Evaluation of Teltec Ireland

EXECUTIVE SUMMARY

Telecommunications is a very attractive sector, and one which should be a focus of Irish industry and technology policy. The rates of market growth and technological change are high, providing entry opportunities and encouraging inward investment as companies expand. The increasingly rich Irish technological infrastructure in electronics and the presence of other electronics and telecommunications firms make Ireland an attractive location, as does the comparatively good supply of highly educated and skilled labour. There is a sufficient mass of activity and sufficient opportunities to access demand that niches within telecommunications equipment manufacturing are attractive for entry. In addition, telecommunications is a highly generic technology: national skills tend to be useful in user industries as well as in the business of making telecommunications equipment.

Teltec addresses a wide spectrum of technologies within telecommunications, reflecting the rather disparate character of the sector in Ireland. Our interviews with industry confirm that levels of interest in Teltec's technologies are significant and growing. In some areas, Teltec has taken a broad approach during the period of raising its own technological capabilities. Over time, Teltec's foci of technological strength are being refined by its interaction with the market and the needs of the developing Irish industry.

A key capability within Teltec is radio propagation studies. In this way, the programme is able to contribute to the development of the national telecommunications network, as this acquires a growing radio-based component. So far, however, working interaction with Telecom Eireann has been limited. Improving and sustaining this relationship is a precondition for Teltec more effectively to contribute to national network development.

As a PAT, Teltec's objectives are to contribute to industrial development within a tight financial framework of declining subsidy. Teltec's contributions to development to-day have two forms: strengthening R&D capabilities via project support; and providing a flow of trained postgraduates into an area of acute skill shortage in order to enable development and expansion. As the requirement for cost-recovery rises, postgraduate education will successively be squeezed out of the programme. In the context of the bottleneck to development caused by the current skill shortage, this is undesirable and implies that funding rules need to be modified to enable postgraduate education to continue to be funded - inside or outside Teltec.

Managing an industry-oriented programme in a university context is difficult. It takes time to introduce the necessary industrial approach and culture. Teltec has made progress in this direction, but more remains to be done in order to exploit the full potential value of central organisation and management. The needed improvements are well within the reach of Teltec, and we are proposing a programme of operational improvements to help with this process.

The scientific and technical quality of the work in the programme overall is solid. Naturally, the projects which are focused on developing capabilities within the universities are stronger on the scientific dimensions, while the client-funded work has more short-term relevance to industry.

Industry is substantially involved in the programme through the client-funded work. Since external revenues are running a small number of percentage-points below plan, there is clearly scope to increase industry's involvement. However, the gap between planned and actual revenues is not large and should be closed via more effective marketing.

A very substantial amount of work has been won on European Union projects which will provide a major share of the programme's external revenues in the period up to 1998. This is important testimony to the quality of the programme. However, there is a clear need to maintain a substantial focus on Irish industry and further work in the coming period should primarily be sought at home.

Evaluation of Teltec Ireland

Teltec has a unique mission within Irish science and technology policy. Its currently planned scale appears consistent with the industrial opportunity and needs. It should therefore be continued as planned.

We found little to criticise in the balance of technologies chosen by the programme. As long as its funding continues to contain a substantial component of fee-based industrial assignments, we expect market forces to continue the current good balance of efforts and to maintain relevance.

The main change we have proposed in strategy is to create more central activities in the programme. It should take on some of the 'technology watch', standards-monitoring and information provision roles often played by Research Associations. In this context, Teltec should strive to take on a role as the natural Telecommunications Forum for Ireland.

We have identified organisational development needs and proposed a programme to handle these. Modified performance indicators are also proposed, which can readily be integrated into the programme's internal information management processes without adding a significant reporting load.

Evaluation of Teltec Ireland

INTRODUCTION

Teltec Ireland is one of seven Programmes in Advanced Technology set up by the Irish government to exploit technological capabilities in the higher education sector in support of industrial development. It aims to provide national capability in research and development (R&D) for the telecommunications community in Ireland.

Teltec was approved by the EOLAS Board in October 1990 and began spending money the following month. However, fee-earning operations only began in 1992, when a Programme Director and a Board of Directors were appointed. From that time, the programme was required to meet rising annual revenue targets by selling research and other services, thereby reducing the level of subsidy to 20% of the programme costs over a seven-year period.

Why Evaluate Teltec Ireland?

This is a 'mid-term' evaluation. Its purpose is to review Teltec's progress, advise the Department of Enterprise and Employment on any policy changes required and to propose any operational improvements which could be helpful through the remainder of the programme.

The evaluation was commissioned by the Department of Enterprise and Employment's Office of Science and Technology and was managed on its behalf by the Science and Technology Evaluation Unit in Forfás, the Policy and Advisory Board for Industrial Development in Ireland.

Broadly, there are two kinds of programme evaluation which are called, in the jargon, summative and formative. A summative evaluation tries only to sum up programme performance. The summative evaluator's job is to be like the judge in the ice-dancing Olympics - awarding points for performance but not becoming involved. In a formative evaluation, the evaluator is much more like a sports coach - trying not only to identify the strong and weak points but also helping to improve the performance.

This is intended to be a formative evaluation. Our formal brief is shown in the following exhibit.

Evaluation Brief

1. Undertake an evaluation of Teltec Ireland in order to determine:

- the appropriateness of the technology areas in which it is involved, particularly in relation to their current and potential impact on industrial development in Ireland, and their relevance to the strategic development of the national telecommunications network;
- the suitability of its current objectives, and the extent to which they are being met;
- the efficiency and effectiveness of its management structure, operating procedures and marketing methods;
- the commercial, scientific, and technical merit of the work being undertaken;

the extent of industry involvement in the programme's activities.

2. Carry out this evaluation by:

- analysing existing data on the programme's performance;
- interviewing Teltec management, individual researchers and engineers, and other interested parties, including key management personnel in Forbairt;
- assessing the quality and relevance of the current and proposed project work, and the facilities available, at each operating centre;
- undertaking a survey of existing and potential client companies, and holding consultations with relevant organisations, to establish the relevance of the programme to current and future industrial needs;
- identifying and commenting on any significant relationships between the programme and other State-supported or private sector activities;
- comparing the programme with any similar initiatives in other countries;

carrying out any other investigations relevant to the purposes of the evaluation.

3. Provide a report of the results obtained, with recommendations on:

- the continuation of the programme – whether it should remain at the same level, be expanded, contracted, terminated or amalgamated with other activities – and its future objectives, in the context of current industrial policy objectives in Ireland, and worldwide trends in telecommunications;
- the optimum balance in the work of the programme between different niche technologies, and in relation to different sectors of Irish industry and overseas clients;
- methods for increasing the level of industrial involvement, and the programme's contribution to the development of Irish industry;
- actions to enhance the cost effectiveness of the programme, and of the PATs in general, through modification of the management structures or improvement in the procedures for dissemination of results, marketing or general administration;
- definitions of possible new indicators which might be relevant to both OST and programme management for continuous or periodic monitoring of performance against objectives.

Evaluating programmes brings a number of important benefits:

- The most obvious benefit is independent measurement: learning from outsiders who have no economic or 'political' interest in the outcome of the programme or how well it has done in reaching its goals
- In economic terms, since state-funded programmes tend to be 'monopoly' suppliers, the evaluation offers a way to provide the 'criticism' that a competitive market is normally expected to provide. This can mean, for example, that users' concerns can emerge; also, that the taxpayer has a proxy voice. If the programme is worth doing - and is well done - it should be possible to demonstrate this to the satisfaction of the taxpayer
- If an evaluation is conducted during a programme, it can provide important management information about the need for 'mid-course corrections' in the programme - allowing increases in effectiveness and efficiency by using experience from the first part of the programme to change procedures in the second part
- More broadly, an evaluation documents the experience of the programme, so that this can be fed forward into the design of new programmes

We believe that working with an international team brings particular benefits: the evaluators are more easily seen to be independent than national evaluators. An international team can bring perspectives and experience from a number of countries, so that the evaluation allows policymakers and programme managers to learn both from their own programmes' experience and from the experience of others.

Evaluation of Teltec Ireland

Method

Our objective in this study was to provide a rounded picture of the Programme's performance and the policy implications. No single method provides this. Neither can a single experimental technique yield convincing results about historical events where we can conduct no control experiments. For both these reasons, we needed to employ overlapping methods and to look for convergence among the findings emerging from each method. To the extent that the various techniques used told the same story we are able to have a high degree of confidence in our explanation and analysis.

We have therefore addressed the brief through:

- Analysing the composition and operation of the Teltec programme and of the Irish telecommunications industry through desk research and interviews
- Meeting with industry to understand its needs and its views of the opportunities provided by Teltec
- Working with a panel of technology experts to review project outputs, visit the University Centres involved and understand the scientific quality and relevance of individual projects in the programme
- Feeding drafts of the project evaluations and our overall report back to programme participants for comment

While an organised and scientific approach to this type of work is crucial, an element of judgement is inescapable in an evaluation, as in much social science. As a matter of good practice we have tried to make our judgements as explicit as possible, in order to allow readers to make up their own minds.

Structure of the Report

This report is designed to be read at three levels:

- The Executive Summary can be read alone. It performs the traditional job of covering in a few pages the substance of the report
- Chapter 5 can be read in isolation. It sets out our main conclusions and recommendations, but does not discuss the evidence which led us to these
- The whole report can be read from front to back in the traditional way. In this case, the reader will be guided through the data, analyses and judgements that led us to our findings. Chapter 5 then translates those findings into conclusions and recommendations

Chapter 1 of the report is intended to provide an introduction and guide to Teltec Ireland. The Chapter therefore describes the programme and its goals. It sets out the unique role of the programme in Ireland. It explains what the programme does, how it is organised, managed and run, and shows what has happened to Teltec-funded postgraduates. Finally, it compares Teltec with some equivalent programmes abroad.

Chapter 2 sets out the findings of our expert panel on the quality and industrial relevance of the programme.

Chapter 3 discusses the telecommunications industry, particularly in Ireland; how technology and technology needs are changing in telecommunications; and industry's views on Teltec.

Chapter 4 discusses the organisation and management of the programme, identifying areas where process-improvements are available.

Chapter 5 draws conclusions and makes recommendations.

TELTEC IRELAND

This Chapter describes Teltec Ireland: the national Programme in Advanced Technology (PAT) for the telecommunications sector. While our report is primarily intended for the funders and other actors in the programme, the intention in this Chapter is also to provide sufficient detail to allow people not closely involved with the programme to read and understand the evaluation.

The Chapter therefore describes the programme and its goals. It explains what the programme does, how it is organised, managed and run. It sets out Teltec's unique role in Irish policy and discusses the special role the programme has played in postgraduate training. Finally, it looks to some other European programmes and institutions to see how other countries address similar policy needs.

Teltec: History

In 1989, EOLAS published a discussion document2 setting out a strategy for spending some of the European Structural Funds then becoming available to Ireland on science and technology for industrial development. Telecommunications was one of a number of growth areas identified where a Programme in Advanced Technology (PAT) would be useful in raising university and industry capabilities and in linking the two.

Telecommunications was prioritised because:

- Indigenous start-up companies were appearing in the sector and appeared strong enough to be sustainable
- The EU was investing heavily in telecommunications and related areas in its R&D programmes, suggesting that this was likely to be a growth node, and also showing which technical areas within telecommunications were likely (based on Europe-wide industrial and research consultation) to have relevance
- Irish universities had themselves been pressing for ways to advance and exploit their telecommunications capabilities, notably through the relevant Special Interest Group in the former National Board for Science and Technology (NBST)
- Grant applications for the HEIC industry-university R&D collaboration programme indicated a significant amount of interest in telecommunications

During the summer of 1990, a 'top-down' specification was made by the EOLAS Information Technology Group for the technology areas to be covered by a telecommunications programme, and the Universities were asked to indicate what roles they could play.

The resulting programme design was tested with an industrial panel comprising a mix of representatives from indigenous and multinational telecommunications companies and published within the public sector . It was accepted by the EOLAS Board in October 1990, and launched immediately under the part-time supervision of an EOLAS official.

For something over a year, the activities of the programme were primarily to invest in capital equipment and to recruit postgraduates at the participating universities. In early 1992, a Director and a first tranche of Teltec-funded research staff were appointed. A Board was convened for its first meeting in April.

Evaluation of Teltec Ireland

The new Director and the Board took the opportunity to review Teltec's scope and its potential client base. The Board was concerned that it had not been involved in the investment decisions of the past two years, which had the effect of committing it to a strategy which it did not 'own'. A series of interviews was therefore conducted by the Programme Director with key figures in the Irish telecommunications industry in order to confirm the nature of demand.

It was decided that not all the needed capabilities were adequately present in the Universities, and that therefore Teltec should fund the strengthening of capability as well as the exploitation of what already existed. An internal Call for Proposals was launched in September 1992 and submissions were refereed by an industrial panel. Through the Call, the Programme Director and Board were able to reduce diversity and duplication within the programme's portfolio. In certain cases, this also involved abandoning capital investments made before the Board was set up, for example in microwave equipment at UCD.

Through the Call, projects were sought which had relevance to the telecommunications industry in Ireland, addressed areas of niche opportunity, had commercial linkage potential and built on the proposer's track record. Many of the projects accepted had the character of 'platforms': exploring and defining an area of technology so that the resulting understanding could be used in future projects. Examples include simulating an indoor wireless communications network or developing UHF radio propagation models.

Projects were to last for two years, covering the period 1993-4. At this stage, little project work was being sold to industry, so the capability-developing work dominated the overall workload. While postgraduate funding is planned to continue, growth in industrial projects should over time move the centre of gravity of the programme away from capability development and towards its exploitation.

During 1993, the programme established and agreed a business plan for 1994-98, setting out detailed income and expenditure targets and identifying measures needed to reach these. Recruitment and training were seen as key problems. Internal time and project control systems were needed, as was deeper understanding of actual and potential clients through market research. The appointment of a marketing manager was mooted in the plan, although the Board had earlier argued that the existing Central Directorate should be able to undertake this work. (In the event, the level of funding granted was insufficient to fund a marketing manager.) The Plan also recognised the need for more management capacity at University Centre level.

Following a reallocation of responsibilities for the PATs within the public sector, all the Boards were disbanded at the end of 1994. Overall management responsibility for the PATs was brought together within Forbairt.

Goals

While the wording of Teltec's mission statement has changed over time, the current version expresses well the consistent intention of the PAT's management, namely

```
        ... to develop within Ireland, in partnership with the
    Universities, an R&D structure


        in selected areas of telecommunications which will
    contribute to the competitiveness
```

```
        of existing industry, attract overseas  industry to
   Ireland and aid in the establishment
```

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   of technology-driven start-up companies.
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After a period of discussion, overall objectives were laid down for the PATs by the Department of Enterprise and Employment at the end of 1992 (Exhibit 1.1).

Exhibit 1.1 PAT Objectives and Performance Indicators

The overall goal of the PATs is to enhance the performance of industry in Ireland through research and technology transfer activities. In order to achieve that goal, each PAT has the following **aims:**

- To establish a research agenda, strongly influenced by the current and future needs of Irish industry and thus the ability to identify and to create new industrial opportunities and exploit existing ones
- To undertake industrially oriented R&D, with a progressively increasing content of projects funded on a contract basis, by both domestic and overseas companies
- To generate intellectual property with commercial potential
- To assist industry in Ireland in identifying and sourcing their technology needs
- To provide expertise to industry in Ireland and, through its interaction with industry, to encourage firms to engage in R&D activity
- To develop skilled and experienced technologists for transfer into Irish industry
- To stimulate the start-up of indigenous technology based companies
- To contribute to attracting mobile international investment to Ireland
- Through its establishment, development and marketing of its capability to become a major resource in the national research and development infrastructure and to achieve and maintain a reputation for excellence
- By its research activities, to contribute to the enhancement of the Universities' capabilities and reputation

These aims are to be achieved under the following **financial criteria:**

- At the end of five years in existence, the level of exchequer funding of the PAT should have fallen to a maximum of 50% of total expenditure
- After seven years, this should have reduced further to 20% of total expenditure. Exchequer funds should be increasingly related to specific strategic activities carried out on behalf of, and at the request of, the Minister
- After five years of operation, there should be a clear indication of support from industry in Ireland. At least 50% of the income from industry at this stage should be from companies located in Ireland
- The level of income from industry should be at least 50% of total income (including exchequer funding) at the end of seven years
- The level of income from the EU Framework Programmes should not exceed 30% of total income (including exchequer funding) at the end of seven years

Non-financial measures of success include:

- Patents granted
- Licence arrangements
- New products or processes introduced in industry
- Start-up of indigenous technology-based companies
- Irish companies worked with on a regular basis
- Foreign companies in this field setting up in Ireland or expanding their existing operations
- The number of technologists trained and placed in Irish industry

Source Programmes in Advanced Technology: Policy Statement Department of Industry and Commerce, Dublin, December 1992

The Department said at the time that it did not expect every PAT to reach every goal. Rather, the Policy Statement was a flexible framework which would evolve based on experience. Nonetheless, it was clearly stated that the PATs

1. Would be mission oriented to obviate the possibility of stagnation and self perpetuation
2. Would have well-defined technical goals
3. Would spin off companies and people over the course of their lives
4. Those PATs not succeeding in their stated objectives would be terminated

From the outset, however, there was contention within the Board about the overall purposes of Teltec.

The basic ground rules for the programme need to be made clear. In particular, the exact meaning of becoming commercial needs to be clarified. The future role of Teltec needs to be clarified. It was accepted as a guiding principle that Teltec Ireland should not engage in any activities which are in competition with Irish industry. The Teltec board should have an input to the formulation of general policy with respect to the PATs ...

A significant group within the Board regarded a high level of cost-recovery as an unrealistic target for this kind of programme. It saw the production of large numbers of postgraduates in telecommunications as a much higher priority for meeting industry needs at a time of continual skill shortage. It questioned the idea that Universities could or should produce short-term R&D results for the benefit of industry, and argued that trying to do this could lead the programme into competition with those it intended to serve. In November 1993, a business plan was agreed which conformed to the Department's financial requirements.

