the AMT Centre to this system creates a market between industry and this new type of consultant. In order to sell its services, the AMT Centre has to deliver something industry wants: there is therefore a mechanism which tends to keep the AMT Centre's work relevant to industry's shorter-term needs. In principle, the AMT Centre's longer-term technology capability needs will be the same as those of industry, so by influencing the research agenda of the Research Unit the Centre secures its own commercial future. It can exert this influence both directly by pointing out its future needs and indirectly through a flow of personnel back and forth between the Centre and the Research Unit. However, while there is a functioning market between the AMT Centre and industry, there is none operating between the Centres and the research Unit: the Centre has no direct way to reward the Research Unit for reorienting its research programme to the Centre's needs.

Conventionally, a PAT spans all the systems blocks in **Exhibit 1.2:** research as well as technology transfer. The contrast between BioResearch Ireland (BRI) and AMT Ireland – the two PATs so far externally evaluated – suggests that AMT may be the less suited of the two to the PAT model. BRI's scope covers both research and technology transfer activities. Its 'core business' is identifying potentially exploitable technologies and capabilities within the existing Irish biotechnology research community and commercialising these through product/process development and packaging IPR for sale. BRI turns science into innovations.

AMT Ireland's core business is to function as an industrial extension service focused on manufacturing technology consulting. AMT helps its customers innovate, but it explicitly excludes the research activity.

This distinction between BRI and the AMT Programme is not only a function of programme organisation, however, but also of technology. Irish universities perform a minute fraction of the world's manufacturing process R&D. It is hard to conceive how the AMT Centres could source a meaningful proportion of their technologies from within their universities and at the same time provide a service, which would satisfy the broad needs of industry. In sharp contrast, BRI can develop and exploit niche technologies at both the research and exploitation/technology transfer stages.

A priori, at least, the case for using the university-based PAT mechanism for the AMT Programme appears weak. The history of the Programme's interactions with industry and the corresponding shifts in its objectives towards the technology transfer function underlines this weakness. With the benefit of hindsight, it is now clear that a different mechanism could have been preferable to that of the PATs. However, the costs of changing horses in mid-stream make it inadvisable to alter the structure of AMT Ireland significantly at this point. Future 'industrial extension service' initiatives should probably be more cautious about using the university-based PAT model.

35 *Increasingly, of course, research funding systems are being guided by longer-term industrial needs, both in national science funding agencies and more especially in international programmes such as those run by the EC.*

Appendix 7 | UK Regional Centres for Manufacturing Excellence (RCMEs)

History

Historically, manufacturing has played the central role in establishing the United kingdom as a global economic power. Although service industries have risen in prominence, especially in recent decades, their strength is in many cases is underpinned by manufacturing sectors. Manufacturing currently accounts for some 20% of UK employment, but around two thirds of GDP.

The importance of a healthy manufacturing base is therefore obvious, as is the need to improve efficiency, productivity and innovation in the face of competition from world markets. The DTI offers a portfolio of services to provide advice, information and counselling and demonstration to act as a 'bridge' between businesses and providers of manufacturing technology and good practice, but the availability of 'hands on' practical advice to manufacturers through public sources is limited to the more general services available through Business Links.

Following a study by Technopolis Ltd of the national need and justification for this form of manufacturing advice and support, the DTI, working in partnership with the Regional Development Agencies (RDAs) in England and with corresponding agencies in Wales and Scotland, has established a network of 12 regionally based Centres of Manufacturing Excellence (RCMEs), aimed at providing information and advisory services primarily for manufacturing based SMEs. The Secretary of State for Trade and Industry will formally launch the programme on 12 April 2002.

Background

In the modern view of manufacturing innovation, organisations like the RCMEs are in a position to play an important role in maintaining and improving the health of national and regional knowledge based innovation systems. Key priorities for the proposed network include understanding how this theoretical potential may be realised against practical SME needs, how this potential may be amplified through linking and enhancing – rather than duplicating – regional networks in order that they are used in a 'value added' way.

It follows that the RCMEs' role will be a powerful one, acting within a wider set of established services provided by other regional, national and public sector players. RCMEs will promote innovation and economic development by increasing the capabilities and the network linkages of actors in the national and regional innovation processes. They will need to take a differentiated approach to their potential customer base, selectively targeting areas of market and systems failure and increasing the abilities of those capable of learning and sustaining their new capabilities over a longer period. They will aim to extend the innovation processes beyond individual regions in order to share knowledge and capabilities, build regional inter-linkage, create wider innovation networks and strengthen the national economy as a result.

To achieve this in practical terms, survey work undertaken to establish the needs of potential RCME users showed that their requirements divide between shorter term 'fire fighting' assistance and longer term assignments which are more akin to consultancy. In both cases a practical hands on approach was seen to be necessary, coupled with working experience from highly experienced advisors recruited from relevant industrial sectors. Whilst satisfying the immediate needs of users, staff working on these projects will also need to be aware of the greater potential for business improvement which comparatively simple problems may conceal, and to be conscious of the wider service provision (regional, national and international) which may be better able to deal with the problem.

General Requirements

The RCME network, which is designed to provide advice and information to businesses in diverse manufacturing sectors, will incorporate five essential factors which will be crucial to success:

- **Quality** – RCMEs will have the best available expertise to serve client needs, provided through professionals with consistent, practical, applied experience. It would be unreasonable to expect 'first line' providers to be able to deal with any given subject at this level; they will therefore be aware of their limitations in this respect and be knowledgeable in alternative sources of help and advice in a wide range of subjects to which they will have ready access through a national network.
- **Speed** – speed of response will be crucial. Businesses, especially SMEs, often have urgent problems which need solving in the shortest possible time. Problems in businesses are often left until they become urgent, or they have a direct and crippling effect on the business in the form of a machine failure or shortage of material. For these reasons, it will be essential that RCMEs are able to respond quickly and positively to calls for assistance.

- **Minimal bureaucracy** – the first two factors are perhaps obvious in principle but demanding in practice. There is however little point in providing them if the delivery system used by the RCME network is over bureaucratic. Whilst a good system of recording and monitoring the activities and use of the network will be essential, it must not be bound by complex application procedures, qualifying criteria and repetitive questions. The system of management must therefore be carefully designed to minimise 'red tape' and it must be supported by efficient and well-designed IT based management information systems. The system should also be regularly tested, perhaps using 'mock' applicants, to ensure that it is performing satisfactorily.
- **Cost** – Although free services would on first thought appear to have the greatest appeal to user businesses, such services are often regarded as of potentially poor value – the adage that 'free assistance is not worth having' often applies in a world where businesses are used to having to pay for services. The service will therefore make a charge to offset or cover costs depending on funding arrangements. Structures which permit limited free time before charges are incurred are favoured in many countries and will help in the case of the RCMEs.
- **User driven** networks incorporate all of these factors in formulae which have been developed to serve the needs of their client base. More importantly, close contact with and feedback from users will ensure that RCMEs are dynamic and adapt to suit the ever changing needs of their client base.

Any network of business support centres must wholeheartedly adopt these principles and be prepared to be measured against them, during bidding procedures and during subsequent operations.

Objectives

There are three principal objectives of the national network of RCMEs:
- Economic - To improve the efficiency and profitability of UK manufacturing businesses, focusing primarily on those employing 250 or less.
- Technical - To improve awareness and adoption of technological solutions to manufacturing needs *appropriate to the needs and abilities of the user business.*
- Management - Working with Business Link services, to improve the capabilities of manufacturing management in target businesses.

The RCME advisors will have a range of 'tools' and solutions available to them in order to generally and specifically improve awareness of issues relating to these objectives, then to assist businesses in arriving at appropriate solutions.

Scope

Businesses Served: The primary focus of the RCMEs will be manufacturing SMEs and in this respect the financial support provided by the DTI and RDAs will be for the provision of services to SMEs. In the European Union an SMEs is defined as employing 250 or fewer, with an annual turnover not exceeding EUR 40 million and /or a balance-sheet valuation not exceeding EUR 27 million.

All manufacturing sectors as defined in the 'Standard Industrial Classification' (SIC Codes) are covered, along with those service companies which are engaged in the manufacturing sectors.

Companies who fall outside of these definitions are not excluded from assistance, but would normally be expected to pay commercial rates for any assistance given beyond dealing with simple enquiries. The RCME director/manager will decide on any cases of doubt in consultation with the RDA/DTI.

Services Provided: The scope of individual centres will vary according to regional needs. Core service requirements and levels of service delivery have however been agreed nationally between DTI, RDAs and their RCME contractors and will be supported by all centres. The broad scope for the core services set out in the next section include:
- analysis of real needs,
- short term advice,
- access to longer term (consultancy/research) advice,
- information/'signposting',
- access to training,
- access to demonstration and testing facilities.

Analysis of real needs demands professional staff with a solid background in industrial 'trouble shooting' across a broad range of technologies and industrial sectors. It would be impossible to expect that such staff should know every answer, more important will be the skill to relate to the callers and their needs, then deal with them or refer them to an appropriate alternative source if necessary.

Short-term advice will consist of a telephone discussion or may on occasion extend to a visit and a letter report summarising the findings. Enquiries in this category could include simple production problems, identification of equipment suppliers and assistance on material selection.

Longer-term advice will be provided through a proposal outlining the work to be done for user businesses, or perhaps through 'standard' consultancy packages such as production or design audits. Examples of projects here might be a study to optimise plant throughput or the re-organisation of a stores to minimise stock.

Information/signposting is best done by those with experience in a subject. For example it is relatively easy to give someone a list of general engineering suppliers in response to an enquiry, but it is far better if the contact knows from their experience which companies are likely suppliers of the actual product required.

Access to training will prompt the member of staff in the centre to be aware of the need for, and availability of, suitable training if it becomes apparent from telephone conversations or visits that one of the root causes of a company's problems is the lack of skills or management ability.

Access to demonstration and testing facilities, such as those available in HE/FE, RTOs and the DTI's 'Inside UK Enterprise' scheme will allow staff in a centre to encourage users to consider more modern technologies and methods.

Services

This section is concerned with ‘core’ services only – those services and the necessary resources underpinning them - which by agreement must be in position to enable an RCME to function efficiently and effectively, and to meet the needs of users. It is fully expected that each RCME will in addition develop its own suite of services and products, according to the needs of local businesses in particular industrial sectors or stages of development. The following guidelines are recommended in order to ensure that users may be assured of certain ‘minimum standards of delivery’.

Coverage of Core Subjects

The RCME Network will be set up to deal with ‘manufacturing issues’. This is a very wide-ranging descriptor in terms of manufacturing technologies.

Whilst it will be impossible to expect every RCME to have expertise in every area of manufacturing and in all sectors, it will be essential for each one to have the same basic set of core competencies, effectively providing user firms with the same entry-level access. Extended knowledge clusters can be offered through RCME Associates, (organisations or individuals appointed in support of the RCMEs, either for individual centres or through the Manufacturing Advisory Service [MAS]) according to local industrial needs. The basic ‘core competency areas’, in which each centre will offer general support will include:

- Practical Production Engineering expertise.
- Materials – including technical specification, procurement strategies.
- Standards – interpretation and reference access.
- Manufacturing Control – covering areas such as factory layout, inventory control, human resource utilisation, scheduling, production control, etc.
- Manufacturing Technology – covering process and production equipment.
- Quality management – including quality systems and Total Quality.
- Factory Control – including materials flow, environmental issues, warehousing, etc.
- Human Resources – organisational design, team working, multi-skilling, capability upgrading, etc.
- ICT in Manufacture – including CIM, CADCAM, EDI, e-commerce, e-procurement, MIS etc.
- Strategic Manufacturing Management – the systems approach, where human resources, finance, machines and material are treated holistically.
- Interfaces between manufacture and other departments/organisations – such as design, marketing, customer service and suppliers.
- Manufacturing good practice examples – concentrating on the manufacturing process.

All manufacturing industries will need to be covered – those falling within the 'manufacturing' SIC codes. It will be impossible to expect the same level of industry specific knowledge for every sector and Associates will therefore be engaged to meet the inevitable shortfalls in coverage by RCME staff.

Depth of Coverage

The RCMEs have been set up to offer a practical, hands-on approach to the provision of information, advice and consultancy to user firms. Whilst for example access to research and research programmes, or high technology testing facilities, may be of interest to some users, the vast majority are likely to require help in the more mainstream areas. This means that there will be an emphasis on practical, pragmatic solutions, which can reasonably be implemented by SMEs. Advice and consultancy must be tailored to their needs, with a good understanding of the operational, cultural, capacity and financial constraints typically experienced by the majority of SMEs.

Types of project

The following is a short digest of the types of core service that all RCMEs will be able to offer. The exact profile, number and format of these will evolve according to local and regional needs. Distinctions have not been drawn between the provision of information and the provision of advice, although strictly speaking these are different and will require differing levels of skill and expertise.

Short-Term Advice and Information

Users of the RCME programme will have different needs, but there are likely to be more requests for information and short - term advice than for consultancy and training. This is because requests for information and advice will generally be the route for initial approaches by users, resulting in a higher volume of contacts. Examples of approaches here would range from seeking the contact details of local environmental control authorities to advice on the selection or treatment of a particular material - for example improving a metal finishing process to remove blemishes. The User Survey resulting from the first phase of the RCME study showed that access to short term advice, and signposting to other sources would be popular amongst SMEs (over 60% were interested), particularly amongst smaller SMEs. These short-term enquiries are expected to outstrip longer-term consultancy or training requests, in terms of volume.