In practice, Teltec has been - and continues to be - managed from the centre in line with the Department's programme goals. However, these goals remain contentious among university partners and some industrialists.

Teltec's Structure and Organisation

Teltec Ireland comprises six University-based Centres and a Directorate, based at the Forbairt campus in Dublin. Originally, a seventh centre was based at the National Electronics Test Centre (NETC), co-located with the Directorate. Subsequently, some of this activity has been absorbed into the Directorate, one of whose members continues to work half-time in a scientific (rather than a managerial) capacity.

Formally, Teltec reports with the other PATs to the Executive Director of Science and Innovation at Forbairt, then through the Forbairt Board to the Department of Enterprise and Employment (Exhibit 1.2).

Exhibit 1.2 Organisation of Teltec Ireland, 1995
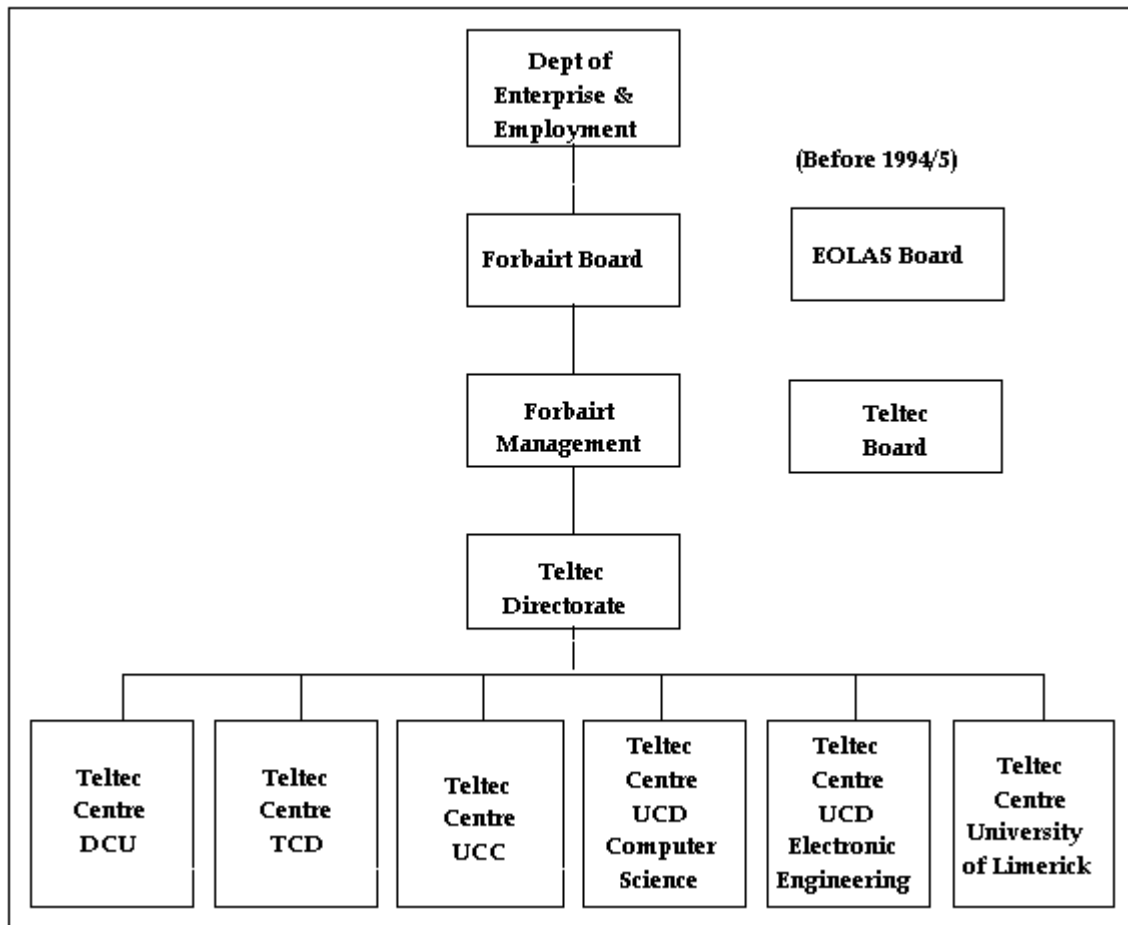
The University Centres are run on a part-time basis by tenured academics, the Centre Directors, who devote some 40% of their time to the programme. The Universities provide premises and pay many overhead costs such as heat and light. In recognition of this, the programme makes an annual budget of £20,000 available to each University, to be used at the discretion of the Director and his University. Typically, this is used to fund additional research in the Centre.

Each Teltec Centre has one or more Research Officers, employed directly by Forbairt or indirectly via the University, and a number of postgraduate students, whose fees and maintenance grants are paid by the programme. Various academics are 'associated' with the programme, typically people supervising the postgraduates.

The Centres earn revenue by selling the efforts of the Research Officers and, more occasionally, the postgraduates and the University academics. Buyers are normally either industry or the EU through its R&D programmes.

Exhibit 1.3 shows the current and projected staffing levels for Teltec, analysed by category. In principle, during the current year, a total of 20 Senior Research Officers (SROs) and Research Officers (ROs) - amounting to some 24% of the total programme staff - bear the brunt of generating industrial income. (In practice some of these posts are vacant.) In two years time, 29 of the programme's 99 staff will be required to generate twice as much industrial money.

As the Exhibit indicates, the Centres vary significantly in size. The smallest, at University College Cork, comprises a total of five people. The largest, at Dublin City University, has

twenty-six. Postgraduates dominate the staff numbers (65%), in line with the former Board's intention that they should be a major feature of the programme.

Exhibit 1.3 Teltec: Current and Planned Staffing

Staff	Direct-orate	DCU	TCD	Universities UCC	UCD CS	UCD EE	UL	Total
Posts, 1995 (at 1 January)								
Centre Director		1	1	1	1	1	1	6
Senior Research Officer		1	1	1	1	1	2	7
Research Officer (Forbairt)		2	1			1	1	5
Research Officer (Uni)		3	3		1		1	8
Post-Graduate		18	7	3	8	7	12	55
Directorate, admin	3	1						
Centre Total	3	26	13	5	11	10	17	85
Programme Total	**85**							
Posts, 1997								
Centre Director		1	1	1	1	1	1	6
Senior Research Officer		2	2	1	1	2	2	10
Research Officer (Forbairt)		2	2	2	2	2	4	14
Research Officer (Uni)		2	1		1		1	5
Post-Graduate		17	8	6	8	8	13	60
Directorate	4							
Centre Total	4	24	14	10	13	13	21	99
Programme Total	**99**							

Source : Teltec Ireland Business Plan 1996-97, Draft C, 16 October 1995

Technology Areas

Teltec Ireland aims to support manufacturers of telecommunications systems and equipment. Users - for example, large companies operating internal multi-site networks based on leased lines - are already relatively well served by private-sector consultants.

Exhibit 1.4 shows the telecommunications R&D capabilities offered through the Teltec University Centres. Certain technologies which were duplicated across centres at the start of the programme have been rationalised. For example, microwave work at UCD Electronic Engineering was originally included within the programme, but has since been dropped.

Exhibit 1.4 Capabilities of Teltec University Centres

Capabilities	Universities					
	DCU	TCD	UCC	UCD-C	UCD-E	UL
Digital Signal Processing						
– Data Comms					▓	
– Speech coding					▓	▓
– Image coding	▓				▓	
Protocol Design & Specification				▓		░
Radio & Microwave Engineering			▓		░	░
Network Management						
– Design & Management	▓			▓		▓
– Security				▓		
– High-Speed Networks, Multimedia	▓			▓		
ISDN Applications	▓			▓		▓
Mobile Communications						
– Systems & Standards						▓
– Radio Propagation		▓				

Key: ▓ Teltec Centre   ░ Available, but Not Offered Via Teltec

The Centres fall into two groups.

Those at DCU, UCD Computer Science and the University of Limerick all offer relatively broad, systems-level sets of technologies. Two-thirds of the manpower involved in Teltec is currently in these areas.

The other three Centres are more narrowly focused on enabling technologies for telecommunications:

- TCD on radio propagation, allowing telecommunications system operators (and broadcasters) to place their fixed transmitters and receivers in the best places in order to get good signal coverage and quality
- UCC on radio frequency and microwave engineering, helping companies design and develop transmitter and receiver equipment
- UCD Electronics Engineering on Digital Signal Processing(DSP), a technique which is important to all coding operations in modern telecommunications hardware and software, but which also has important uses outside telecommunications, for example in control applications

Financial Performance

The overall financial performance of the Programme is falling somewhat behind Plan (Exhibit 1.5). (As at the end of November 1995, the Director's best estimate was that the Programme would achieve a 32% recovery on total costs of £1.8m for the year, compared with a target of 37%.)

Exhibit 1.5 Income and Subsidy Requirements 1992-1997
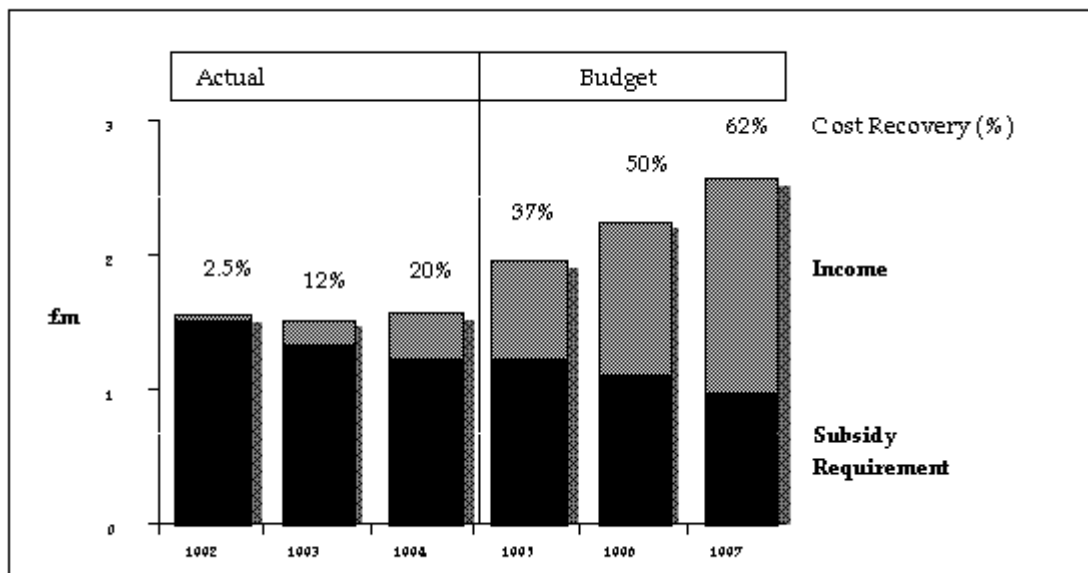
Source : **Teltec Ireland Business Plan**, Draft, 16 October 1995

While at this stage in Teltec's development the total cost-recovery target is relatively undemanding compared with later targets, the income performance is impressive. Postgraduate sponsorship was planned to be a significant component in revenue, but has in practice been modest. Commercial and EU revenues have therefore been found to make up much of the shortfall.

It has been difficult to attract industrial funding for postgraduates. In the period to December 1995, the programme was able to invoice £151,000 to industrial sponsors for postgraduate training. The new, industry-focused Universities were best able to attract such funding: £61,000 at the University of Limerick and another £60,000 at DCU. Growing to the planned size will therefore depend on obtaining higher than originally planned levels of income from EU and industrial projects.

Up to December 1995, the programme generated some £1.2m in external revenues.

Teltec's Role in Irish Research and Technology Policy

Teltec is a significant and unique part of the national effort both in university-based R&D and in its role as part of the 'technology infrastructure' available to Irish-based companies.

The University-based R&D funding system in Ireland essentially has four components: recurrent University funding; the National Research Support Fund; EU programmes; and the PATs.

A significant part (25%) of the recurrent funding provided to the Universities from the education and science budget is normally imputed to their research role. In reality, the

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Universities have no way to manage the boundary between education and research - a boundary which is, in any case, fuzzy at the postgraduate level. Recurrent funding effectively means that the Universities exist, that they have some level of laboratory provision and that academics have some part of their time available to do or to supervise research. It provides no project-specific resources, guaranteeing academic freedom to do any kind of research, provided it does not cost any money. This is a completely normal characteristic of a modern University system.

In most countries, the state sets the direction of University research through having some sort of National Science Foundation which provides marginal, project-specific resources for University research. The National Research Support Fund Board plays this role in Ireland, through six funding schemes (Exhibit 1.6).

Exhibit 1.6 National Research Support Fund Schemes, 1995

Scheme	£m p.a. (approx.)
Basic Research Grants Scheme	1.5
Strategic Research Grants Scheme	1.0
Applied Research Grants Scheme - RTCs +DIT	0.8
Applied Research Grants Scheme - Universities*	0.8
Research Scholarships (PhDs)	0.5
Industry Scholarships	0.3
Total	**5.0**

Note: *Formerly HEIC

While the Basic Research and Research Scholarships schemes are oriented to maintaining scientific capabilities in Ireland, the other schemes are industry-oriented. Strategic Research Grants are available for the technologies which have been prioritised in policy: namely, those for which PATs also exist. The object of the Strategic grants is to support the research 'base' from which the PATs draw. The PATs themselves may not receive Strategic grants. Rather, the associated academics should receive them, in order that they may create industrially-exploitable results over the medium term. (An unfortunate side effect of this rule is that academics feel they need to distance themselves from the PATs in order to obtain Strategic Research money.) The PATs are, however, eligible to receive Applied Research (formerly known as HEIC) grants, which are jointly funded by the state and industry.

Masters-level scholarships require industry co-funding. There is no significant scholarship scheme which is wholly state-funded. This is a particularly important problem for industries like telecommunications which have a high R&D-intensity and a large appetite for postgraduates.

The most striking characteristic of the National Research Support Fund is its small size. Irish researchers are therefore strongly driven to orient their work towards the European Union's science and technology funding programmes. These tend to be applied, oriented to developing and exploiting existing member-state scientific capabilities.

In Ireland, the PATs represent a resource twice the size of the National Research Support Fund: some £10m per year. Their goals are clearly industrial, but because there is so little national research funding and because the PATs are located on campus, the Universities are naturally tempted to turn to them as a source of 'National Science Foundation' finance for their internal scientific agendas. This builds conflict between the university and the industrial sides of the PAT into the "partnership" which they are supposed to comprise. This conflict has been particularly important in Teltec's history.

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The PATs cover major areas which were seen as 'growth technologies' at the end of the 1980s:

- Biotechnology
- Advanced Manufacturing Technology
- Advanced Materials
- Optoelectronics
- Power Electronics
- Software
- Telecommunications

Other technology programmes with a similar remit to the PATs include the National Microelectronics Research Centre (NMRC) in Cork, the Polymer Centre in Athlone and Teagasc's major food technology research programme.

Within this range of programmes Teltec's technological activities are unique. Teltec's systems-level, DSP and radio propagation work have no technical counterparts in the other PATs. The microwave engineering work at Cork deals with a class of components and semiconductor design technologies which are not handled by NMRC.

The NMRC's focus is also at the component level, while Teltec's work at UCC is more concerned with building components into systems .

Because modern telecommunications relies very heavily on software, we considered specifically the question of whether closer cooperation - or, even, merger - would be desirable with the Software PAT.

The Software PAT is legally constituted as three separate companies, each corresponding to a University PAT Centre.

- Centre for Software Engineering, at DCU
- Multimedia Technologies Ireland, at the University of Limerick
- National Institute for Management Technology, at UCC

Teltec has recently instituted some cooperation with the Limerick multimedia centre, since telecommunications is becoming one way to deliver multimedia (for example, via the InterNet). However there appear to be no closer synergies available. Software engineering is neither more nor less applicable to writing telecommunications software than to writing other types of application. The National Institute for Management Technology at UCC is concerned with executive information systems and other types of administrative and business computing, which have little bearing on the telecommunications equipment manufacturing focus of Teltec. On the demand side, the market segments served by the software PAT do not map onto those served by Teltec. Teltec therefore plays a unique role within the state-funded infrastructure which supports industry in Ireland.

Teltec's Contribution to Postgraduate Education

At the end of 1995, Teltec was supporting 53 postgraduates - mostly at Masters level. Some 57 had already passed through the programme, providing a significant source of R&D manpower to the telecommunications industry. Exhibit 1.7 shows the destinations of these postgraduates and indicates that the bulk of the postgraduates go on to work in telecommunications. The emigration rate is high by international standards, but follows an Irish tradition of leaving and - in many cases - returning home later with international experience. Overall, this record represents an important contribution to meeting the need for telecommunications capabilities in the labour market.

Exhibit 1.7 Teltec Postgraduates, First Destinations (at October 1995)

Universities		15
- In Ireland	9	
- Abroad	6	
Irish Industry		22
- Indigenous Telecoms	7	
- Multinational Telecoms	6	
- Broadcom	4	
- Other Irish Industry	5	
Other		20
- Emigrated*	12	
- Not in Industry	2	
- Dropped Out	6	
TOTAL		57

Note: *On the available data, nine of these work in telecommunications companies Reasons and destinations for the drop-outs are not recorded. However, there tends to be pressure on postgraduates in telecommunications to leave university before completion in order to enter the industry as engineers

Foreign Telecommunications R&D Programmes

The structure of the PATs is relatively unusual. R&D activities intended to support industry are typically either located within a single institution, such as a national laboratory, or distributed across many institutions through an open call for proposals, such as in the EU science and technology programmes. The PAT model involves setting up a 'virtual' institution across several universities. While there are now 'virtual' or 'distributed centres of excellence' emerging in scientific research , Industry R&D support programmes tend not to take this form.