It is anticipated that there will be three types of deliverable for this service:

- **Quick query** – typically where the enquiry is straightforward and the RCME has readily available in-house expertise to deal with an issue. This service will be free of charge. Typically calls will be dealt with in a matter of minutes up to a two hour maximum. If a return call has to be made to an enquirer then this should occur within a four-hour working period. The response will be delivered over the telephone, fax or email, with surface mail being used for back-up information. It will be necessary for each RCME to consider whether 're-use' of the service (limited or unlimited) will be allowed. This may lead to a small number of firms using the service more than is their 'due' to receive free advice. However, if re-use is not allowed, then those firms which arguably need external help the most, could be disadvantaged.
- **Day delivery** – a response will be given within a period of 8 working hours, after a period of 8 working hours maximum research. Mixed media will be used to deliver this service – including the telephone, as interaction is likely to be important – but also using email, fax and possibly the web as appropriate. This service will also be free of charge, up to a maximum of 8 hours work. Again, it will be necessary for individual RCMEs to consider whether 're-use' of the service is allowed.

For both of these advisory services, the Internet, on-line services and CD-ROMs will be used to conduct much of the research. In addition the RCME web site (see the Web site section under MAS) will be useful. For example, a library of 'Frequently Asked Questions' (FAQs) and useful links to other web sites will be built up. Discussion forums will also be used to elicit other solutions to queries from browsers, although experience of participation in this type of environment is often perceived as time-consuming and the added value to the contributing respondent is not always apparent.

The third service, which will be offered, is slightly different to the two outlined above. It is the provision of current awareness services, as the initial RCME study project showed that this was the third most desirable service amongst SMEs, regardless of size. There should be few limitations on an RCME's ability to deliver this service, as extensive capital resources or specialist expertise are generally not necessary.

Market or Technology Watch

Initially this service will be offered for a limited set of topics – possibly markets and technology. It can take the form of an electronic newsletter delivered by email, or as a web-based service available through MAS. The scope of such a service may range from a weekly update delivered by referring to a number of well known periodicals and delivered by email (rather like FT awareness services which are delivered electronically) to a monthly digest of news, facts and figures, possibly with some accompanying analysis. Depending on the type of service offered it might either be free of charge, or chargeable at a nominal fee. As an optional extra, it may also be possible for an RCME to build customised information products which meet local needs in more depth. These could include customised manufacturing research reports, or manufacturing 'masterclasses' for example. These are likely to be delivered as a chargeable service.

In addition, there is another service which potential users expressed an interest in and may be made available through RCMEs. This is however considered to be a non-core product, and is included for completeness only:

- **Equipment or Technology Demonstration** – this service will be dependent on the location and capabilities of the RCME Network Contractor and their access to demonstration facilities. Typically, expensive capital equipment, especially using advanced technology, is only available in private companies, Universities, and RTOs. It will be the choice of the RCME whether or not they will charge an 'entry fee', although only 24% of SMEs in the scoping study indicated that they would be willing to pay. For those RCME contractors who do not have access to demonstration sites, referral to the Inside UK Enterprise programme may prove a suitable alternative.

Consultancy Advice

This service will be appropriate where the client or the RCME have identified a manufacturing issue which can not be dealt with as 'short term'. It is likely that this element will involve at least one visit to a client site. It will be usual for the advice to be delivered by a single consultant, but this is not be a stipulation. The provision of consultancy advice will be a chargeable service, delivered personally in the majority of cases, although electronic communications will be used as appropriate. In order to reassure clients about the possible cost levels, it is suggested that the service is structured as follows:

- **Two-day diagnostic** – This will enable the RCME consultant to see the physical context in which the problem or issue in question takes place, and/or to spend time investigating the issue in depth with relevant personnel. The process will consist of one day spent at a client site, discussing a problem or issue, and a second day spent writing a short report, which will then be delivered either personally or electronically (with the facility to interview the consultant afterwards). This service will be charged at a fixed rate as agreed between the controlling RDA, their RCME contractor and DTI. Following this diagnostic, the client will have the option to move forward into a full consultancy project to address any problems identified or to take action on the findings themselves.
- **Full consultancy project** – this service can either follow on the from the two day diagnostic, or be a 'standalone' service. It will normally be delivered by a single consultant, and will be chargeable. The client SME will be presented with a fully costed proposal, and a schedule of work, which will be contractually binding between the two parties. Usual commercial, contractual and confidentiality controls will be in place.

Charging for this type of project will again be subject to agreement between the controlling RDA, their RCME contractor and DTI.

Training Programmes

Training in the context of RCMEs will not duplicate the services of other funding agencies, but rather will be intended to provide training in support of some of the manufacturing issues identified in the course of diagnostic and consultancy projects.

There are several scenarios for providing training services. Firstly, courses can be delivered by the RCME personnel – at a client site, or at the RCME location. Secondly, requirements may be sub-contracted to a professional trainer, or the enquiry could be referred to the SBS or another Business Support Organisation to deal with. Thirdly, a cluster of firms may require a training course to be specially designed for them.

Courses offered may either be proprietary modules, or bespoke. The former could feature as a 'standard portfolio item', accessible via the RCME national web site, MAS (see the Web site section). Bespoke training courses are more akin to 'consultancy services' as they need to be designed individually; as such they are much more expensive, but if the cost is defrayed across a cluster of firms (in a supply chain, for example) this will be more attractive. Training will be chargeable within the overall daily rates envisaged.

Other Facilities

As well as the types of pro-active services described above, the RCME Contractor will be able to offer some or all of the following facilities:

- **Seminars / workshops / conferences** – this will be dependent on the location and facilities of the RCME Contractor's site. Provision of these facilities will be both useful to the work of the Centre and an ideal way to help regional manufacturing businesses to network together.
- **Meeting rooms** – it will be useful for clients and RCME staff to have facilities to meet each other, especially for smaller firms.
- **Library and Information Facilities** – again this is dependent on the facilities of the RCME Contractor site, but these may be useful to allow users to browse reference services.

Duration and Cost of projects

The services discussed above may be simply characterised as 'short term' (provision of information and advice and some training) and 'long term' (consultancy and more substantial training provision). On the basis set out in this section it is considered reasonable to allow an average of 1 working day for short-term enquiries (advice and information) against a maximum of 2 days duration. These will be answered free of charge to users.

For longer-term help (training and consultancy) an average of 7 working days support will be allowed, within a maximum duration of 10 days, for which a 50% charge will be made. These figures will vary according to regional needs and the priorities considered by the relevant RDAs, but the 50% charge will be mandatory to comply with European Commission rules on industrial support.