In order to understand whether Teltec was also in other respects an unusual way to tackle the creation of national telecommunications R&D capability, we took a sample of telecommunications research centres from five countries and compiled five short profiles using a combination of secondary sources and direct contact with the institutions involved. Our criteria for including institutions in our sample were: similarity of overall mission with that of Teltec; European location; and availability of information. Three of the centres we examined are of comparable size to Teltec. All are public or semi-public institutions, all undertake private contract work for industry and have similar, but not identical, missions.

Exhibit 1.8 provides summary information, comparing Teltec with the foreign examples. Five main conclusions emerge

- Teltec is already of a size which foreign policymakers believe provides a viable basis for supporting telecommunications with industrially-oriented R&D
- However, it covers a very broad span of technologies, given its size. Some other small programmes are more focused: on using computers in communications (FTK); on the technical issues associated with satellite-based telecommunications (CSER/SSTL). TRC covers a very wide set of areas, though not at the telecommunications systems level where Teltec seeks to operate
- Postgraduate and industrial training are both major foci in this type of programme or institution
- The degree of dependence on EU contracts is relatively low - typically below 20%

- Contract research services receive varying degrees of emphasis. However, none of the examples we found have a cost-recovery target as ambitious as that of the PATs. 50% cost recovery would be a more normal level, with government often funding the programmes through a mix of recurrent or 'core' funding and project-specific money

Exhibit 1.8 Teltec and Foreign Programmes

Centre	Staff Size	Students	Coverage of Technologies	Turnover (£)	Funding	Technology Transfer		
						Train Students	Train Industry	Coord Progs
FINLAND: VTT- Information Technology Division	188	small amount PhDs	mobile, comms, broad-band networks, satellite comms, network-management, multimedia, telecoms IC design	£12.1M	40% Govt 25% pub.con 25% priv.con 11% abroad	yes	no	yes
GERMANY: FTK – Telecoms Research Institute	25+	none	data security, PC comms, ISDN, multimedia protocols high-speed networks	from contracts only £47,875	>50% regional some EU, some contracts	no	no	yes
FRANCE: ENST – Telecom Paris	300	150 PhDs	comms systems, electronics systems, image process. business comms, multimedia, mobile comms, network design and management	from contract research only £1.6M	50% France Telecom	yes	yes	no
NETHERLANDS: TRC – Telematics Research Centre	30	none	telematics system models, smart cards, multimedia, security, socioeconomic analysis, network servs., EDI, mobile comms, home telematics	N/A	70% direct (public + private) 30% contract	no	yes	no
UK: CSER & SSTL Centre for Satellite Engineering Research	25	40 PhDs 60mscs	mobile comms, speech/image coding, DSP, network studies, radio propagation, satellite on-board processing	CSER £2.49M SSTL £7M	CSER – 45% Govt grants 35% industry 20% EU SSTL – all private contract	yes	no	no
Teltec	30	55	DSP Protocol Design Microwave Engineering Network Management ISDN Mobile Comms	£1.8m	Target is 20% state subsidy compared with >60% today	yes	yes	no

While Teltec shares characteristics with some comparable foreign institutions, therefore, its dependence on EU programmes is unusually high and its cost-recovery goals are extremely ambitious compared with the norm.

Conclusions

Teltec was established as a partnership between the state, the universities and industry with the intent of fostering economic and industrial development in and through the telecommunications sector. Its history has been characterised by internal dissent about whether this goal is best achieved by focusing on the production of high-quality postgraduate manpower, by providing R&D services to industry or by some mixture of the two.

Teltec has now reached its operational scale and put in place an organisation of some 85 people, including postgraduates. It has a budget of £1.8m this year, and seems likely to undershoot its cost-recovery target of 37% by some percentage-points. However, major EU projects won in 1995 will provide a good basis for continued revenue growth in the next three years.

In the longer term, Teltec is required to operate with only a 20% state subsidy. This is considerably less than is usual in equivalent foreign programmes and represents a major challenge to the programme.

The Expert Panel's Findings on Teltec

This Chapter discusses the part of the evaluation conducted by our panel of expert 'peers'. It explains the method we used and synthesises the findings of the panel about Teltec and about the sample of projects we reviewed. The aims of this part of the evaluation are to obtain the judgements of professional scientists about the quality of the work being done in the programme, as well as their assessments of its relevance and impact - both within the scientific community and in industry.

In the report as a whole, the findings of the expert panel are used together with data from industry and our own analysis in order to reach overall conclusions and policy recommendations.

Method

For this part of the Teltec evaluation, we used what we call a 'structured peer review'. Our experience is that this works well across many disciplines and we have found it can be used with success in programmes which have industrial as well as scientific aims. Only scientists and industrial practitioners are competent to make many of the kinds of judgements discussed in this Chapter. Generalist evaluators cannot make scientific quality judgements. On the other hand, practising scientists and industrialists rarely have the time (or, often, the required competence in programme evaluation, science and industry policy) to undertake a rounded evaluation of a programme. Asking peers to make the judgements of which they are uniquely capable within the structure and analytical framework of a wider evaluation is therefore a powerful way to reach conclusions.

Ideally, in a structured peer review we select a panel of experts based on the suggestions of people in the programme to be evaluated, the funding body and our own investigations about likely candidates. We establish a 'long-list' of potential candidates and telephone them to discuss their areas of expertise, the relevance of their skills, their interest in taking part in the evaluation and their suggestions for other people whom we should approach. Once a consensus begins to emerge in the discussions about suitable panel members, we test a short-list of names with the programme management and the funding organisation to see whether the people on the list are acceptable.

It is vital that the people being evaluated have professional respect for the members of the peer review panel - otherwise the panel's findings will not be accepted. From the short-list, we then select three experts, based on a combination of their backgrounds and their availability, and feed their names back to the members of the programme.

In this case, Forfás wished to select a contractor for the Teltec evaluation based partly on the identity of the scientific and industrial experts involved. Our search process had therefore to be more truncated, based on our own ideas about the most suitable 'domain experts'. We were, however, able to test the proposed panel with the Programme Director, who was happy with its composition. Subsequently, at our start-of-project meeting with the University Centre Directors, no objections were raised to the panel composition.

The panel consisted of:

- Prof Peter Cochrane, Head of BT Laboratories Advanced Research, Martlesham. From this position, he has a deep understanding not only of telecommunications technologies but also of their commercial applicability and relevance
- Prof John O'Reilly, University College London, who holds a chair in telecommunications and has a mixed academic and industrial background prior to moving to UCL. He has a strong understanding of the academic/industry interface, in part derived from managing campus companies. He has also chaired the committee

in the old UK Science and Engineering Research Council (now renamed EPSRC) which covered telecommunications research
- Prof Sven-Olof Öhrvik, who was formerly head of R&D at Ericsson Radio where he oversaw the transition from analogue to digital technologies, and who was then Professor in Applied Electronics at Lund, Sweden. He is recently retired, but continues to research, teach and to coordinate one of NUTEK's telecommunications programmes. He was director of the IEEE's Region 8 (Europe and the Middle East) and was recently Visiting Professor at the Institut für Nachrichtentechnik und Hochfrequenztechnik at the University of Vienna

This team combines a broad and strong experience across telecommunications with a profound understanding of both the research frontier and industrial relevance. The panel is therefore well qualified to do its work

- The members have global expertise and reputations in the relevant fields - and are recognised as such by the members of the Teltec programme
- They have a view not only of what large organisations can do in telecommunications, but also of what is possible for young SMEs
- The experts have complementary backgrounds, creating a 'rounded' view. Their experience spans the three types of organisation that should be involved in a telecommunications research programme: equipment manufacturers; telecommunications operators; and universities

We structured the peer review exercise using a system of checklists and score-sheets which prompt the experts on the various dimensions to be considered and which force key judgements to be made in numerical - as well as verbal - form. Our experience with using this technique in evaluation is that it ensures issue coverage and that it brings the benefits of 'objectification', in Popper's sense - namely, that findings can be written down, discussed and criticised. Crucially, it also allows the experts' qualitative judgements to be checked for consistency, analysed and compared.

The scales used for scoring were determined by the experts themselves. They were not set with reference to external criteria since the purpose of the scoring is internal to the evaluation . We used scales from 1 (low) to 5 (high). The mid-point of the range means 'acceptable at a national level' or 'averagely good,' so a score of '3' is an honourable result, if not necessarily an exciting one. Scores below '3' suggest problems. A score of '5' broadly represents the global leading edge: world class science or 'best practice' performance.

We conducted the review by visiting each of the Teltec Centres for up to a day. Ahead of time, we asked each University coordinator to select projects for review:

- They should involve as many of the Teltec and associated academic staff at the University as possible
- They should together represent a large proportion of the Teltec funding received by the university
- They should either be complete or have reached a stage where there is a clear output for the panel to look at

The Universities provided project descriptions and examples of papers or publications from the projects to be reviewed, which our panel reviewed before visiting.

During our visits, we spent some time discussing the management of the centre with the responsible University Centre Directors. However, the main part of each visit was made up of project presentations and discussions of the projects.

Each project presenter was asked to answer these questions, in order to help the panelists make their evaluation:

- What did I do in the project?
- What was the resulting contribution to knowledge?
- How did this fit in with my other work and work in the field?
- What were and are the next steps following on from the work?
- Who benefits industrially, and how?

Based on the advance materials and the presentation, each expert completed a score sheet for each project which covered the following dimensions:

- Scientific Relevance Is the work of intrinsic interest? Is it relevant to world science?
- Scientific Quality Does the work show adequate understanding of existing knowledge and methodological approaches? Could it contribute to knowledge?
- Technological Impact Does the project show understanding of up-to-date technologies? Could it make a significant contribution to knowledge?
- Internal Performance Is the research agenda sound? Is the work adequately resourced and managed? Do projects reach their research goals and their scientific goals?
- Match with Irish Industrial Needs Is the project in an area where it could make a difference? Does it build competence?
- Match with User Needs Are there users capable of exploiting project results ? Can specific users be identified?
- Educational Impact Does the project open up more opportunities for postgraduate training? Will it make an impact on the undergraduate curriculum?
- Overall Judgement What is the expert's overall view of the project?

In addition, the experts wrote a short set of comments on each project.14 Obviously, any expert team is not equally qualified to make judgements on all dimensions. Where possible, therefore, we have looked for alternative indicators - especially by understanding customers' views - on order to reach a balanced overall view of the programme.

Checking the Experts' Performance

While it is extremely useful to use numbers as a way to express expert judgements about quality and relevance of projects, we need to be careful not to over-interpret - especially as the sample of projects is itself small (27). The numbers reflect judgements. They are not data which cause judgements. Our analysis of the scores has therefore to be consistent with the qualitative judgements made by the experts. Our statistical methods must be simple, and we need to test that our experts' numerical judgements make sense.

As a first test, we needed to check that our experts were scoring projects in a way which made intuitive sense. In addition to checking numerical scores against qualitative judgements, we calculated the mean scores for each of the dimensions examined above, and looked at how individual experts' scores compare with the mean.

Exhibit 2.1 Experts' Behaviour: How Their Scores Varied
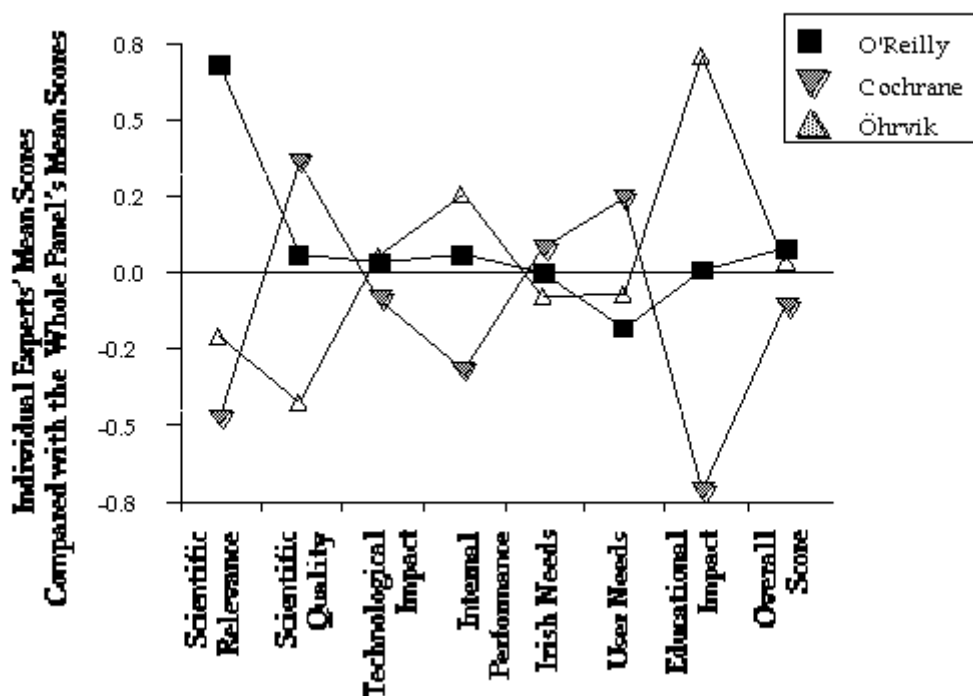
The Overall scores given to each project by the experts are very similar. The scores they allocated to individual dimensions of projects , however, show some variations which appear to reflect the backgrounds of the panel members . John O'Reilly takes a broader view of scientific relevance than the other experts, probably reflecting current (UK) university thinking in the applied sciences.

The scoring behaviour for Internal Performance shows the kind of tension we would expect to see in this panel: the industrial scientist is less impressed by the way university people organise and manage their projects than the two full-time professors. Peter Cochrane (who recruits from many universities) seems less inclined that Sven-Olof Öhrvik (who for the last seven years has focused on working at one university) to see individual projects as having an effect on what happens in education. There is some disagreement about Scientific Quality, but here we are not able to offer an intuitive explanation.

The opinions and scores of the panel as a whole, of course, are an amalgam of the three experts' views, which in turn tend to reflect their experience. In interpreting the panel's views, we need therefore to recall its balanced composition across industry and academia. Three full-time professors or three leaders of major R&D laboratories might well have come to different conclusions. We believe the perspective of a panel balanced between industrial and academic research is exactly what is needed to evaluate work which is supposed to straddle these two worlds.

Logically, each of the dimensions on which the panel has scored projects is separate from the others. As a second check, Exhibit 2.2 shows a very simple analysis of this, indicating the pairs of scores which are most strongly correlated . In practice, projects which are good on one dimension tend to be good on at least some of the others. The correlations suggest that the panel sees a cluster of projects which are well performed, have technological impact and address Irish needs. However, most of the correlation coefficients are not all that high, showing that the variables considered are relatively independent of each other. It is particularly interesting that there is a negative correlation between Scientific Relevance and the Needs variables. This reflects the mixture in our sample of 12 university-oriented, capability-developing projects undertaken using the internal funding from the 1992 Call for

Proposals and 15 industry-related projects. It suggests that the panel saw quite a number of the capability-building projects as not addressing industrial needs (which could be a problem), and that some industrial projects were not scientifically relevant (which is not).

Exhibit 2.2 Correlations Between Experts' Scores for Individual Project Dimensions
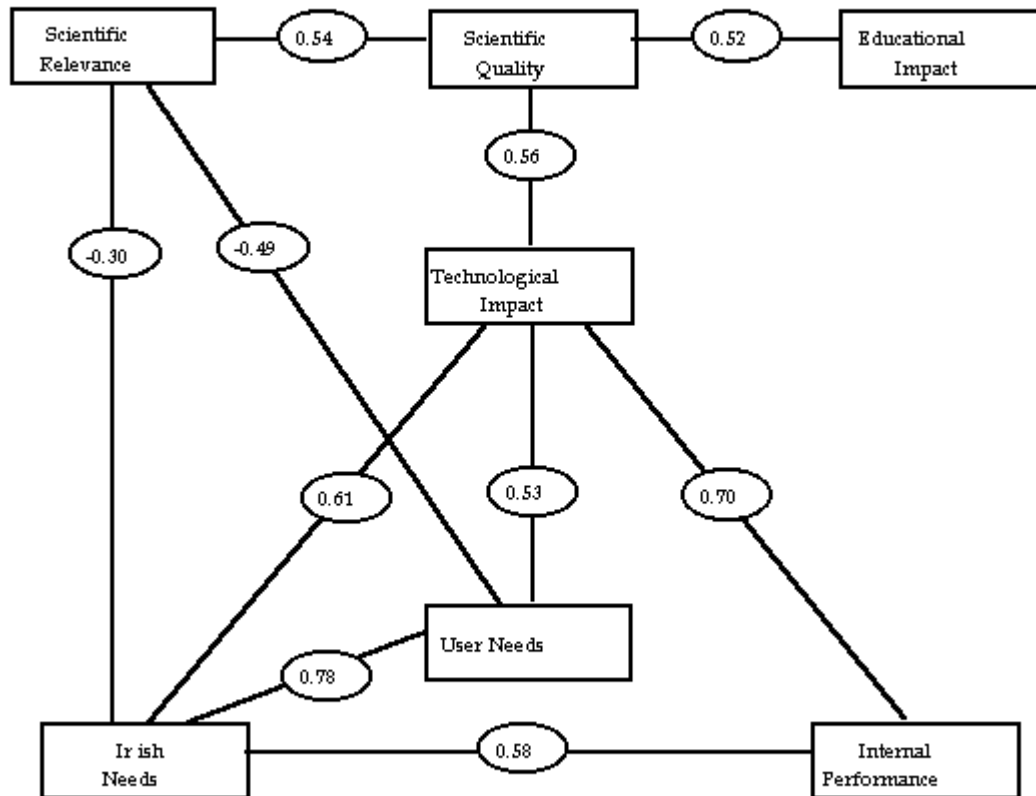
Basis : Correlation coefficients between the experts' averaged scores for each project.

The final check on the experts' scores is to look at the relationship between the scores for individual dimensions and the experts' overall judgements about each project. Exhibit 2.3 shows that their thinking was most strongly influenced by the impact of the projects on the technological community. Quality was also important, as was the way the projects were done and their ability to meet needs. Overall, the panel scored projects in a way which is consistent with Teltec's role at the boundary between university science and industrial application.

Exhibit 2.3 Correlation Between Scores for Individual Dimensions and Experts' 'Overall' Judgements of Projects

Scientific Relevance	Scientific Quality	Technological Impact	Internal Performance	Irish Needs	User Needs	Educational Impact
SR	SQ	TI	IP	IN	UN	EI
0.30	0.70	0.86	0.78	0.63	0.43	0.49

Findings: Teltec Projects and University Centres

Exhibit 2.4 shows the average project scores for each of the two groups of University Centres, and for the Teltec programme as a whole. At the aggregate level, the panel views the programme's performance as acceptable at a national level. The mean scores for Teltec hover around the '3' level on all dimensions, consistent with the fact that some of the projects are concerned with developing capabilities rather than, at this stage, exploiting them.

Disaggregating to look at individual Centre scores, two Centres stand out from the rest. UCC scores very highly in terms of industrial relevance, while DCU lies below the other centres on most dimensions. (We shall see, however, that when the panel takes an overall view of DCU as a Centre, its opinion is more positive.)
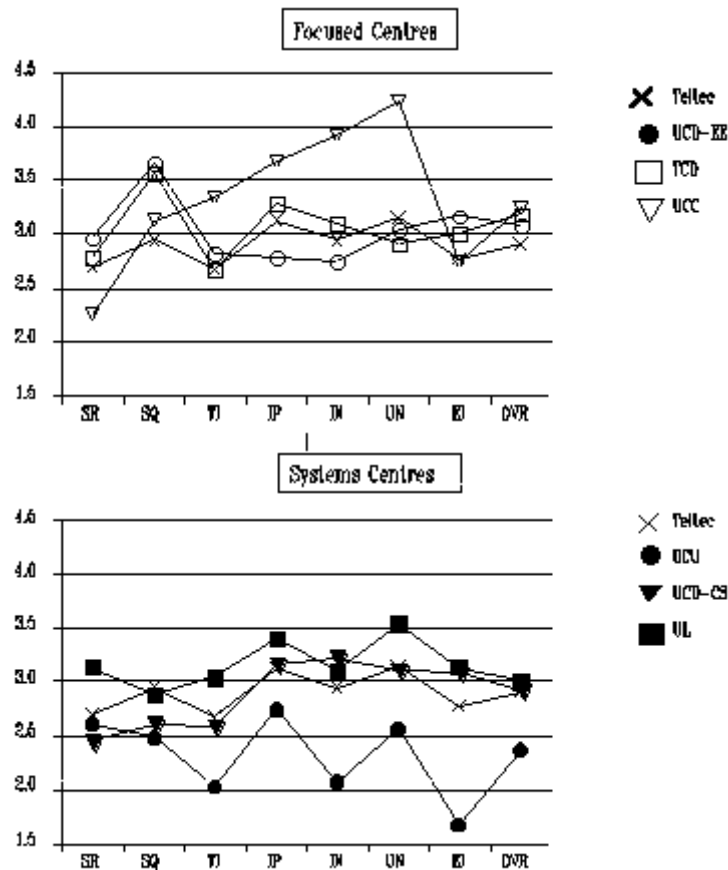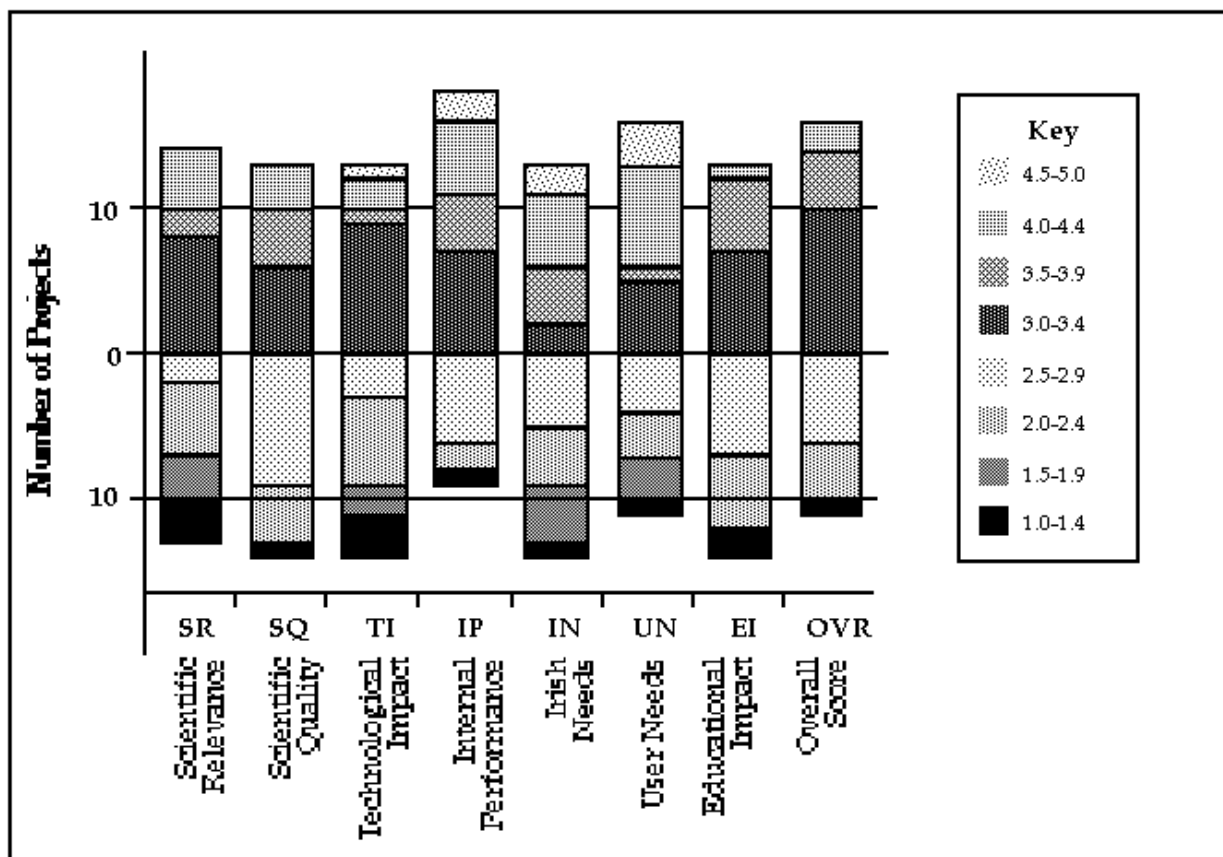

Exhibit 2.5 shows how the scores are distributed for the 27 projects reviewed. The parts of the bars above the zero line represent the numbers of projects achieving a score of '3' or more: namely, those of acceptable to good quality on each dimension. The parts of the bar below the line show the numbers of projects with lower scores on the respective dimensions.

Exhibit 2.5 Distribution of Experts' Scores for Teltec Projects (22)

In interpreting Exhibit 2.5, however, we need to recall that individual Teltec projects may comprise different acceptable 'bundles' of characteristics. As an industry support programme, for example, Teltec should be prepared to trade low Scientific Relevance for high ability to meet User Needs, and so on.

The project scores are strongly weighted towards the centre of the scale. About half (10-15) of the projects are in the range 2.5-3.4 on the scientific, technical and Internal Performance dimensions. There is a handful of projects which are doing really quite exciting science, though the panel is not convinced that they will all have significant technological impact.

There is a greater number of projects of low scientific relevance. These tend to comprise work for industry, so their low scores on this dimension are not problematic: they may even in some cases be a virtue. The Internal Performance scores cluster in the middle and upper part of the range, so there are no strong danger signals here.

The spread of scores for the Needs dimensions is more even than for the other categories. While some projects seem strongly needs-oriented, the programme has yet to produce a clear end-user needs orientation across the portfolio. In particular, some of the internally-funded projects are difficult to relate to Irish and User Needs.
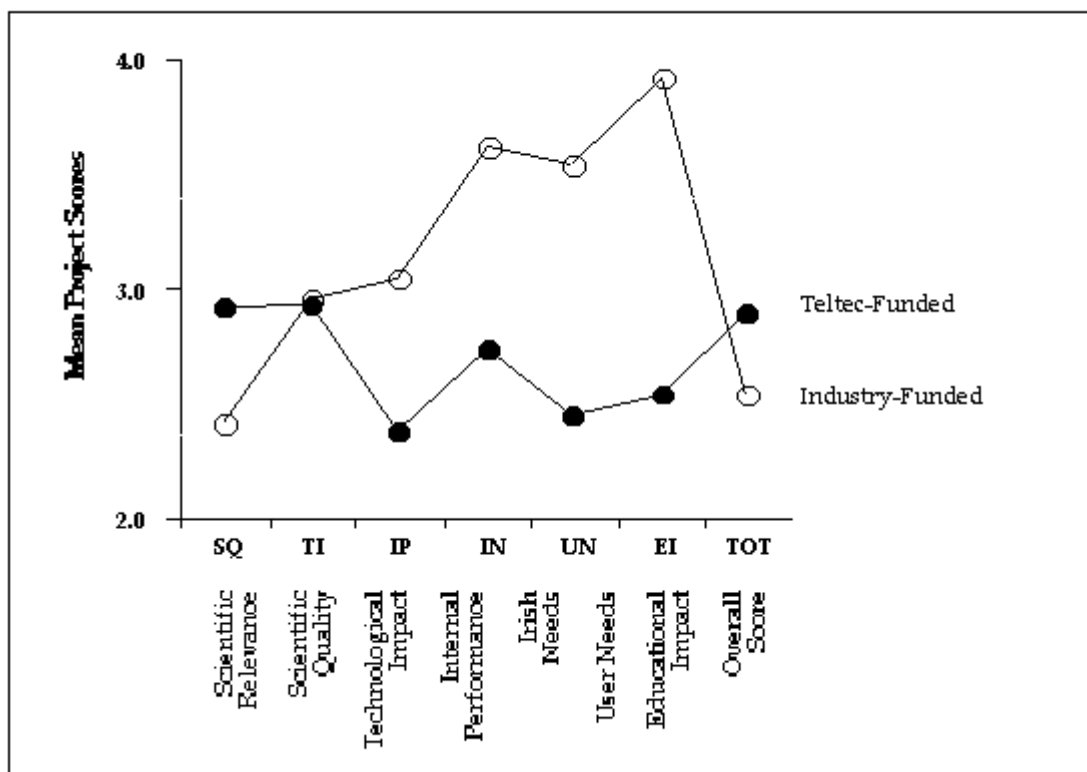
The Educational Impact scores reflect the fact that this type of programme has limited opportunities to impact the undergraduate curriculum. It can and does increase substantially the availability of postgraduate training opportunities in telecommunications, which is an area of acute industrial skill shortage in Ireland as in other industrialised countries.

On the overall view, out of the 27 projects reviewed the panel sees just 2 of the projects as being excellent, scoring 4 or more; just one as below standard (less than a score of 2); and the great bulk (24) as acceptable at a national level.

Disaggregating the sample (Exhibit 2.6) between the 15 projects funded internally by Teltec and the 12 projects part- or wholly-funded by industry confirms that the programme happily sacrifices Scientific Relevance in favour of addressing needs in doing work for industry. Somewhat counter-intuitively, the panel found that the industrially oriented work was also more likely to bring educational benefits. While it recognises that the role of the Teltec-funded work is to develop the capabilities of the programme and the associated academics, the comparatively low scores given to these projects on the 'needs' dimensions suggests that a stronger link is needed between the capabilities targeted for development and their eventual industrial exploitability, especially in Ireland. (The panel's comments on individual capability development projects bear this out.)

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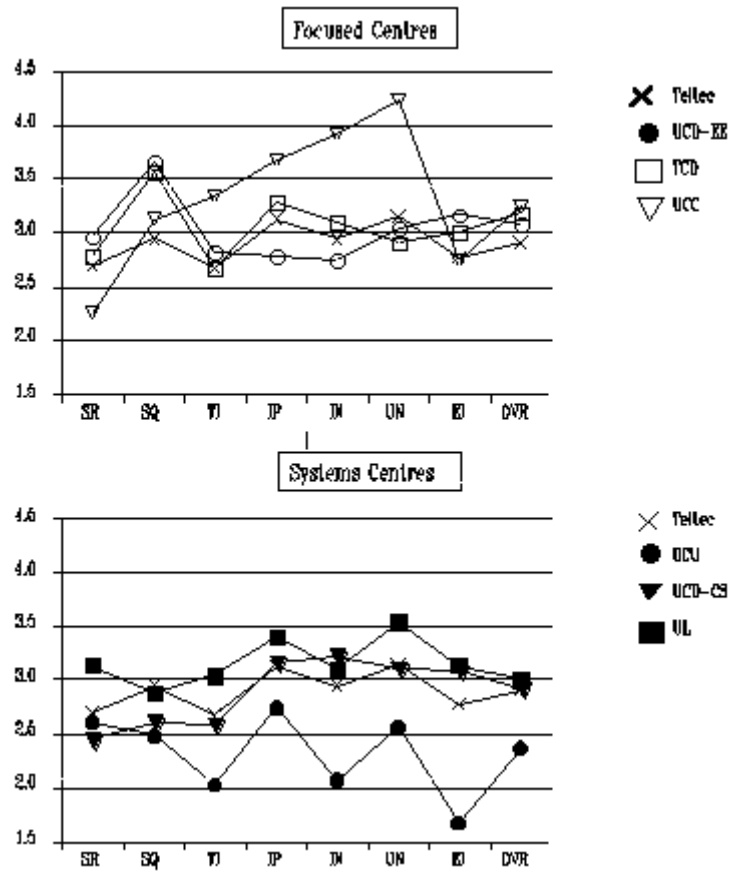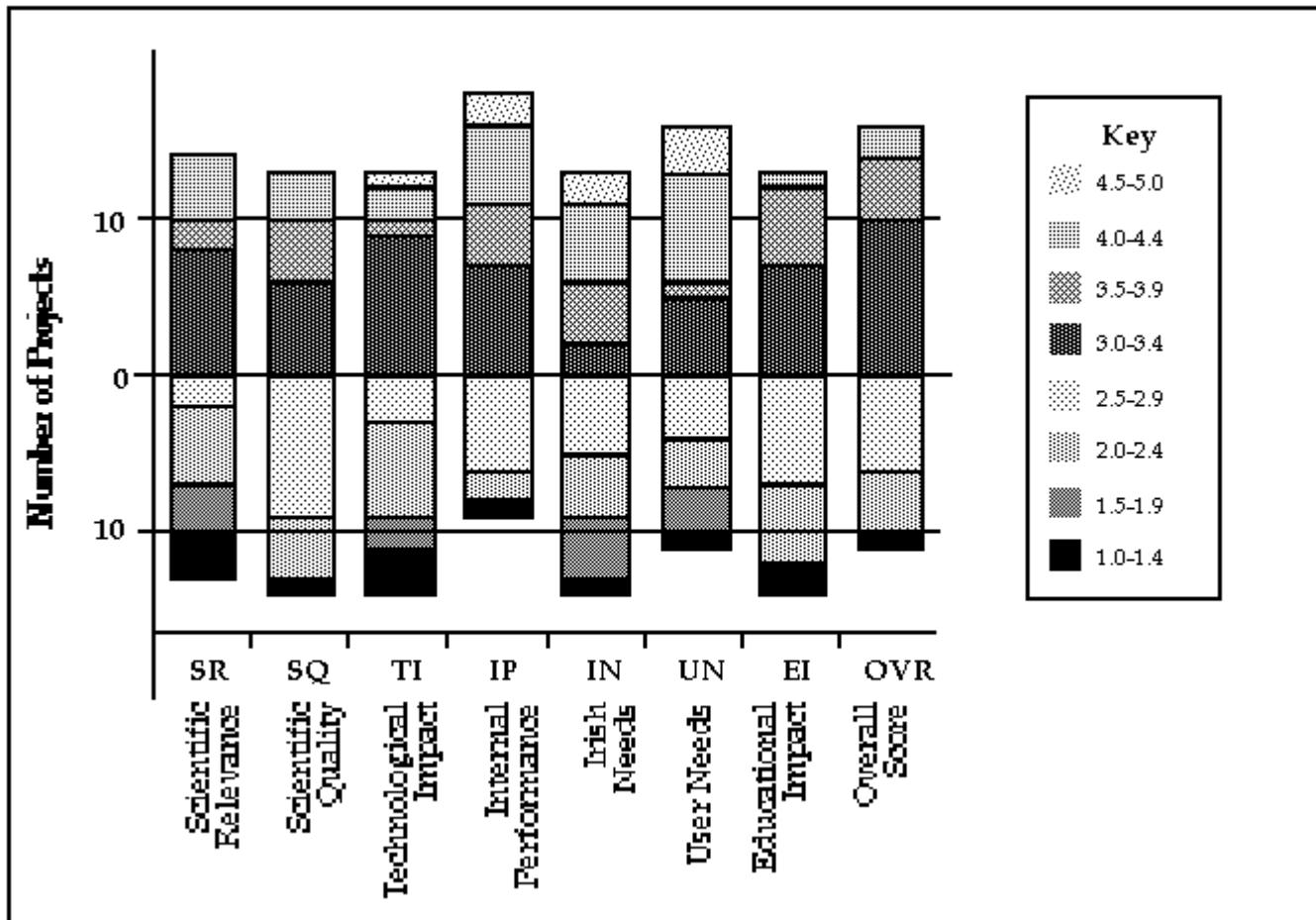
Focused Centres