Appendix 8 | UK International Technology Promoters Programme (ITP)

This programme was developed to improve the technology transfer process between UK companies and organisations in other important world markets. The following sections describe its principal objectives and how the programme operates.

History

The ITP Programme is one of four main elements of the DTI's International Technology Service, which aims to help businesses learn more about and access technology developments in key overseas markets through information, missions and staff placements. The pilot ITP began operations in July/August 1996. Following a positive evaluation by Technopolis Ltd in 1998 funding was extended to 2002, during which time it trebled in size. The programme is likely to be extended further from April 2002.

The Programme

After competitive tendering, the Department of Trade and Industry (DTI) engaged the international management consultants, Ernst & Young (E&Y) to manage the programme on their behalf. Following the 1998 evaluation the programme was re-tendered and as a result is managed by Pera International. The switch from a management consultancy based organisation to a technology based one has been considered important to the programme's later success.

The programme originally employed six 'Promoters', this has since increased to fourteen. All are professionals with extensive track records of involvement in overseas technology transfer. They are paid market salaries and receive benefits as they would in the commercial marketplace - this again ensures high calibre individuals who are well respected by users.

Aims and Objectives

Principal aims of ITP focus on the provision of hands-on advice covering products, new technologies, licensing, supporting information and the provision of seminars on potential overseas contacts/markets. Four countries were initially covered by the programme; France, Germany, Japan and USA, but coverage has been extended to include more EU and central European countries. The initial countries were selected as the top investors in R&D, based on an international comparison. Later countries have also included those which have high potential for the transfer (both in and out) of innovative products and ideas.

Contact

Potential users contact the programme either directly through the programme managers, the Promoters themselves, or indirectly through intermediaries. Advice and assistance through ITP is free of charge to both users and intermediaries. Intermediaries include Trade Associations, Higher Education Establishments, Government and Private Laboratories, Investor Groups and Business Links. The ITPs contact these organisations, both in the UK and overseas, on a regular basis in order to develop and maintain close working relationships. Much of the Promoters' work in the first instance consisted of developing these contacts.

The Promoters

The group of Promoters provide a wealth of experience on their target countries and through their specialist technical and business experience. By networking closely with each other, the DTI, intermediaries and the managing contractor, Pera, they provide pragmatic and comprehensive coverage to users on a wide range of topics associated with overseas technology transfer. This, when added to their ability to visit potential contacts in target markets and their fluency in languages means that they represent a powerful resource which was previously only available on a fragmented basis from other sources.

Users

By definition 'Users' are UK businesses in any sector. These vary greatly in their levels of applied technology, overseas market experience and ability to bring about and fund change. An essential feature of the Promoter's role is to provide advice appropriate to client needs, helping directly where possible or referring them to appropriate sources.

Management

Pera, one of the Europe's largest technology transfer and consultancy organisations, manage ITP from their Technology Centres in the UK Midlands. As programme managers, Pera's key duties are as follows:

- The recruitment of ITPs, including establishing and managing systems for running the programme.
- Managing the network; aspects such as employment, salary and benefit provision, team building, policy advice to DTI, marketing the programme, reporting and continuous improvement.
- Evaluation, including the creation of performance measures and monitoring the effectiveness of the programme.

The ITPs are direct employees of Pera under short-term contracts. As programme managers, Pera are therefore responsible for the promoters' performance, development, programme value for money, budgetary control and the reporting of these aspects to DTI on a regular basis.

The ITP Programme in an International Context

In this section, we set out some general experiences based on our interactions with technology transfer programmes abroad. This will help to place ITP and similar programmes in context.

Users

Technology transfer is interesting for a small number of companies at particular moments in their development. Probably the hardest problem faced by technology transfer programmes is to identify the companies at the right time and to link the programme's offer with the companies' strategic needs. An intelligent network of referrers or intermediaries is needed as a key partner to the ITPs' focused efforts. If others' experience is valid, a 'shotgun' technology-push approach will not substitute for the needed 'search and screen' effort. The routine dissemination of technology transfer 'offers' to companies tends to produce costs but few benefits.

A corollary is that the ITPs need to be based close to their customers, as indeed they are. They need the time and ability to understand users' strategies in order to focus their efforts on transfers and partners which fit with business needs. In the Irish system, which Technopolis also evaluated, uses a mix of regional Technology Transfer Executives and people permanently posted abroad in the target markets, the foreign-based people tend to make visits to Ireland in order better to understand the clients referred to them.

To make appropriate use of technology transfer programmes an internal rule of thumb is that a company must have the "three M's" of Management, Markets and Money in order to be suitable. That is, it must be relatively well established, be clear about what it is doing and have the management capabilities needed to carry this through. It must have an established market position and tenable distribution arrangements. And it should be financially sound. These concepts are of fundamental importance, and, as we shall discuss, there is early evidence that ITP should focus more on these requirements.

Without these attributes, a company will be an unattractive partner for a foreign partner. However, there is no need to be in a 'high-tech' field. Indeed 'low-tech' companies getting involved in the Irish Technology Transfer Programme (TTP) were just as likely as high-tech ones to enter discussions with potential partners.

In general, however, our work in Ireland found that companies making use of inward technology transfer also had their own R&D capability: these two sources of technology are complementary; they are not substitutes. Again, as we shall see in this evaluation, the majority of interviewed user companies do have an internal R&D capability.

Impacts

The major impacts of the Irish programme on capabilities related to networks, products and markets. By extending companies' 'reach' to partners with whom they would not otherwise have worked, the Programme opened new sets of business possibilities. For example, the type of middle ranking US companies which lack European distribution and can benefit from licensing products to European manufacturers were often completely unknown to their Irish counterparts. Once the link had been made, it became possible to transfer a series of product and process technologies. While it is very problematic to try to place a defined economic value on this type of network extension, it clearly has the potential to open the door to considerable possibilities.

Intermediaries' assessments of the likely impact of the ITP Programme also favoured the creation of networks and partnerships as the most likely outcome. This was mirrored to a large extent by the users, although they also encouragingly anticipated significant product extension or creation.

Mastering a technology is a significantly more complex matter than implementing a related-product or related-market diversification - which is what most of the ITP work has amounted to so far. In a sense, the most interesting dynamic effect of technology transfer programmes could be the creation of these new capabilities, enabling further innovation and economic development based on internal capabilities.

However, except in a few exceptional cases it is difficult to see this type of effect over short operating periods and this has been one of the main reasons for extending ITP so far. The support system can help encourage this type of longer-term technological learning through the provision of R&D support, education and training, and by helping companies take a strategic view of technology acquisition.

Other Technology Transfer Programmes

Different programmes 'disengage' with their users at different points in the technology transfer process. Typically, the Embassy-based services restrict themselves to establishing contact between potential partners. In selected cases, others may support their users through the deal-making process. Any ITP could handle the business part of this process.