Systems Centres

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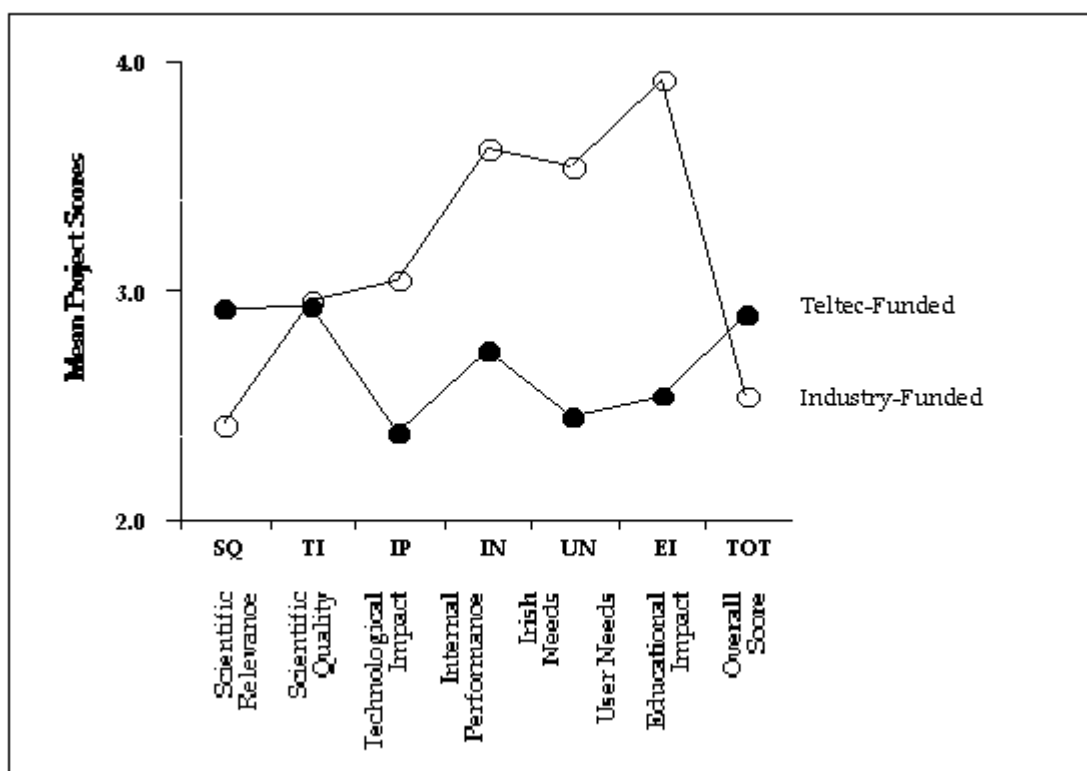
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Exhibit 2.6 Comparison of Internal and Externally-Funded Projects

Findings: The Teltec Programme as a Whole

In addition to evaluating individual projects, we asked the expert panel to make a separate judgement about the Teltec programme as a whole. Exhibit 2.7 shows how their opinion of the programme differs from the average of their judgements about individual projects.

Exhibit 2.7 Scores for the Programme and Average Project Scores
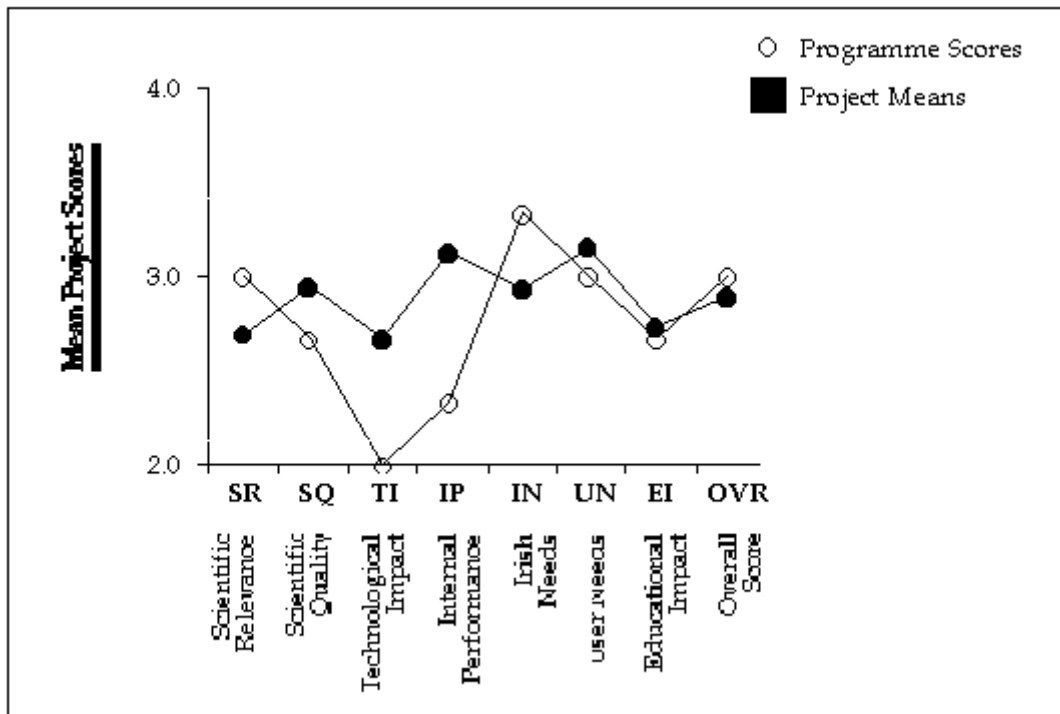
The points of greatest divergence are on Technological Impact and Internal Performance. While individual projects were seen as making some impact, there was some way to go in affecting the way R&D is done in Irish telecommunications overall. The programme's Internal Performance was seen as low compared with that of the individual projects. This is because only a limited amount appeared to be happening at the level of the programme as a whole to unify it and to produce customer value from the overhead costs involved.

Conclusions

The expert panel comprised people with scientific and technological expertise across a broad range of telecommunications technologies and with backgrounds which straddle telephone company R&D, equipment manufacturing R&D, university research and campus company management.

The panel viewed the quality and relevance of Teltec work as acceptable at a national level. A small number of individual projects was excellent. There is room for improvement as the programme matures, but the panel recognised that a good deal of the university research - and, also, some of the industrial consultancy - involved the programme in moving along learning curves. The capabilities being built provided bases for further performance improvements.

The panel questioned whether all of the capabilities being built up in the Universities in fact had relevance to Irish-based industry. Some of the Intelligent Network, network design and management work could only be exploited by very large manufacturers and operators outside Ireland, who have their own internal technical capabilities in these areas. However, there were signs that the programme is starting to focus on a sub-set of these broad areas relevant to Irish industrial needs.

With regard to the programme as a whole, the panel was anxious that it functioned in a fragmented way. Little value seemed to be added by the fact of its being a single, centrally

directed programme serving a coherent set of customers rather than being multiple independent, technology-based centres.

TELTEC AND THE NEEDS OF INDUSTRY

This Chapter considers Teltec's performance from the perspective of actual and potential industrial customers: namely, those people and organisations for whose benefit Teltec ultimately exists.

First, we draw a thumbnail sketch of the telecommunications industry as it relates to Ireland and Teltec. One of the useful things that the Teltec Directorate has been able to contribute to the policymaking process in Ireland has been expert input into the Telecommunications Industry Task Force which reported in 1995 . We do not duplicate the Task Force's analysis here, but simply point out the main data and trends which are salient to thinking about Teltec's future.

Next we describe the interviews we conducted with actual and potential Teltec customers, looking in turn at their views on Teltec's performance as a supplier of R&D services and their perspectives on their own current and future technology needs.

Finally, we draw conclusions for Teltec's future.

The Telecommunications Industry

Telecommunications is unusual in being a very R&D-intensive industry. It has a substantial appetite for postgraduate-level engineering skills.

The Telecommunications Industry Task Force has accessed some of the most recent market research on telecommunications in the open literature, as well as making estimates of activity in Ireland . Based on the Task Force's figures, the global market for telecommunications equipment today is of the order of 140 - 150 BECU and growing at 5 -7%. World demand for traded telecommunications services is about five times this amount, and growing at a slightly faster rate. (The real rate of activity growth is a little higher, because increased liberalisation is allowing growth in corporate networks, whose services are not traded.)

Europe is relatively well-placed in telecommunications equipment, making about 36% of the equipment sold globally but consuming only about 25%, so that about one third of European production is exported.

The Irish market is, of course, very small in relation to world markets: some 0.5% of the European market, or 0.1-0.2% of the global figure. However, Irish industrial policy has fostered an industrial concentration in the newer electronics-based industries. Hence, Ireland's share of production is much higher than her share of consumption, with most of the resulting exports going to other parts of the European Union. In 1993, the indigenous companies in the sectors turned over about £60m, of which 70% went to exports.

Teltec's estimates of telecommunications employment are shown in Exhibit 3.1. Some 65% of the jobs in telecommunications equipment manufacturing are in multinationals. Partly because of this importance of multinationals, growth rates are volatile. In the recent past (1989-91), Ireland has achieved a growth rate in telecommunications equipment output twice the global norm. Recent investment decisions by Motorola could easily add 50% to telecommunications manufacturing employment. However, the fact that Motorola's current expansion is partly being housed in the abandoned Amdahl plant is a poignant reminder of the potential fragility of this type of multinational-led growth.

Exhibit 3.1 Estimated Telecommunications Employment

Total equipment production		6050
Hardware manufacturers	4450	
Software manufacturers	1600	
Equipment resellers		630
Support/consultancy		720
Telemarketing, teleworking		1300
Network operators		12900
Total Employment		21600

Source Telecommunications Industry Task Force,
Telecommunications, Employment and Growth, Forbairt, 1995

Our discussions with telecommunications multinationals highlight the fact that they no longer invest in Ireland simply in order to obtain labour cost advantages. Thanks to a successful policy of industrial development, Ireland can no longer begin to compete on a simple cost basis with locations in Eastern Europe, the Far East, the People's Republic of China or even Portugal. Rather, the attractions are a mixture of: EU market access; English language; a highly skilled and educated workforce; a developed and helpful technological infrastructure; grant incentives; and a low company tax regime. For example, Pulse Engineering operates with a labour force of 150 at its headquarters in the USA, 200 in Tuam, Co Galway and 6000 in the People's Republic of China.

Highly automated, world-class electronics manufacturing processes are being brought to Ireland in the knowledge that they can safely be operated, supported and - to an increasing degree - incrementally developed in that location.

Today, there are over twenty telecommunications multinationals operating in Ireland. Five of the world Top-10 telecommunications equipment companies have plant in Ireland: Alcatel; AT&T; Motorola; Nortel; Ericsson.

However, for Ireland the largest are not necessarily the most important. Exhibit 3.2 shows schematically the directions in which telecommunications is growing. The traditional growth driver is the process of extending traditional telephone systems and services - POTS or Plain Old Telephone Services, as the industry sometimes call them in ironic reference to its own appallingly excessive use of acronyms. There is a roughly linear relationship between GDP and the number of telephone lines per head of population, so this source of telecommunications growth comes as part of the economic development process.

Exhibit 3.2 Growth Directions in Telecommunications
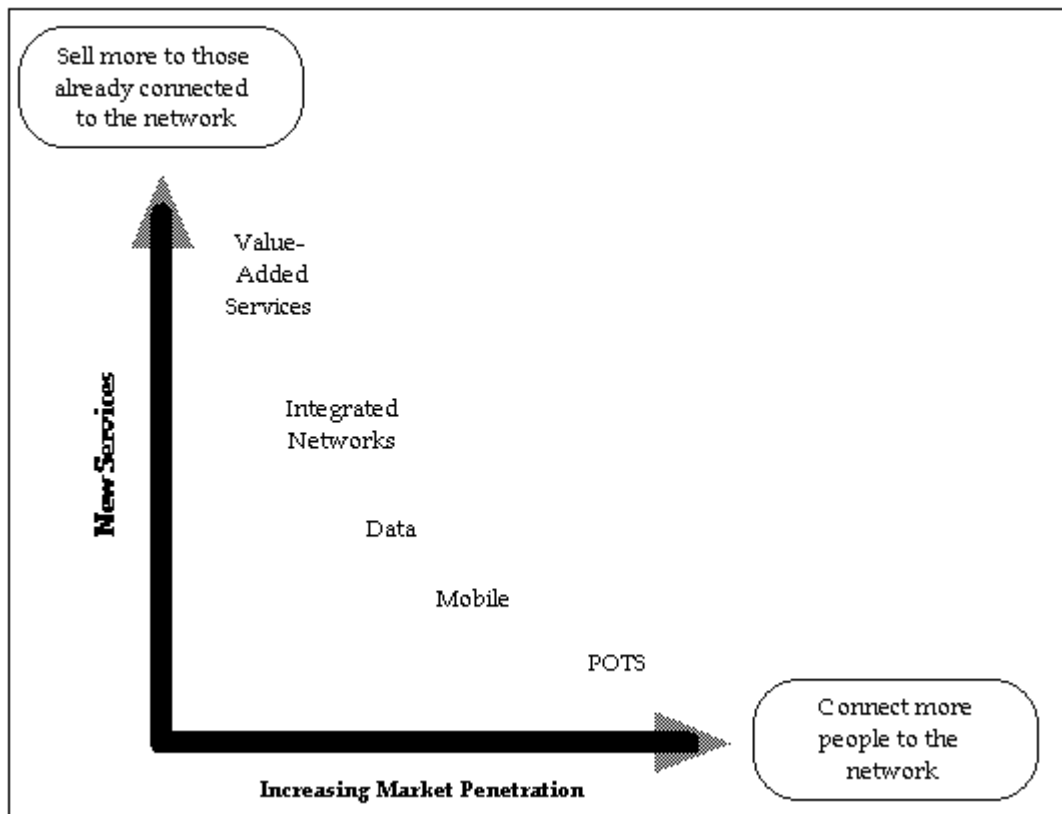
The other source of growth is the increasing choice and complexity of telecommunications services and technologies. Much of this growth has been enabled by increasing liberalisation. Mobile and data communications, value-added services, increasing integration in services and networks provide new equipment manufacturing opportunities. While the established majors have significant scale and other advantages in POTS, competition in many of the newer segments is much more open. The growth rates are much more interesting too, as Exhibit 3.3 suggests.

Motorola and Ericsson - both of which have significant presence in Ireland - have captured the high ground in mobile communications. Together they hold up to 80% of the global systems market, providing a massive source of growth. In 1992-3, they respectively grew by 21% and 34%.

Other segments of the industry have even higher growth rates. Data communications specialists Cabletron (who have a new plant on the Plassey Technological Park in Limerick) and 3Com (with a new plant in Co Dublin) grew respectively at 34% and 43% in the same period. Indigenous companies are benefiting from these new market segments, too, whether they sell components and sub-systems to foreign majors or distribute to the market in their own right.

Exhibit 3.3 World Telecommunications Equipment Expenditures

Type of Equipment	1990 (BECU)	2000 (BECU)	Annual Growth (%)
Public Switching	28	41	3.7%
Transmission	22	36	5.0%
Cable	9	13	3.0%
Satellite	3	5	2.9%
Mobile Communications	10	28	11.0%
Data Communications	10	25	9.0%
PBX and Key Systems	9	15	5.6%
Customer-Premises Eqpt	9	16	5.9%
Other	7	10	4.2%
Overall	109	189	5.7%

Source : Forbairt; CEC Studies

The industrial structure that results from the growth drivers shown in Exhibit 3.2 is therefore developing in two ways. First, the traditional POTS equipment suppliers, especially the large traditional switch manufacturing businesses, are consolidating as technological change drives down the cost-per-line of a telephone switch or the cost-per-bit of transporting signals through a network more rapidly than the market can grow to compensate. Second, the new, fast-growing niches have allowed a plethora of new companies to grow and bloom. Ireland certainly should not let go of its links with the former group of companies. They are far from dead, and they have inbuilt advantages in developing some of the newer technologies and niches such as Integrated Networks. However, the second group provides very interesting opportunities - both in terms of capturing inward investment and in generating indigenous growth.

In our view, therefore, the telecommunications equipment manufacturing sector is a major opportunity for Ireland, which should continue to be a focus of industrial - and therefore technology - policy. Its characteristics of growth and flux, its dependence on skill and education, its international character all work to Ireland's advantage in expanding its position.

Customer Views of Teltec

Our meetings with the Teltec programme and the work of the expert panel provide a crucial 'Supply-Side' perspective. It is important to check this against the perceptions of actual and potential customers.

Exhibit 3.4 People and Organisations Interviewed

| People	Organisations
Gilbert Little*	Aldiscon Ltd
John McAuliffe	ALPS Electric (Irl) Ltd
Bill Hunt	Analog Devices BV
Jerry Catrell	Armstrong Electronics Ltd
W Purser	Baltimore Technologies Ltd
Gerry Cahill	Broadcom Eireann Research Ltd
Paul Maloney	CAMP
John Moran	Cork Multi Channel
Joe O'Callaghan*	Cornel
Ray Kavanagh	Dept of Finance
John Ronaghan*	Ericsson
Jim Mountjoy*	Euristix
Brendan Lyons	Farran Technology
Liam Hamilton	Garda Siochana
Ken Gleeson	GEC Plessey Telecommunications Ltd
B Maher	Hormann Electronics Ltd
Anthony Bermingham	Lake Communications Ltd
Ian Cahill	LM Ericsson Ltd
Brian McCoy	M/A Com Eurotec
Michael Peirce*	Mentec
Graham O'Donnell	Microsol Ltd
Tino Renni	Motorola BV
Gerry Cahill	Nortel Ltd
Mike Gilmartin	Pulse Engineering Ireland
Ray Bulger	Silicon & Software Systems
Joe Dwyer*	Telecom Eireann
Pat Shanahan*	Tellabs Ltd

Note : *Former Board member

We interviewed 27 organisations in order to obtain their perspectives. Exhibit 3.4 provides a list of those we met. We used a semi-structured interview approach - making sure we covered the issues we wanted to know about, but also leaving space for the people we met to surprise us with issues we might not have considered. In most cases, we were able to collect the interviewees' opinions of Teltec's service and their views on their organisations' current and future telecommunications technology needs in the form of numerical ratings.