Mixing the ITP function with other roles can result in dilution, and can make ITPs' market presence sporadic. Having ITPs work in parallel with the Embassy and Consular staff gives the scale needed to have a division of labour where the Foreign and Commonwealth Office people (embassy staff) do the high-visibility, 'representative' work, while the ITPs focus on individual, business-need-driven company-to-company interactions on their regular visits.

A 1995 SPRINT/EIMS study on Technology Brokers in Europe, carried out on behalf of the European Commission, concluded that financing schemes to help companies to search for, select and acquire existing technologies and to adapt them to their specific needs are less well developed than other schemes intended to finance collaborative research programmes (this is not only true at the European level but also in most national systems of innovation).

The EIMS study came to the clear conclusion that technology brokerage is not a profitable business. "Nowadays, no technology broker can make a living from technology brokerage alone." Therefore, they tend to evolve towards a more global technology management consultancy role. The study found that the low profitability of this activity has hampered the growth of the technology brokerage business and "... justified the development of free and inexpensive public services which are usually limited to technical information or contact services."

Awareness building and defining technology transfer needs among companies with limited innovation capabilities is onerous. It is exactly this part of the technology transfer process that is an unattractive proposition for private consultants. Public support services can be more 'patient' and developmental with their clients than private ones.

While the mode of operation of most programmes is in principle to aim for the larger and more capable companies, in practice many of these companies are comparatively small. Nevertheless, our interviews in other countries and in the UK have shown that even the capable companies often need additional support in pointing them in the right direction. It is exactly this role which the ITP Programme was designed to fill.

Other international programmes which have similar objectives to ITP include the Swedish STATT network of science and technology counsellors and the Norwegian 'industrial attachés' (NIA) programme. Both tend to focus on higher level research on, and supply of, information and technological intelligence rather than the hands-on business development role of ITP.

Appendix 9 | Some data regarding Human Resources in R&D

Scientific Workforce:
The **relative number of scientists and engineers is with 4.3 per 1000 employees in Estonia 1999 relatively high** (compare with Hungry 3.1, Czech Rep. 2.6, Slovenia 4.1; but Sweden and Finland > 9). EU average is 5.1 (1997).

University level – graduates from master courses

Field of science	*1995/96*	*1997/98*	*1998/99*	*1999/00*
Total	410	586	672	698
All natural sciences	58	76	53	84
... of which natural sciences	48	62	39	64
... of which mathematics / computer sciences	10	14	14	20
Engineering	14	48	65	63
Medical sciences	172	204	164	120
Agricultural sciences	20	25	19	21
Social sciences	80	92	209	184
Humanities	29	67	78	81
Other (mostly teacher training)	35	74	84	145

Source: ESA.

University level – graduates from doctoral courses

Field of science	*1995/96*	*1997/98*	*1998/99*	*1999/00*
Total	38	106	135	117
All natural sciences	6	17	30	30
... of which natural sciences	6	17	24	26
... of which mathematics / computer sciences	-	-	6	4
Engineering	6	4	9	8
Medical sciences	15	73	78	52
Agricultural sciences	7	6	7	6
Social sciences	-	1	6	11
Humanities	4	5	5	10
Other (mostly teacher training)	-	-	-	-

Source: ESA.

Full-time equivalents (FTE) R&D personnel (incl. researchers, technicians and other R&D personnel)

	Higher education	*Government sector*	*Private non profit*	*Total non profit*	*Business enterprises*	*Total*
1996	2.224	2.200	19	4.444	...	...
1997	3.042	1.214	15	4.272	...	...
1998	3.077	1.069	14	4.160	440	4.600
1999	2.907	1.005	15	3.927	618	4.545
2000	2.305	984	40	3.292	...	...

Source: ESA.

Note the 25% decline in the public sector from 1996 to 2000. Note also the relation between people working in the business and in the public sector: Only about 16% working in business sector. Though there are statistical problems and also the figures will be a little better in 2001, this is one of the most striking factors.

Out of 3.292 FTE in all non-profit sectors in the year 2000, 2.392 FTE are researchers. They work in the following fields:

Natural sciences	*Engineering*	*Medical sciences*	*Agricultural sciences*	*Social sciences*	*Humanities*	*Total*
859	431	214	193	348	350	2.392

Source: ESA.

R&D personnel – in industry 1998 and 1999, by economic sector; see also BERD numbers in the following section: data can only be judged as very unreliable.

	Full time equivalent 98	*Total number 98*	*Full time equivalent 99*	*Total number 99*
9.1.1.1 Primary sector	*3*	*5*	*1*	*3*
9.1.1.2 Secondary sector	*112*	*219*	*198*	***362***
Manufacturing total	***104***	***203***	***172***	***297***
Manufacturing of food and beverage	11	16	17	42
Manufacturing of chemical products	28	54	41	67
Manufacturing of electrical + optical instruments	**9**	24	23	48
Manufacturing of transport equipment	29	32	33	33
Electricity, gas, water	6	11	12	26
Construction	2	5	14	39
9.1.1.3 Tertiary sector	326	562	**419**	**749**
Of which computer service			69	147
Of which R&D firms			53	82
Total	**440**	**786**	**618**	**1114**

Source: ESA.

In 1999 only 0.54 researchers and engineers per 1000 workers were employed in Estonian enterprises. EU average about 2.5.

Appendix 10 | Overview of interviewed organisations and persons

Firms

Agro-food sector	- Mr. V. Kolbakov
Artec Design Group	- Mr. K. Kevvai, Mr. J. Põldre, Mr. A. Kuusik, Mr. G. Poola
Asper Biotech	- Mr. A. Kaldalu, Mr. N. Tõnisson, Mrs. M. Leego
Balteco	- Mr. L. Sumberg
Curonia Research	- Mr. A. Reinsalu
Cybernetica	- Prof. Ü. Jaaksoo
Eesti Põlevkivi	- Mr. L. Kaljuvee
Elcoteq Tallinn	- Mr. I. Petersen
Elcoteq Helsinki	- Mr. T. Pitkänen
Elvex	- Mr. A. Kasak
Ericsson	- Mr. V. Sepp
Estiko Plastar	- Mrs. G. Viia
Estla	- Mr. J. Slivinski, Mr. E. Berik
JOT	- Mr. A. Elbrecht
Kemm Electronics	- Mr. E. Kaeval
Kevelt	- Mr. I. Järving
Microlink	- Mr. A. Martinson
Norma	- Mr. P. Tibbo
Pro-Syntest	- Mr. M. Eek
Quattromed	- Mr. E. Mölder
Regio	- Mr. J. Jagomägi
Silmet	- Mr. M. Pilv
Tallegg	- Mr. A. Käsper
Tarkon	- Mr. V. Erlich
Tartu Õlletehas	- Mr. R. Sööt
Thulema	- Mr. A. Kull