Those organisations we visited which had experience of being Teltec customers gave us the overall scores shown in Exhibits 3.5 and 3.6. The sample sizes are limited, but the numerical scores are consistent with the qualitative discussions in these and other firms.

Exhibit 3.5 shows that the programme is performing a wide range of services, from major applied research projects through to small measurement and test operations. To this picture, of course, must be added Teltec's growing volume of work in EU programmes, which is largely precompetitive and therefore at the level of applied research and advanced engineering.

Exhibit 3.5 Range of Services Supplied
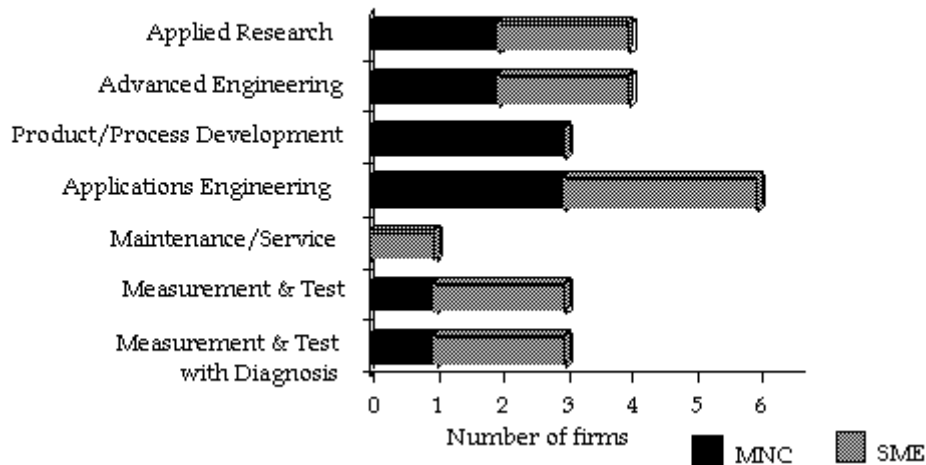
Most of the customer ratings are good. The multinationals awarded slightly lower scores, especially on the questions comparing Teltec with alternative suppliers. This is likely to be because the multinationals have a broader and more international range of comparisons on which to draw than smaller indigenous companies.

Exhibit 3.6 Project Buyers' Ratings of Teltec Service
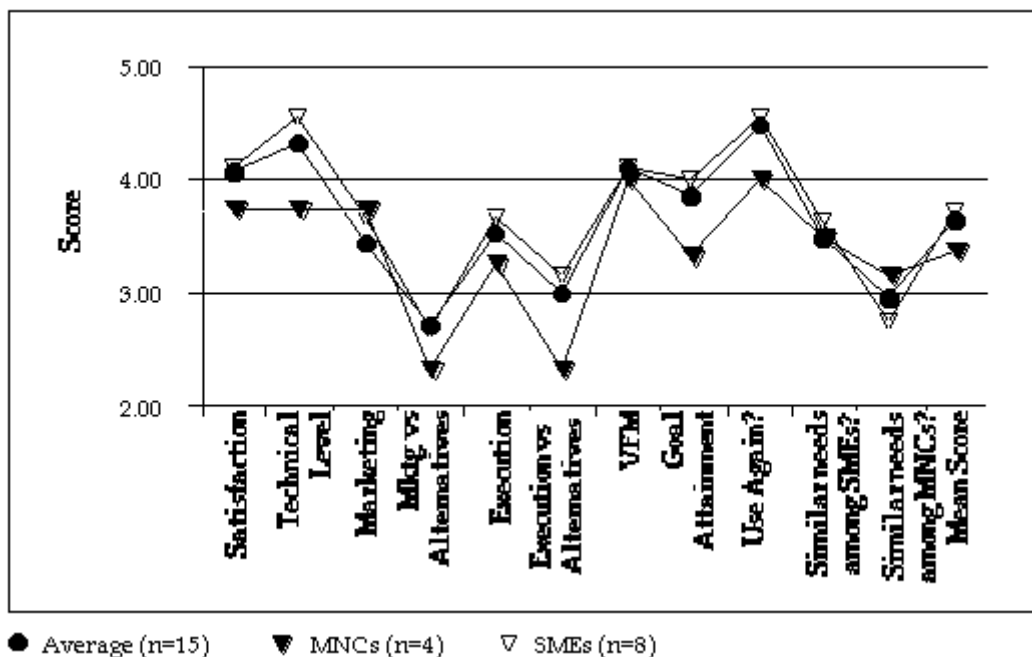
Overall satisfaction ratings were high, and users were very willing to use Teltec again in the future. Customers mostly felt the technical level of the service they were given was very high. Projects generally reached their goals, though the MNCs were less happy on this score than the indigenous companies. This is likely to be because the MNCs tend to have a clearer idea of what they want and therefore specify more precise goals. Everyone thought Teltec offered good value for money (the lowest score on this dimension was '3').

Users were a little more critical about the professionalism of Teltec's marketing, its project management and project execution. In particular, they felt that it did less well on these dimensions than potential alternative supplier organisations - essentially technical consultants

from abroad. Here, too, the MNCs took a less positive view than the others. The questions about the applicability of Teltec's skills to other companies in Ireland suggested that there was a fair level of additional demand to be tapped. In the scores - and, more important, in the qualitative discussions - there is a suggestion that the importance of Teltec to MNCs can be underrated. The multinationals place a high (and increasing) value on working in countries where there is a strong national technological infrastructure. We suspect there are at least three reasons why this importance has been growing in Ireland in the past few years:

- Rising costs in Ireland mean that MNCs locate there less for cost reasons than used to be the case
- De-layering combined with the need to serve local and regional markets in an increasingly differentiated way while still using total corporate capabilities (so-called 'glocalisation') is forcing MNC branch-plants to operate more autonomously
- The availability of strong skills and a growing university research capability are affecting location decisions. For example, M/A Com stated clearly that the presence of NMRC and the Teltec microwave engineering centre at UCC were instrumental in the parent company's decision to locate in Ireland, and specifically in Cork. Motorola described its systematic search for university research linkages in Ireland and the role these played in creating arguments for location and expansion in Ireland

It would take a large study of a different sort to this one to test these ideas. However, they correspond closely enough to the discussions we have been having with Irish-based multinationals over the past four years of evaluating PATs that we would certainly regard them as strong hypotheses.

A number of other important observations on Teltec's performance emerge from our demand-side interviews.

Teltec's publicity has been spread extensively in Ireland. People in the telecommunications industry felt that few potential buyers would now be unaware of the programme's existence. However, the challenge is to follow up this initial success in creating a basic level of awareness in order to build what the advertising profession calls 'share of mind': namely, the continuing awareness among customers that Teltec can help them. This requires continuous, proactive marketing, both through information channels (publications, conferences, training courses) and through active management of actual and potential accounts. Teltec's marketing (as opposed to advertising) performance today could be improved. As one interviewee said, "You can't just paint the bridge once. You have to be constantly working at it - reminding people you exist and working on the service to keep it up-to-date and relevant." Building 'share of mind' will involve a more proactive marketing role at the University Centre level than is usual today.

Buyers are always suspicious of new suppliers, so much of the business Teltec has won so far has involved small-scale, confidence-building assignments. To the extent that these have allowed Teltec to win its spurs, it should become possible to sell larger pieces of work. The corollary is that Teltec needs actively to follow up the work it has sold: making sure the client is satisfied; understanding the role of the assignment; identifying follow-on opportunities; and building the client's sense of being taken seriously by professionals with the client's interests at heart.

Smaller companies, in particular, have difficulties in keeping up with the high rate of change in technology, markets and standards within telecommunications. While Teltec helps with some of these issues, the need is considerably larger. The felt need seems to be for something like a Research Association - providing information, advice and R&D services to the sector. Some of these services would be unique to individual clients, and confidential in nature. Others, especially in information and standards, should be multi-client services.

The dissolution of the Teltec Board has caused some sense of alienation from the programme among key individuals in the industry. We suspect that the Research Association model could

be used to create an industry forum or 'club' - drawing the community closer together, and thereby helping to increase both the willingness to cooperate and Teltec's revenues. The Telecommunications Industry Task Force proposed the idea of a Telecommunications Forum. Teltec could usefully seek to convene and manage such a Forum, thus serving both its own and the national interest.

Teltec is primarily seen as a research resource. It is not useful for outsourced product development or for systems integration. Its service portfolio is therefore lacking with respect to implementation: a typical failing of university-derived activities. Some customers would find Teltec more attractive if it were able to provide this type of service, in competition with foreign consultants. Others already see Teltec as a competitive threat - though probably more of a threat to services they themselves might at some unspecified future date be interested in delivering rather than their current activities.

Teltec's willingness and ability to tackle very small assignments was seen as a strength. Commercial consultants generally need to see potential revenues which exceed some minimum value before they are interested.

For certain customers who had a long-standing relationship with the academics involved in the programme, Teltec was simply a new bureaucratic nuisance which got in the way of their old relationships. There was some concern that this raised the effective price of services to end-users. At the same time, the injection of equipment into the Universities that had been funded through Teltec had been very welcome.

Parts of Teltec - especially the UCC activity - were seen as undercritical. There was no sense that the programme actually created any synergies among the Centres or, therefore, additional value from the customer's perspective compared with a wholly university-based programme. While it is generically the case that 'corporate overhead' activities and their benefits tend to be invisible to customers, this customer observation underlines the need to bring the programme more closely together.

It has been difficult to exploit situations where Teltec has contributed unique value to a company. While entrepreneurs naturally shy away from royalty deals, there may yet be ways to capture more of the benefits from successful and profitable projects. (For example, it might well be more attractive to construct a deal where commercial success triggered a postgraduate sponsorship.)

Demand-Side Prospects for Teltec

Two crucial factors about the nature of the market influence Teltec's longer-term economic prospects: How many more customers can Teltec win? What do the customers need?

Data on fast-moving sectors such as telecommunications become old very quickly. In order to get a 'snapshot' of how well Teltec has penetrated its natural market - the Irish-based telecommunications industry - we compared its pattern of sales, using the invoices issued up to October 1995, with the companies identified by the Teltec Directorate as being in the telecommunications business. (This exercise in identifying the potential set of customers was originally done for internal marketing purposes and subsequently exploited by the Telecommunications Industry Task Force.)

Exhibit 3.7 shows the results of the comparison. It suggests that Teltec has made considerable progress in reaching its major target group - the telecommunications equipment manufacturers. There remains room to expand in this segment, however. The number of companies served could reasonably be expected to double. Better marketing and customer management should allow more work to be sold to each client. Overall it would not seem unreasonable to look to achieve revenues 3 - 4 times higher than present levels.

Evaluation of Teltec Ireland

Experience shows there is also scope to serve many customers outside the telecommunications equipment segment. The software multinationals are difficult targets, because most of them are not focused on telecommunications. However, more telecommunications niche suppliers could be addressed among the indigenous firms.

We do not see the equipment resellers as a meaningful target segment. They should have little need for Teltec's services. The one sale achieved so far was a £300 test, and created so little awareness in the firm that during our interview the company denied ever having heard of Teltec.

Service companies and network operators are more interesting, especially as opportunities to establish new telecommunications, broadcasting and rebroadcasting networks continue to increase. A crucial question is whether Teltec can serve Telecom Eireann.

Teltec has successfully served Irish telecommunications companies not identified on the Task Force list as well as companies in other parts of the electronics industry. It is likely to find increasing amounts of user need in this latter area as the boundary between telecommunications, computing and multimedia continues to blur.

The two remaining segments are dominated by TCD's radio propagation service. The ability to do propagation studies using maps and satellite data is very interesting for companies considering bids for radio-based communications licences, since they can obtain useful data on likely costs and service levels without the risk of their being seen in the field and of alerting their competitors to their interest. The Irish public authorities, of course, constitute a special market for Trinity College Dublin.

Overall, this discussion of Exhibit 3.7 suggests that there is considerable 'headroom' for Teltec to grow. We need, also, to remember that the Exhibit represents a snapshot taken in a fast-growing and dynamic industry. There are existing plans which will add some thousands of jobs to the telecommunications equipment sector and new companies continue to start up. In addition, the programme is likely to remain involved in EU programmes for the foreseeable future.

Exhibit 3.7 Teltec Market Penetration, to December 1995

Category	No of Companies			% of Telecoms Employment Addressed
	Total	Served by Teltec		
		Number	%	
Telecoms List				
Telecom Eqpt MNCs	21	6	29%	48%
Telecoms Eqpt Indigenous	19	4	21%	40%
Software MNCs	15	0	0%	0%
Software Indigenous	24	2	8%	9%
Eqpt Reseller MNCs	6	1	17%	18%
Eqpt Reseller Indigenous	12	0	0%	0%
Service Cos	16	2	12%	6%
Network Operators	3	0	0%	0%
TOTAL	116	15	13%	8%
Total excl Telecom Eireann	115	15	13%	28%
Others, Not Listed				
Irish Telecoms Cos		9		
Irish, Non-Telecoms Cos		12		
Telecoms Cos Abroad		6		
Irish Public Services		3		

Basis : Teltec Invoices to December 1995
Teltec list of Irish-Based Telecommunications companies

Against this background, Teltec's ambition to raise its external revenues from £600,000 in 1995 to the £1.585m in 1997 implied by its current expansion plans and the Department's funding targets is certainly ambitious, but it is not ruled out by any evident structural impediment on the demand side. Major questions are whether Teltec can move to a more commercial mode of behaviour in order to capture the revenue and whether it can manage the growth in activity that would result.
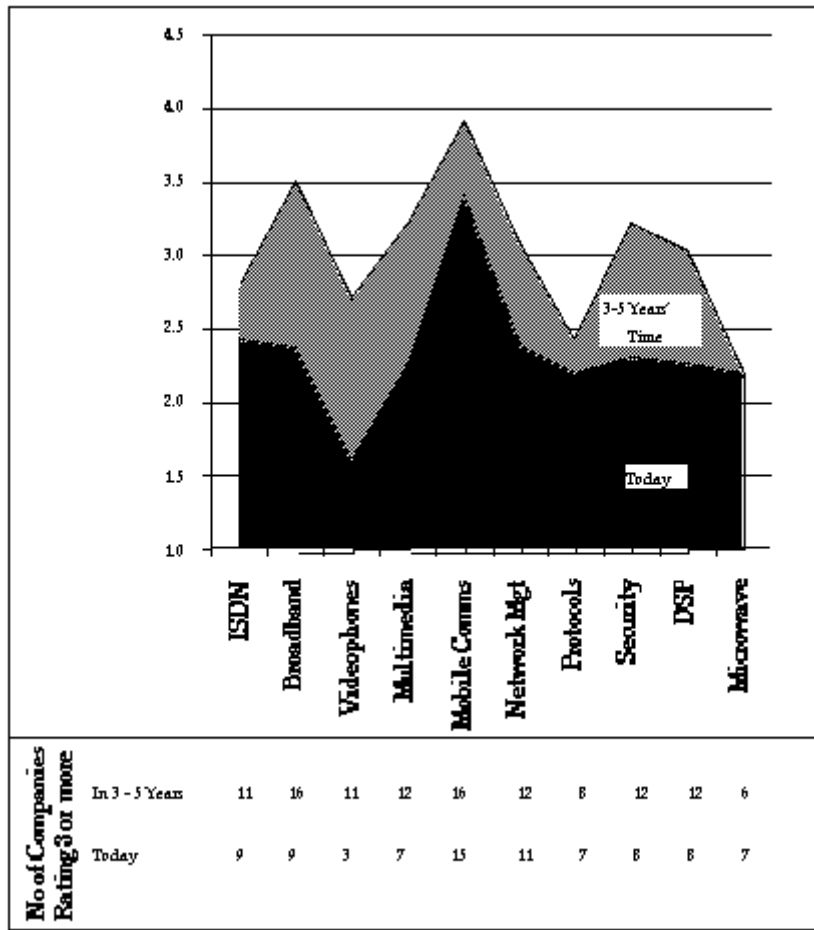
During our interviews, we sought a broad indication of the relevance of Teltec's technologies to customers' businesses today and in 3 - 5 years time. Clearly, the minutiae of matching individual user needs with individual Teltec capabilities need to be resolved case by case through the marketing and selling processes. In broad-brush terms, however, there was a significant level of interest in all of the technologies.

Exhibit 3.8, which displays the findings, needs careful interpretation. Strictly, the average scores for interest in each technology cannot be compared with each other, since we do not properly understand how our sample relates to the universe of relevant companies. We can not, therefore, on this basis conclude that DSP is a less important component of Teltec's portfolio than Mobile Communications. What we can say with some confidence is

- In each of Teltec's technology areas (except video telephony) there is a big proportion of the sample that finds the technology area to be important to its business today
- The level of interest and relevance of all of the technologies is rising for the companies which gave us their ratings
- The numbers of existing companies using Teltec technologies is expected to rise, especially in broadband, video telephony-related areas and multimedia

Exhibit 3.8 Demand-Side Evaluation of Technology Importance

No of Companies Rating 3 or more	ISDN	Broadband	Videophones	Multimedia	Mobile Comms	Network Mgt	Protocols	Security	DSP	Microwave
In 3 – 5 Years	11	16	11	12	16	12	8	12	12	6
Today	9	9	3	7	15	11	7	8	8	7

Basis : 20 responses

The level of definition of Exhibit 3.8 is very coarse. Our questionnaire actually broke down the Mobile Communications, Network Management, DSP and Microwave Engineering areas more finely. The finer definition only produced additional information in the case of Mobile Communications.

Today, 15 companies give mobile communications technology a priority of 3 or more. Of these, 5 rated radio propagation a priority, 9 rated hardware and software design and 7 rated system and network planning. Looking into the future, the number giving priority to radio propagation rises from 5 to 9; hardware and software design rises from 9 to 13; and system and network planning rises from 7 to 9.

While potential customers' ratings of Teltec's technologies are therefore positive at a broad-brush level, at a more detailed level there is scope for fine-tuning. In particular, as Chapter 2 suggested, some areas may only be addressable at a scale so large as not to be relevant in Ireland. Detailed understanding of customer needs must be used to find the viable specialisms within these areas.

A key problem for Teltec on the demand side is the character of Telecom Eireann as a (by international standards) small telephone company with limited technological capabilities. Telecom Eireann has no central R&D function. Technical responsibilities are devolved to operating division level, making it hard for the company to obtain an overall perspective on technology or to absorb changes and information about opportunities in a timely way.

Naturally, Telecom Eireann has been under pressure to participate in European programmes. In order to do so, it has established the Broadcom joint venture with Ericsson and TCD.

Unlike Ericsson, however, which has long experience in learning through such semi-external ventures (eg its Ellemtel joint venture with Swedish Telecom), Telecom Eireann has no such tradition and no real mechanisms for absorbing capability. With its research options being exercised effectively at a double remove from operation, Telecom Eireann is not able to bring detailed operational experience to bear on research problems. Its lack of a technology vision makes it hard for it to guide even external research in useful directions.

Structurally, we would expect there to be a close relationship between Teltec and Telecom Eireann. Each actually needs the other in order to improve its relevance and performance. Sadly, on our present understanding, Telecom Eireann seems to function as a spectator rather than as a participant in technological change.20 While this is undoubtedly the right posture in certain technologies - for example main office switches - there are many other areas (for example, network planning and management) where internal technological work is needed in order to have the required level of understanding to be a good procurer and a good operator.

Conclusions

Telecommunications is a very attractive sector, and one which should be a focus of Irish industry and technology policy.

The rates of market growth and technological change are high, providing entry opportunities and encouraging inward investment as companies expand. The increasingly rich Irish technological infrastructure in electronics and the presence of other electronics and telecommunications firms make Ireland an attractive location, as does the good supply of highly educated and skilled labour. The importance of postgraduate-level inputs means that Teltec's role as educator is significant for the industry. There is a sufficient mass of activity and sufficient opportunities to access demand that niches within telecommunications equipment manufacturing are attractive for entry. In addition, telecommunications is a highly generic technology: national skills tend to be useful in user industries as well as in the business of making telecommunications equipment.

Our industry interviews led us to conclude that users are fairly well satisfied with Teltec's service. Teltec offers good value for money, and they intend to use the service again. Weaknesses are mostly in the areas where University-derived businesses tend to be weak: marketing; selling; and project management. These problems can be corrected by training and mentoring. The programme is currently fragmented. Customers would see more value in Teltec if they could perceive and access it as a genuinely integrated service.

Analysis of Teltec's current market penetration suggests that there is little structural reason why the programme should not reach its long-term revenue targets - provided it adopts an aggressive and commercial approach. It would probably help if Teltec could position itself as in some way 'belonging' to the industry, perhaps in the style of a Research Association, rather than as an external supplier of services.

In broad-brush terms, potential customers see Teltec's range of technologies as relevant to their businesses both today and in the future. However, we believe that at a more detailed level the programme needs to continue to refine its orientation to focus more on segments appropriate to its scale. This is partly a circular problem. Today, Teltec has little practical contact with Telecom Eireann. Cooperation over large-scale operational questions would improve Teltec's capabilities, and arguably those of Telecom Eireann itself.

MANAGEMENT AND ORGANISATION OF THE PROGRAMME

This Chapter reviews managerial needs in Teltec. It is easy to underestimate both the difficulty and the importance of 'overhead' functions in a programme like Teltec, where the Directorate has responsibility but rather limited power. The freedom of the Directorate to manage determines whether Teltec is to be an effective, united programme or a collection of relatively uncoordinated University-level initiatives.

Strategy

We pointed out in Chapter 1 that Teltec's history has been characterised by disagreement about the central purposes of the programme. This uncertainty has led to a larger problem: namely, the inability of the programme as a whole to agree and implement a business strategy. Creating agreement and implementing a strategy are, we believe, preconditions for Teltec's further development - in particular, if it is to have a chance of meeting the Department's goals for the PATs, but also if it prefers credibly to redefine itself in some other terms.

History and current practice are that Teltec has been and is a collection of disparate University Centres, each with its own game plan dictated by its own circumstances. Most of the University departments involved have a track record of working with industry and with EU programmes. Teltec has added to the Universities' resources, making them better able to do these things - both in terms of equipment and human capabilities. To date, this has largely meant Centres doing 'more of the same'. In some cases, they had enough existing industrial activity to be able to decide when and whether to pass work through the Teltec books or to account for the revenue elsewhere. Now, the pressure for reductions in subsidy is increasing. Centres need to decide - individually and collectively - whether they remain committed to the programme and - if so - how the programme is to reach its financial targets.

Operating as a PAT essentially entails having a business strategy. That is, in addition to the Universities individually knowing what they are about as Universities, Teltec has to know and have control over what it is doing as a business.

The essence of business strategy is a decision about what to sell and to whom. Sustainable strategies build on structural advantages. In Teltec's case these advantages compared with individual University approaches are supposed to be something to do with operating at a national level as a 'virtual' or 'networked centre of excellence' for telecommunications R&D. The needed elements of a strategy are therefore:

- Understanding user needs and how these are segmented among groups of potential customers with similar requirements
- Refreshing the programme's capabilities, in order to keep it relevant in a sector where technological change is rapid and continuous
- Having processes in place which bring the best available Teltec resources to bear on individual user needs, irrespective of their origins within the Teltec network
- Operating a reward-system which makes it attractive for all the participants - customers, Universities, Forbairt on behalf of the state - to remain involved

Over the years, Teltec and the programme's designers have undertaken a number of exercises aimed at understanding needs. Our discussions with a sample of actual and potential customers (see Chapter 3) suggest that they have done a pretty good job of understanding these needs in technology terms, though it has to be said that this has been achieved partly by including quite a long list of technologies within the programme. However, it is difficult to see a link from the definition of technological needs to the division of labour among the University Centres either in terms of the technologies they handle or in terms of the customers they target. Indeed, there are overlaps in both capabilities and sales activities - essentially because the Centres do not cooperate in executing any larger strategy.

The Role of the Directorate

A key role of the Teltec Directorate should be to design and implement such a strategy. Over time, in order to meet the Department's PAT goals, we would expect to see a process whereby the collection of University partners gradually comes together into a coherent whole. This can only be done with the willing cooperation of the Centres.

Three factors have slowed down this needed process of integration.

1. Historically, neither the Teltec Board nor the University Centres have accepted the validity of the PAT goals
2. The decentralisation of Teltec Centre management to University faculty has left the Directorate almost powerless to manage programme resources
3. In the last year or so, a significant reporting workload appears to have been imposed on the Directorate by the Telecommunications Task Force and the needs of the reorganised public sector, significantly reducing the Directorate's ability to create the needed day-to-day synergies

As a result, the efforts of the Directorate to develop and implement a unified programme strategy and to materialise the value inherent in its central role have often been frustrated.

The main roles of the Directorate should be:

- Leading strategy development and implementation
- In particular, defining those aspects of the programme which go beyond the competences of individual University Centres
- Managing and coordinating the sales and client management processes
- Playing 'coach' in order to enhance the skills of the programme members, especially in business-related areas for which their University backgrounds do not tend to equip them
- Financial management and control
- To direct the use of centrally-funded resources (including manpower) as far as is needed to achieve coordination across the programme and generate the needed financial returns

In particular, to fulfil this last role, the Directorate needs line control of the Research Officers employed in the Centres.

In strategy development, the need is now to go beyond agreeing the technological division of labour that has largely been achieved between Centres and to agree with them what this means in terms of detailed market research needs, client targeting, sales and marketing effort.

Our industry interviews suggest there are some aspects of strategy which can best be implemented by the programme in a central way:

- Addressing the fragmentation of the telecommunications industry in Ireland by redefining Teltec in part to function more as a virtual Research Association than as a consultancy. This means developing the idea of membership, creating a focal point or forum for the community. The lack of an effective telecommunications industry trade association in Ireland leaves Teltec the opportunity to assume this role via newsletters, conferences, training and the creation of a Steering Committee as a focal point for industry discussions. (The loss of this function was one unfortunate side-effect of the dissolution of the PAT Boards at the end of 1994.)

- Defining shared services, such as technology tracking, standards monitoring and an inquiry/referral service
- Periodically conducting 'look ahead' studies, to confirm the direction of technological development and needs and to unite both the programme and the industry around this vision

The Directorate needs the ability to take an active role in sales and client management by professionalising these functions.

- A managed process is needed for generating and qualifying leads and to manage the sales process across the programme
- Client contacts and relationships are today informally managed and jealously guarded at Centre level. A single knowledge base is required which can be exploited across the programme
- Visit reports are not generated, so there are few data available which could be used in managing the sales process. A compact visit report format should be devised and implemented across Teltec
- Sales planning and key account targeting strategies are needed. This includes the need to allocate people as 'key account managers' to specified clients to avoid the current problem that users seem to be 'marketed at' once and then left to their own devices rather than being kept aware of the additional services they could buy and being shepherded towards making more use of Teltec
- More use needs to be made of reference sites and accounts

The Directorate has played an important role in raising programme business capabilities through a standardised approach to contracts and IPR. It should continue to play 'coach' by providing an ongoing programme of training such as

- Marketing, selling and client management
- The consulting process
- Negotiation
- Project management
- Presentation skills

A project management tool and a 'consultative selling' training course have already been bought for the programme. However, more continuous activity is needed in order to introduce a customer-oriented consulting-like culture - something which is itself rather alien in the university environments where the Teltec Centres work.

The Directorate has devised and implemented a system of financial management and control which, given the complexities of what it is trying to manage, is simple and transparent. The reality to be managed seems to us to be more complex than is needed. In particular

- Complexity and confusion is caused by passing some employment contracts and some client contracts through some University books some of the time. As a result, complex accounting transactions are generated between partly incompatible accounting systems. As far as we can understand, this complexity results from a tussle for control between the Universities and Forbairt or Teltec. In some cases, clients are confused about whom they are dealing with. Needless costs are generated
- Operating the programme within the state's cash accounting system imposes counter-productive inflexibility on budgeting (especially capital budgeting) and financial management

Some of the University Centres find Teltec's financial reporting requirements tiresome. At the level of the planned and regular reporting that is needed in order to manage the programme and to provide management information back to the University Directors, we do not see evident problems in the current system. We are told, however, that requests for additional

information have frequently been made in order to satisfy the needs of the civil service. Clearly, this has caused some frustration.

The Directorate has difficulty in playing its role in part because it does not 'own' the resources - especially the people - it funds within the Universities. The solution of employing Centre Managers, which work well in AMT Ireland, would be too expensive in Teltec with its larger number of Centres. A 'lead SRO' function could, however, usefully be created to help the Directorate manage across the programme. This would have the additional benefit of freeing Centre Directors from some of their administrative load.

Personnel

Teltec is struggling across the board with the fact that it works in areas of acute industrial skill shortage. The programme needs to strike a balance between playing a role as a training ground for industrial telecommunications engineers (which implies a fairly high labour turnover rate among the Research Officers) and the need to create and retain capabilities. Especially given the small scale of the individual University Centres, the programme is extremely vulnerable to the loss of individuals. Most seriously, UCC's viability depends on retaining a single Senior Research Officer whose skills are extremely marketable, both in Ireland and abroad.

In order to retain personnel, Teltec needs greater freedom to act as a commercial organisation. It needs to be able to set market-driven rates of pay. It needs to be able to reward individual performance. Above all, it needs to provide a sufficient sense of security to allow the Research Officers to stay.

The present two- or three-year, fixed-term contracting system is causing higher than necessary labour turnover.

While, rationally, a two-year contract with the state is in many respects much more secure than conventional industrial employment which can be (and often is) terminated at minimal notice, neither the Research Officers nor Irish society seems to see things that way. Research Officers feel under pressure to find a 'proper job', not fixed-term employment. They are typically of an age where marriage and children are on their personal agendas, increasing their felt need for security. They say they find difficulty in raising a mortgage on the basis of their fixed-term contracts.

Teltec's personnel difficulties are not unique. They are certainly shared with AMT Ireland, Materials Ireland, the Manufacturing Consultancy Service at Forbairt and no doubt with much of the rest of the state's technical support system. Resolving these difficulties seems to be incompatible with the present state structures. This is an important reason why Teltec needs to be operating in a more commercial environment.

Prices and Costs

The Teltec Directorate has carefully calculated the programme's pricing needs in order to define a consistent policy. Teltec has therefore been operating a system of pricing based on defined rates from which discounts are offered which reduce year on year in order to move the programme towards its financial targets. This makes eminent sense in terms of calculation. It also has a psychological purpose: namely, to inform customers about realistic price levels and to have them understand that they are receiving a subsidy.

We suspect, however, that this policy has two undesirable effects. First, it encourages Centres to sell at the 'discounted list price' rather than seeking the highest price the market

will bear. Second, it tends to build the idea of discounts into the market and the way industry perceives Teltec. We would prefer a system of pricing which maximises both the perceived value of Teltec's services and its revenues. This could involve price discrimination between new and established companies, or between multinational and smaller, domestically-owned firms. Teltec could also usefully explore a pricing basis which contained an element of a success-fee, whether in the form of royalties, postgraduate sponsorships or some other mechanism. There should also be some way to reward centres in proportion to their revenue generation, for example via discretionary research funding. This could replace the existing 'flat fee' paid to the Universities for Centre Directors' services.

However, a precondition for moving to a more flexible pricing system is that the rewards for those who set the prices - effectively those at the Centre level - are influenced by the profitability of the business they conduct. These rewards need not necessarily be in the form of cash in individuals' pockets. Especially in a university environment, time, space and postgraduate support for research are often at least as attractive.

At historical levels of cost recovery, there has been little pressure to count the costs of doing individual assignments. In particular, Teltec has kept timesheets only for EU projects, where this is effectively a condition of contract. In practice this means that the programme does not know its unit costs, does not know whether its job costing processes produce accurate predictions for pricing purposes and does not have a discipline for containing its largest cost: namely, labour.

Rising revenue needs will soon be forcing the issue of timesheets. Teltec should implement a unified timesheet system across the programme immediately, so that it can begin to use data in order to learn about and tune its performance. We recognise that this is counter-cultural in a University context - even though academic engineers and scientists are normally among the first to insist on the importance of data as bases for understanding processes.

Conclusions

Teltec already has the elements of a strong management system, which could enable it to develop beyond present revenue levels to become a largely self-sustaining activity. Useful tools and approaches can be taken over from other PATs which are further down the learning curve and modified or improved to meet Teltec's needs. The central issue is whether the University Centres are, in practice, interested in meeting the overall PAT goals.

To the extent that they are, it will be possible to 'empower' the Directorate. The measures then needed are relatively clear and simple. They involve creating and implementing a shared strategy; generating centrally-organised client services which create value from the programme for Teltec's customers; coordinating and professionalising the customer interface; raising Centre staffs' non-technical skills through training and mentoring; tackling the constraints of the state system on personnel policy; raising prices through price discrimination; and taking control of costs through measurement.

CONCLUSIONS AND RECOMMENDATIONS

This Chapter briefly summarises our conclusions from the report up to this point. It then sets out options for the Programme. Finally, it lists actions which should be taken to improve the programme's effectiveness and efficiency - including its ability to meet the objectives laid down by the Department for the PATs - and indicates some steps which should be taken to follow up this evaluation.

Conclusions

Telecommunications is a very attractive sector, and one which should be a focus of Irish industry and technology policy. The rates of market growth and technological change are high, providing entry opportunities and encouraging inward investment as companies expand. The increasingly rich Irish technological infrastructure in electronics and the presence of other electronics and telecommunications firms make Ireland an attractive location, as does the comparatively good supply of highly educated and skilled labour. There is a sufficient mass of activity and sufficient opportunities to access demand that niches within telecommunications equipment manufacturing are attractive for entry. In addition, telecommunications is a highly generic technology: national skills tend to be useful in user industries as well as in the business of making telecommunications equipment.

Teltec was established as a partnership between the state, the universities and industry with the intent of fostering economic and industrial development in and through the telecommunications sector. Its history has been characterised by internal dissent about whether this goal is best achieved by focusing on the production of high-quality postgraduate manpower, by providing R&D services to industry or by some mixture of the two.

Teltec has now reached its operational scale and put in place an organisation of some 85 people, including postgraduates. It has a budget of £1.8m this year, and seems likely to undershoot its cost-recovery target of 37% by some percentage-points. However, major EU projects won in 1995 will provide a good basis for continued revenue growth in the next three years.

In the longer term, Teltec is required to operate with only a 20% state subsidy. This is considerably less than is usual in equivalent foreign programmes and represents a major challenge to the programme.

Our panel of scientific and technical peers which reviewed the programme viewed the quality and relevance of Teltec work as acceptable at a national level. A small number of individual projects was excellent. There is room for improvement as the programme matures, but the panel recognised that a good deal of the university research - and, also, some of the industrial consultancy - involved the programme in moving along learning curves. The capabilities being built provide bases for further performance improvements.

The panel questioned whether all of the capabilities being built up in the Universities in fact had relevance to Irish-based industry. Some of the Intelligent Network, network design and management work could only be exploited by very large manufacturers and operators outside Ireland, who have their own internal technical capabilities in these areas. However, there are signs that the programme is starting to focus on a sub-set of these broad areas relevant to Irish industrial needs.

With regard to the programme as a whole, the panel was anxious that it functioned in a fragmented way. Little value seemed to be added by the fact of its being a single, centrally directed programme serving a coherent set of customers rather than being multiple independent, technology-based centres. Customers would see more value in Teltec if they could perceive and access it as a genuinely integrated service.