Group discussion with firms

Silmet	- Mr. M. Pilv
Canon	- Mr. A. Haamer
Saint-Gobain Sekurit	- Mr. A. Kasak
Federation of Engineering Ind.	- Mr. A. Hõbemägi
Viru Keemia Grupp	- Mr. J. Purga
Eesti Energia	- Mr. I. Aarna
Ass. of IT and Telecom companies	- Mr. I. Bartels
Elcoteq	- Mr. I. Petersen
Microlink	- Mr. A. Martinson

Universities / R&D Institutes

Tartu University (management)	- Prof. J. Aaviksoo
Tartu University (management)	- Prof. H. Everaus
Tartu University, Institute of Technology	- Prof. T. Kivikas, Prof. M. Karelson, Mr. R. Luht
Tartu University, Institute of Physics	- Mr. A. Aabloo, Prof. K. Haller
Tartu University, Institute of Chemical Physics	- Prof. M. Karelson
Tartu University, Faculty of Medicine	- Prof. T. Asser
Tartu University, Institute of Physical Chemistry	- Prof. E. Lust
Tartu University, Department of Chemistry	- Prof. J. Järv
Tartu University, Faculty of Biology and Geography	- Prof. A. Heinaru
Tartu Molecular Diagnostics Centre	- Prof. A. Metspalu
TTU (management)	- Mr. A. Kamratov, Mr. M. Kivilo, Mr. K. Parre, Mr. T. Tamm
TTU Innovation Centre	- Mr. R. Tamkivi
TTU Engineering Centre	- Prof. R. Küttner
Department of Radio and Comm. Engineering, TTU	- Prof. A. Taklaja
Department of Electronics, TTU	- Prof. M. Min
Department of Materials Technology, TTU	- Prof. P. Kulu

Department of Polymeric Materials, TTU	- Prof. T. Kaps
Department of Basic and Applied Chemistry, TTU	- Prof. M. Lopp
Faculty of Civil Engineering, TTU	- Prof. K. Õiger
Department of Thermal Engineering, TTU	- Prof. A. Paist
Institute of Cybernetics, TTU	- Prof. J. Penjam
Faculty of Power Engineering, TTU	- Prof. O. Liik, Mr. J. Jöller
Department of Environmental Engineering, TTU	- Prof. K. Hääl, Prof. E. Loigu
Department of Machinery, TTU	- Mr. M. Eerme
Centre of Biomedicine and Biotechnology	- Mr. E. Truve

Government

Academy of Sciences	- Mr. J. Engelbrecht
City of Tallinn Enterprise Dept.	- Mr. M. Repnau
Estonian Investment Agency	- Mr. A. Viirg, Mrs. A. Varvik
KREDEX	- Mrs. M. Rute
Ministry of Economic Affairs	- Mr. R. Malmstein
Ministry of Education	- Mr. R. Vaikmäe, Mrs. H. Lutterus
Ministry of Finance	- Mr. R. Mändmets, Mr. M. Kalda, Mr. T. Porgand
Ministry of Finance, EU expert	- Mr. A. Keskpaik
Mission of the Republic of Estonia In the European Union	- Mr. T. Räim
Research and Development Council	- Mr. M. Tiits
Regional Development Agency	- Mr. Ü. Alamets

Experts

ETLA	- Mr. H. Hernesniemi
TEKES	- Mr. J. Romanainen

Appendix 11 | Overview of background information, studies and reports

Policy Documents

- Knowledge Based Estonia, Estonian Strategy for Research and Development 2002-2006, Ministries of Economic Affairs and Education, 2001/2002
- Preliminary National development Plan 2000–2002
- National Development Plan 2001–2004
- Pre-accession Economic Programme – Republic of Estonia, 2001
- National Programme for the Adoption of the Acquis (NPAA) – Office of European Integration, 2000 and 2001
- Estonian Progress Report for the Commission Review, Office of European Integration, 2000.

Other strategic Documents/information

- Estonian law on the organisation of R&D – 1997
- Statute of the Department of R&D – Tallinn Technical University 2000
- Development of R&D Activities at Tallinn Technical University for 2002-2003
- Business plans Tallinn Technology Park and TTU Innovation Centre
- General background materials on Tartu University, the TU Innovation Centre and TU Science Park
- Power point presentation with general information about TTU
- Power point presentation about ESTAG activities
- SPINNO proposals (entrepreneurial universities) by Tallinn and Tartu University
- "Green Paper" about the pilot project "Development of a Regional Co-operation Network for Innovative Entrepreneurship in Estonia – Report related to EU Structural Funds
- Feasibility Study for an Economic and HR Development Project in the Tartu area – PHARE/CARIN, 2001
- High tech venturing in Estonia: background report for the SPINNO programme – Technopolis and KU Leuven R&D, 2001

Background studies/reports

- Research and Development in Estonia, Structure and Trends 1996–1999, R&D Council, 2001
- R&D in Estonia, R&D Council 1998
- Scientific Development in a small country – Estonian academy of sciences, 1999
- Review Estonian Economy 1999 – Ministry of Economic Affairs
- Innovation policy in six Candidate Countries: Estonia profile – Estonian Institute for Futures Studies, 2001
- Reports on the Candidate Countries' Measures to Promote Entrepreneurship and Competitiveness – European Commission, 2001
- The State of small business in Estonia – PHARE report 1998
- Country report Estonia: monitoring, updating and disseminating developments in innovation and technology diffusion in Central and Eastern Europe – Economist Intelligence Unit – 2000
- Technology policy in Estonia: system planning and development of implementing agency (ESTAG) – Finnish Institute of public management 2001
- Technology Policy for Improving competitiveness of Estonian Industries – ETLA – Helsinki 1997
- Inherited and emerging absorptive capacities of the firms and growth prospects in Estonia – ETLA – Helsinki 1998

Statistical data/facts and figures

- Official statistical data on GDP; R&D-expenditures; industrial structure; industrial production; industrial investments; sectoral developments; exports; sub-contracting; education and labour force,1999–2001
- Facts and figures about the Estonian economy and economic sectors – Estonian Investment Agency 2000

International good practices

- Report on “New ideas about Research for Development” (in Developing Countries) – Technopolis 2001
- An International Comparative Study on Initiatives to Build, Develop and Support Competence Centres – Technopolis 2001
- International Good Practices in High Tech Venturing – Part of SPINNO report by Technopolis and KU Leuven R&D, 2001
- International comparison in Monitoring and Evaluating Technological Top Institutes
- Technopolis 1997
- Reports on UK Regional Centres for Manufacturing Excellence – Technopolis 2000
- Power point presentations on the K plus Competence centre programme in Austria
- Power point presentation on the STRATA-MAP project

Appendix 12 | Questionnaires used in the interviews

1. Firms

General business issues

- History of your company
- The most relevant competitive factors for your company
- Who are your main competitors
- What will be the critical factors/needs for growth in the next years

R&D[36] as part of the business process

- Where does your company get new technology and new knowledge from
- How is R&D organised within your firm
- Main bottlenecks/opportunities in relation to R&D performance

Networking

- Your R&D co-operation with suppliers, competitors, business organisations, Research Institutes and/or Universities
- Your opinion about Universities as partners for Industry
- Your main needs for external support/R&D co-operation in the next years and possible co-operation with Competence Centres

Estonia in general

- Your opinion about the situation and prospects (technological developments) of Estonian industry in general.
- Your opinion about the technology fields in which Estonian R&D efforts should be strengthened (technology fields promising future economic success).
- Your opinion about the effectiveness of external business support in Estonia.

2. Individual researchers

- Your own co-operation with industry: how is it organised, what are the topics, what are the possibilities or bottlenecks and constraints for further development of this kind of co-operation
- Do you participate in Estonian and international applied R&D networks or programmes
- What is your vision of the general support and of the legal and organisational framework, the funding and the Intellectual Property rules provided by the University
- How do you assess the R&D performance of Estonian industry. If you could spend extra R&D money, what would be the 5 Estonian companies you'd like to co-operate with
- How do you estimate the potential market for science-industry R&D co-operation in Estonia, what are in your opinion the most promising research topics and do you see any interesting multi-disciplinary research fields arising
- Can Competence Centres contribute to create more applied R&D and more science industry co-operation. Can you suggest any other other instruments
- Assessment of Estonian Universities as a partner in R&D development : now and in the future: recommendations for improvements
- Assessment of Estonian Industry as a partner in R&D development : now and in the future: recommendations for improvements

3. University management

Internal situation

- Your R&D capacity: priority areas, level, infrastructural situation and funding (fundamental vs. applied research)
- Your organisation: how are R&D programmes established; the level of concentration/de-concentration; the allocation of reponisibilities; who can make contracts with industry; where are the benefits going
- The main constraints, bottlenecks and opportunities in relation to applied R&Dperformance and the establishment of science-industry contracts
- The expected development in next 5 years of applied research and science-industry co-operation

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[36] *Research & Development is often only identified with science on an academic level. But in this interview we'd like you to proceed from a broad definition of R&D, in all cases relevant to business development and growth, but ranging from fundamental longer-term industry-related research to actual process and product development.*

External networks

- The history, content and organisation of external R&D co-operation and networks; especially science-industry co-operation (also amount and turnover and breakdown of project based vs. longer term contracts)
- Description of client composition (what kind of firms, sectors, technology areas)
- Assessment of the actual and potential Estonian client market
- "SWOT" of Science-Industry co-operation; recommendations for improvements;
- The potential role and tasks of Competence Centres and suggestions for other instruments to improve applied R&D and Science-Industry Contracts

Estonia in general

- Your assessment of R&D capabilities in Estonian Industry: main characteristics and bottlenecks; recommendations for improvement; what private sector "technology areas" should be mirrored by University R&D
- Your assessment of government R&D and innovation policy: recommendations for improvement

4. Foreign direct investments policy expert

- We'd like to discuss the characteristics of Foreign Direct Investments (FDI) in Estonia in terms of sectors, investments, human resources and R&D activities/potential
- We'd like to discuss any information you might have about the influx of skilled foreign managers, engineers and scientists into Estonia
- We'd like to discuss the connections between Foreign Direct Investments and Estonian industry and with the Universities and R&D institutes
- We'd like to discuss the policy framework and strategy for the attraction of FDI in Estonia
- We'd like to discuss the main bottlenecks and incentives to attract FDI (also looking at the role that Universities, Research programmes, R&D Institutes and Science – Industry co-operation could/should play) and your ideas about possible improvements
- We'd like to ask your opinion about other measures the Estonian government could or should take to stimulate the competitive power and innovation capacity of the Estonian economy in general and FDI in particular
- We'd like to ask your opinion about other measures the Estonian government could or should take to stimulate the development of the Universities and R&D Institutes in Estonia in general and their connection with/relevance for FDI in particular

5. Estonian Investment Agency

- We'd like to discuss the characteristics of Foreign Direct Investments (FDI) in Estonia in terms of sectors, type of investments, human resources, present R&D activities and R&D potential
- We'd like to discuss any information you might have about the influx of skilled foreign managers, engineers and scientists into Estonia
- We'd like to discuss the connections between Foreign Direct Investments and Estonian industry and with the Universities and R&D institutes
- We'd like to discuss the main bottlenecks and incentives to attract FDI (also looking at the role that Universities, Research programmes, R&D Institutes and Science – Industry co-operation could/should play) and your ideas about possible improvements
- We'd like to discuss the strategy for the attraction of FDI in Estonia in the coming years (also in the light of EU accession)
- We'd like to hear your opinion about the possible connections between Investments policy and R&D policy
- We'd like to ask your opinion about other measures the Estonian government could or should take to stimulate the competitive power and innovation capacity of the Estonian economy in general and FDI in particular
- We'd like to ask your opinion about other measures the Estonian government could or should take to stimulate the development of the Universities and R&D Institutes in Estonia in general and their connection with/relevance for FDI in particular

6. KREDEX and Estonian Regional Development Agency (ERDA)

- What services does your organisation offer to Estonian firms (content, organisation, target groups (sectors, firm size, firm characteristics) and what is your role or niche in the overall Estonian system of Business Support measures and organisations

- Are you connected to or co-operating with other service organisations
- Can you describe your target groups in terms of competitive power, innovation capacity, human resources and research and development capacity
- Can you describe your target groups in terms of their needs for external support
- What are the possibilities, bottlenecks and constraints for further development of the competitive power and innovation capacity of Estonian firms
- What measures should the Estonian government take to stimulate the competitive power and innovation capacity of Estonian firms
- What is in your opinion the actual and potential role of the Estonian Universities and Research Institutes in the economic development of Estonia
- What is your estimation of the size and quality of the Estonian "R&D market" and the target groups/spearheads for science-industry co-operation

7. Ministry of Education legal expert

- We'd like to discuss the national and institutional legal frameworks for the Estonian Universities and R&D Institutes and for their scientific activities, applied R&D activities and science-industry co-operation
- We'd like to discuss in more detail Ministry –University relations (contracts; funding principles; IPR regulations; degree of freedom on different levels: what can the University do, what can a Department do) and the inner organisation of Universities (what has to be done according to the law, what can be done in freedom by the University itself)
- We'd like to discuss the legal framework for vocational and higher education in Estonia
- We'd like to discuss the strong and weak points of these legal frameworks and the possibilities for further development (also related to the influence of European Union regulations)
- We'd like to hear your vision on the development of R&D Competence Centres in relation to these legal frameworks (possible legal structures)
- We'd like to ask your opinion about other (legal) measures the Estonian government could or should take to stimulate the competitive power and innovation capacity of Estonian firms (also looking at the system of education)
- We'd like to ask your opinion about other (legal) measures the Estonian government could or should take to stimulate the development of the Universities and R&D Institutes in Estonia