Our industry interviews led us to conclude that users are fairly well satisfied with Teltec's service. Teltec offers good value for money, and they intend to use the service again. Weaknesses are mostly in the areas where University-derived businesses tend to be weak: marketing; selling; and project management. These problems can be corrected by training and mentoring.

Analysis of Teltec's current market penetration suggests that there is little structural reason why the programme should not reach its long-term revenue targets - provided it adopts an aggressive and commercial approach. It would probably help if Teltec could position itself as in some way 'belonging' to the industry, perhaps in the style of a Research Association, rather than as an external supplier of services.

In broad-brush terms, potential customers see Teltec's range of technologies as relevant to their businesses both today and in the future. However, we believe that at a more detailed level the programme needs to refine its orientation to focus more on segments appropriate to its scale. This is partly a circular problem. Today, Teltec has little practical contact with Telecom Eireann. Cooperation over large-scale operational questions would improve Teltec's capabilities, and arguably those of Telecom Eireann itself.

Teltec already has the elements of a strong management system, which could enable it to develop beyond present revenue levels to become a largely self-sustaining activity. Useful tools and approaches can be taken over from other PATs which are further down the learning curve. A central issue is whether the Universities are, in practice, interested in creating a programme which has over-arching value beyond that brought by the individual University Centres.

To the extent that they are, it will be possible to 'empower' the Directorate. The measures then needed are relatively simple. They involve: creating and implementing a shared strategy; generating centrally-organised client services which create value from the programme for Teltec's customers; coordinating and professionalising the customer interface; raising Centre staffs' non-technical skills through training and mentoring; tackling the constraints of the state system on personnel policy; raising prices through price discrimination; and taking control of costs through measurement.

Strategic Options for Teltec

The strategic options available for the state in managing Teltec are conditioned by the special circumstances of the Irish national innovation system, the PATs and the telecommunications industry.

As we have argued in this report, the national innovation system devotes unusually few resources by international standards to university research and to postgraduate training. This problem needs to be addressed, irrespective of what happens to Teltec. This weakness, however, undermines a central assumption of the PAT policy: namely, that there exists a well-found university system, already equipped with the means to generate a flow of potential innovations for the PATs to transfer into industry. In practice, therefore, Teltec - like some other PATs - has been driven to use the high rates of subsidy available in the early years of the programme in order to build the missing capabilities in the Universities themselves. To the programme's and the Universities' credit, considerable progress has been made on this front, though there remains a longer-term worry about funding the renewal of capabilities once subsidy rates fall to low levels.

The telecommunications industry - like many of the IT-based industries - in Ireland and elsewhere suffers from constant and acute skill shortage. As Teltec's difficulties in obtaining postgraduate sponsorships from industry graphically illustrate, there is a real market failure here. Industry depends for its growth and prosperity on having a good supply of trained R&D

manpower, yet an individual company cannot easily fund studentships because it is unlikely to see a return on its investment in the form of a new employee. To date, Teltec has been helping to remedy this market failure by using its subsidy income to fund postgraduates. As subsidy levels decline, this will no longer be possible.

Teltec has made a unique and valuable contribution to industrial development in Ireland and to making Ireland an attractive location for foreign investment - increasingly for R&D as well as for production activities. There is no case for closing down the programme. There are two broad strategic options for continuation: growing the programme within the prescribed PAT form; or breaking the mould.

We believe it is perfectly feasible to develop the programme on conventional PAT lines. There appears to be adequate 'headroom' on the demand side, and the delivery capabilities of the programme are growing. Industry likes the service provided so far, and we have indicated that this service can (and should) be further developed to incorporate some of the functions of a Research Association, thus increasing its attractiveness. However, the economics of the PAT model will shape the programme in ways which involve risks or may be undesirable.

- The academic Centre Directors will become demotivated as cost-recovery requirements rise. The programme is likely to need increasing central management and links with the Universities may progressively weaken
- Postgraduate numbers will fall significantly, yet there is no other mechanism to deal with the skill shortage in this area
- The 'enabling technology'-focused Centres at UCC, TCD and UCD-EE will be economically vulnerable, especially to the extent that they continue to serve SMEs and the public sector - neither of which pays well. Their exposure to the unattractive economics of serving those who need help the most is further exacerbated by their lack of EU funding. They may not survive at low subsidy rates except in the unlikely event that internal cross-subsidies are introduced between Centres
- Some Centres may choose to defect. In the case of UCD-EE - whose declared intent is to do so if the PAT model is pursued to high levels of cost recovery - this may not be a major problem, seen in a national perspective. The group there has a long, strong record of balancing academic and industrial research and would undoubtedly continue to do so - though, perhaps, at a slightly reduced scale. Other defections are less probable but would be more likely to lead to real reductions in activity
- Despite the formal limit on EU funding laid down in the PAT guidelines, Centres will increasingly be driven to seek such money in order to reach their income targets. The PAT rules already recognise the value of doing some EU work, as well as the diversion involved in doing too much. Nonetheless, Centres will find it implausible that they will be closed down for exceeding their EU income maxima and may focus on this to the detriment of a more balanced portfolio

This scenario would become rather less gloomy if the state were able separately to increase its spending on university research and postgraduate education in telecommunications. In the ideal case, this would be in the context of more general increases funded, presumably, from the Education budget. A mechanism more closely focused on telecommunications could involve the Department of Enterprise and Employment in a decision to provide equivalent funds, based on the argument that this funding has strategic value for industrial development. At the limit, the Department could choose to fund the postgraduate training part of Teltec in lieu of industry, so that the income would be treated as industrial sponsorship.

The alternative option of 'breaking the mould' involves an explicit recognition that - at least in the case of the telecommunications sector - the PAT model is not the best one for fostering industrial growth and development. Rather, an approach which simultaneously offers help with innovation and a way to widen the R&D manpower bottleneck may be more useful. This approach, of course, also has costs and risks

- The most obvious cost is financial, through reduced cost recovery by the programme

- There is also a potential opportunity cost. It may be the case that, for example, another PAT, perhaps operating under conventional PAT funding rules, would produce a better return in industrial development on the taxpayer's investment. Our sector-focused study can obviously not offer evidence about this - beyond noting the high growth rates and potential in the telecommunications sector, the exceptionally high rates of growth achieved in Ireland in recent years and the potential of this growth rate for creating jobs
- Reduced pressure for cost recovery also brings the risk that resources will be wasted in the form of 'organisational slack' within Teltec. Tight managerial control and the process improvements suggested below are the best ways to limit this risk

No matter which way the Department elects to move, we believe this set of organisational improvements is a precondition for improved performance.

Recommendations

- Owing to the inherent attractiveness and importance of the sector, the state should continue to invest industrial and technology policy monies in telecommunications
- Teltec has shown itself to be an important and useful policy instrument to this end, and should continue to receive state support at least at the current and projected levels
- Resources should be used within the programme in order to continue the focusing of Teltec's efforts towards applicable niches with relevance to paying Irish customers, and away from broad technologies which have limited relevance to Ireland (see Exhibit 5.1).

Exhibit 5.1 Panel's View on Teltec Technical Funding Priorities

TCD	Radio propagation research	Maintain capability
	Radio propagation service	Key national resource
UCD-EE	DSP	Highly applicable in industry
		Consider applications beyond telecoms
		Commercial work high quality
		Retain
UCD-CS	ISDN/ATM Standards	Useful as a technology tracking service, not a research focus
	Network management	Sensible, niched approach to an area which contains large competitors
	Network security	Industrially exploitable
	Protocol design	Industrially exploitable
DCU	Video codecs and processing	Widely known technologies, but big potential impact in industry
	Intelligent Networks }	{Continue to focus the effort against
	Broadband/ATM }	{specific client needs
UCC	Microwave engineering	Large, easily demonstrable industrial value
UL	Network management }	{Continue to focus
	Wireless LAN }	{the effort against
	ISDN }	{specific client needs
	DECT/Mobile communications	Big impact possible in Ireland

- A programme of strategic, managerial and operational improvements should be launched to increase the programme's ability to reach its overall goals. The main elements of this programme are:

- Programme-wide strategy and activities, to integrate the disparate Centres into a unified whole
- Creating some programme-wide services and foci for the programme, allowing it to position more as a Research Association than as a business venture. These services should include technology and standards tracking, training and enquiry services
- Strengthening marketing, selling, consulting and project management capabilities within the programme through an ongoing programme of training and mentoring. Significant additional resources are not required. Temporary external help may be needed in the marketing area, but there is no case for a permanent marketing manager
- Review Research Officer staffing levels at the Centres in the light of the incoming workload and revenues
- Prices should be set more flexibly at centre level - provided the Centres have an incentive to maximise their revenues
- Timesheet discipline should be introduced so that Teltec can understand its costs and practice cost-based pricing

- University faculty should no longer be required to play a 'line management' role in Teltec. They and the Directorate should be supported by 'lead SROs' in the Centres
  - The present fixed management fee paid to the Universities should be replaced by performance-driven, variable funding for research to be performed at the University Centre Directors' discretion
  - A device should be found to remove Teltec from the constraints of state personnel policies and allow it to operate a commercial manpower regime in order to attract and retain necessary staff in an area of skill shortage, reward performance and swiftly part company with underperformers
  - More generally, Teltec should operate as a limited liability company whose shares are held by the state, in order to allow it to operate flexibly
- The improved programme should be monitored and - after a year - reviewed by the Forfás S&T Evaluation Group
- In order to increase its relevance to the strategic development of the national telecommunications network, as well as to underpin its technical capabilities areas relating to large networks, the programme needs more effective links with Telecom Eireann. Teltec should seek - and the Department and/or Forfás should encourage - the creation of a long-term framework agreement between Teltec and Telecom Eireann. Continuation of such an agreement would be a condition of purchase in the event of Telecom being partly or wholly privatised.

Performance Indicators

Ideally, programmes like the PATs need performance indicators which help policymakers, programme managers and individual members of the programme staff understand performance and which encourage them to act in ways which maintain or improve that performance. Indicators should help with

- Understanding costs and benefits
  - Accountability: telling policymakers whether the return on the taxpayers' investment in the programme is positive. (This return is, of course, not necessarily monetary)
  - Policy Optimisation: helping policymakers understand whether to shift resources from one programme to another which offers a greater return of the taxpayers investment
- Driving performance through monitoring, following the principle that 'what you measure is what you get'
  - Programme Management: encouraging programme managers to fine-tune programme performance in ways which produce high values in the performance indicator scheme
  - Incentives: encourage individual members of staff to behave in ways which have favourable impacts on the performance indicators

Even in industry, where finally all behaviour has to be optimised with respect only to a single maxim - profit - it is comparatively difficult to implement coherent performance indicator schemes. Knotty problems quickly arise, such as how to encourage behaviour which creates long-run customer satisfaction and loyalty by sacrificing short-run profits.

In policy, the problems are even tougher, since policymakers and programme managers normally work with multiple objectives, many of them non-financial. Some of the costs, and many of the benefits, of programmes are hard to monetarise.

Evaluation of Teltec Ireland

A practical disadvantage of performance indicator schemes, however, is that they tend to add to the reporting burden. They are particularly difficult to implement in a university culture where industrial-style cost-accounting and reporting traditions are absent. An efficient performance indicator scheme is therefore integrated with other information systems used in running the programme.

The Department has evolved a set of financial performance criteria for the PATs which - while ambitious - clearly set the parameters of the performance desired. They specify a sharp decline in exchequer funding, in order to keep the PATs focused on user needs and to obtain a clear sign from customers that the PATs are doing something economically worthwhile. They require focus on Irish-based industry and limit the share of EU funding admissible after 7 years, again in order to tie the PATs to their industrial development purpose. The Department plays a continuing role in the management of the PATs, and is itself equipped to ensure that they remain true to their purposes.

The financial performance indicators are powerful: they drive the programmes towards the desired behaviour; they sound alarm bells if PATs are underperforming and miss their annual financial targets; they provide a simple way to inform the Department of overall performance. These are the three classically good characteristics of performance indicators.

Non-financial indicators are more problematic.

- Patents granted is a questionable measure when comparing across different technologies (especially where non-patentable activity such as software is involved) and where numbers of patents involved are small. The value of one patent can be many times that of another, both in scientific and in money terms. It is not helpful to know that one group has three patents and another has five. Patents also apply much more to product development than to process development or technology exploitation, activities which generally have more economic impact
- Licence arrangements This indicator suffers the same problems as patents. The value in counting lies wholly in the encouragement the act of measurement provides
- New products or processes introduced in industry are also not commensurable. They have to be understood at the case level in order to gauge their importance
- Start-up of indigenous technology-based companies is an interesting measure, in so far as the programme acts as an enabler for starting up viable enterprises. The key drivers for setting up new firms are external to S&T programmes. Teltec can do little to affect the supply of potential entrepreneurs. It can only help them on their way, once they have decided to set up a company. Hence, this is at best only a very partial indicator of the programme's performance. It also carries the risk of encouraging spin-out by start-ups which have an immature technical or business concept, or which lack the business skills to survive. If an indicator is to be used in this area, it should look beyond counting spin-offs to consider job numbers and sustainability
- Irish companies worked with on a regular basis is an indicator giving a crude sense of the programme's interface to industry and the value industry perceives from the programme. At the limit, it can encourage the formation of a closed circle of dependent clients when the real objective should be company development - eventually weaning the companies from the support service
- Foreign companies setting up in Ireland Unfortunately, location decisions are rarely monocausal. This indicator can only be understood through cases. In addition to considering new and expanded investments, it should logically also try to cover disinvestments averted, though convincingly identifying these events or attributing credit is very difficult
- The number of technologists trained and placed in industry is an interesting measure for University departments. However, in a programme such as Teltec, it conflicts directly with the revenue objective. This indicator should be used to measure activities which aim directly to train and place technologists

In general, a shortcoming of these types of non-financial indicators is that they individually represent 'snapshots' of longer-term development processes.

A performance indicator system for Teltec should mix financial with non-financial indicators, largely within internal management and marketing systems (Exhibit 5.2).

Exhibit 5.2 Databases Needed for Operation and Performance Indication
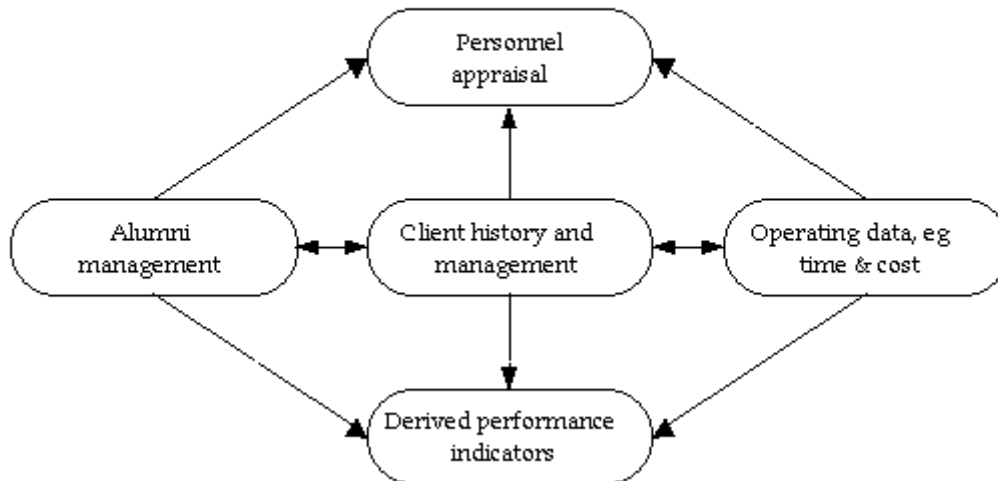
In addition to the financial reporting and control system required of the PATs - which itself provides the key performance indicator - Teltec should be tracking three aspects of its operation in order both to manage its affairs and to spin off indicators.

- Alumni of the programme - both postgraduates and Research Officers - should be tracked. Their first and subsequent destinations should be monitored and the programme should maintain contact with them, because they are a crucial source of sales opportunities, recruits and intelligence. Indicators can be spun off this database
- Clients should be tracked centrally. This will enable the programme to take a view of company development and proactively to propose involvement where appropriate. Data can be assembled from projects and visit reports, allowing Teltec also to take a view over time of the effectiveness of its interventions. Part of the standard project report should be a consideration of additionality. On this basis, it can prioritise marketing efforts - and also provide a longer-term indication of the usefulness of its role
- Operating data on time and cost are, of course, needed for internal management purposes. They also provide a way to understand the extent and cost of the programme's commitment to individual clients

The driver connecting these operating and indicator data and programme performance is the personnel appraisal process, which provides a reason for staff to work in ways consistent with producing good showings in the performance indicators.

The performance indicators actually used by the programme can include some of the non-financial ones discussed above, provided these are read in combination with a more qualitative account of performance. The following indicators would provide a useful account of the programme's performance, if delivered as part of an annual report

- Financial performance
- Postgraduate degrees awarded and postgraduate destinations
- Contributions to company development
- Technological capability
- Jobs and growth
- Encouraging investment

- Inward investments
- New, technology-based start-ups

Next Steps

There are four pieces of unfinished business to be dealt with. The latter two go well beyond a narrow evaluation of Teltec, but relate to the conditions necessary for Teltec and similar initiatives to operate in a healthy manner.

1. Implement and follow up the proposed operational improvement programme
2. Decide among the funding alternatives set out for Teltec, and implement the chosen solution
3. Resolve the legal status of the PATs by placing them in a legal structure which frees them from the inflexibilities of the public service and effectively allows them the same freedom of action as companies
4. Review policy on postgraduate and University research funding, with a presumption that funding levels should rise

Finally, while we have not been able to identify any simple way to obtain synergy by merging Teltec with all or part of another PAT, it is clear that customer constituencies do overlap between PATs and that several work in related domains, especially within electronics. A larger-scale review of the PATs' activities and their customer bases could usefully be undertaken in order to identify potential cost savings from synergies and, also, to ensure that learning and tools are being transferred between the PATs.