8. Ministry of Education policy expert

- We'd like to discuss the role that your Ministry performs in relation to scientific development, Science Competence Centres and applied R&D development in Estonia
- We'd like to discuss the present situation and developments with regard to vocational and higher education in Estonia (also in connection with human resources for Estonian industry)
- We'd like to ask your opinion about the most promising areas of fundamental and applied research in the near future in Estonia
- We'd like to hear your vision on the role R&D Competence Centres could fulfill in the realisation of stronger science-industry co-operation and possible connections of these Centres with policy measures related to University development and fundamental research
- We'd like to discuss the tasks that R&D Competence Centres should fulfill to be able to stimulate the R&D capacity of Universities, R&D Institutes and Estonian Industry
- We'd like to ask your opinion about other measures the Estonian government could or should take to stimulate the competitive power and innovation capacity of Estonian firms (also looking at the system of education)
- We'd like to ask your opinion about other measures the Estonian government could or should take to stimulate the development of the Universities and R&D Institutes in Estonia

9. Ministry of Finance

- We'd like to discuss the structure of funding in Estonia for fundamental research and applied R&D: in general and for projects and programmes
- We'd like to discuss the Estonian regulations and legal frameworks for R&D funding and R&D performance
- We'd like to discuss the strong and weak points of the structure of funding and of the regulations and the possibilities for further development (also related to the influence of European Union regulations)
- We'd like to hear your vision on the development of R&D Competence Centres in relation to the structure of funding (possible funding structures)

10. Academy of Sciences and R&D Council

- We'd like to ask for information about and your opinion on existing and coming policies and (financial) measures in relation to scientific development, Science Competence Centres, applied R&D development and science-industry co-operation in Estonia
- We'd like to ask your opinion about the most promising areas of fundamental and applied research in the near future in Estonia
- We'd like to hear your vision on the role R&D Competence Centres could fulfill in the realisation of stronger science industry co-operation
- We'd like to discuss the tasks that R&D Competence Centres should fulfill to be able to stimulate the R&D capacity of Universities, R&D Institutes and Estonian Industry
- We'd like to ask your opinion about other measures the Estonian government could or should take to stimulate the competitive power and innovation capacity of Estonian firms
- We'd like to ask your opinion about other measures the Estonian government could or should take to stimulate the development of the Universities and R&D Institutes in Estonia
- We'd like to ask your estimation of the size and quality of the Estonian "R&D market" and the most important target groups/spearheads for future science-industry co-operation

11. Structural Funds expert Ministry of Finance

- I'd like to discuss the role that your Ministry performs in relation to EU accession and the preparation of Single Programming Documents and other documents related to the allocation of EU funding
- I'd like to discuss the strategy and priority areas underlying the allocation of Structural Funds and other EU funding in Estonia in the coming years
- I'd like to discuss the operationalisation of this strategy, in terms of management structure, co-funding, application procedures, etc.
- I'd like to discuss the (future) role of Structural Funds and other EU funding in improving the Estonian Innovation System and the R&D performance in Estonian Universities, R&D Institutes and Industry
- I'd like to discuss the connections between the Structural Funds, other EU funds, Investment policy and R&D policy in Estonia
- I'd like to ask your opinion about any other measures the Estonian government could or should take to stimulate the competitive power and innovation and R&D capacity of Estonia

12. City of Tallinn

- What are the policy measures and the strategy of the City of Tallinn related to the economic development of the city (especially looking at the role of the University, the R&D Institutes and the new Technology Park)
- What services does your Department offer to firms in Tallinn (content, organisation, target groups (sectors, firm size, firm characteristics)
- Is the City of Tallinn financially, legally or in other ways involved in R&D initiaves at the University, the stimulation of science-industry co-operation or the stimulation of R&D in firms
- Is the City of Tallinn financially, legally or in other ways involved in the development of higher and vocational education
- Can you describe the characteristics of Tallinn enterprises (also the start-ups) in terms of their competitive power, innovation capacity, human resources and research and development capacity
- Can you describe the characteristics of Tallinn enterprises in terms of their needs for external support
- Are you connected to or co-operating with other service organisations
- What are the possibilities, bottlenecks and constraints for further development of the competitive power and innovation capacity of the business community in Tallinn

- What measures should the Estonian national government take to stimulate the competitive power and innovation capacity of Estonian firms
- What is in your opinion the actual and potential role of Tallinn University and the Research Institutes in the economic development of Estonia

13. Mission of the Republic of Estonia in the European Union

- We'd like to discuss the role that you and your colleagues perform to stimulate international R&D co-operation with Estonia and the initiatives your are working on at the moment
- We'd like to discuss your role in connecting Estonia to EU programmes, like the 5th and 6th Framework programmes and we'd like to know in which projects and programmes Estonia is already participating or planning to participate
- We'd like to ask your opinion about the present state of the Estonian R&D system and it's capabilities to co-operate with Estonian and foreign partners in applied R&D and development projects.
- We'd like to ask your opinion about the most promising areas of fundamental and applied research in the near future in Estonia
- We'd like to ask your vision on the role R&D Competence Centres could fulfill in the realisation of stronger science-industry co-operation in Estonia and possible connections of these Centres with international partners and programmes
- We'd like to discuss the possibilities you perceive for co-funding the Centres and projects and programmes from international sources
- We'd like to hear your opinion about possible connections between R&D policy, Foreign Direct Investment policy and EU accession policy (i.e. the Structural Funds)
- We'd like to ask your opinion about other measures the Estonian government could take to stimulate science-industry co-operation in Estonia

14. International experts

- Your opinion about Estonian industry in terms of the competitive issues and "drivers for change" for the next years and the related needs for external business support
- Your view on the strengths and weaknesses of the Estonian business support system (also in relation to the needs of Estonian industry)
- Your opinion about the actual and potential role of the Estonian Universities and Research Institutes in the economic development of Estonia
- Your opinion about the characteristics of the Estonian Universities, R&D Institutes and Estonian industry in terms of their capabilities to work together on applied R&D, technological development and innovation in Estonia (and their capabilities to intensify international co-operation)
- Your opinion about the most promising areas of fundamental and applied research in the near future in Estonia
- Your estimation of the potential size of the Estonian "R&D market" and the scientific and industrial target groups/spearheads for science-industry co-operation.
- Your vision on the role R&D Competence Centres could fulfil in the realisation of stronger science-industry co-operation
- Your vision on R&D policy in Estonia in general, also in relation to Investment policy and EU accession policy