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Howard Partners Pty Ltd ACN 090 817 369

Department of Education, Science and Training

Evaluation of the Cooperative Research Centres Programme

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Howard Partners Pty Ltd
Unit 13, Macquarie Court, 26 Macquarie Street, Barton, ACT, 2600.
PO Box 4090, Manuka, ACT, 2603.
Tel: 02 6273 5222; Fax: 02 6273 4888.
www.howardpartners.com.au

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> *Australia must match the technology push provided by its strong research base with the demand pull of industry and other research users.*
>
> Minster for Science, announcing the first 15 CRCs, 14 March 1991.

Introduction

This is a Report of an Evaluation of the efficiency and effectiveness of the CRC Programme and an assessment of the clarity and appropriateness of the current CRC objectives as the Programme evolves. It is an evaluation of the Programme as a whole – not of individual CRCs.

The CRC Programme was established in 1990 with a purpose to "match the technology push provided by [Australia's] strong research base with the demand pull of industry *and other research users*".[1] The first 15 CRCs were announced in March 1991. A further 108 CRCs were approved over the ensuing 10 years, including 39 applications for renewal. In December 2002 a further 22 CRCs were approved; these are due to commence in July 2003.

Up until end June 2002 the Commonwealth, through CRC Programme funds, had contributed $1.15 billion to the CRC Programme. Industry and other participants had contributed a further $680m giving a total level of cash placed with CRCs of $1.83 billion. This contribution has been supplemented by $2.73 billion in "in kind" contributions, giving a total level of funding of $4.56 billion.

The CRC Programme is primarily an industrial research programme that supports industry and business development across a broad range of sectors, including agriculture, fishing and forestry, information and communications, mining, manufacturing, energy, health care, water services, transport and construction. The Programme also delivers outcomes in relation to resource sustainability, particularly in the context of the conservation, repair and replenishment of the nation's "natural capital" and the maintenance of biodiversity. In addition, the Programme supports social outcomes through the promotion of public and environmental health.

The arguments for public involvement in industrial research are well rehearsed and it is not proposed to restate them in this Evaluation. The point is that publicly supported collaborative research can deliver substantial benefits to the economy, industry, and the community over the longer term through the creation and application of knowledge that enhances international competitiveness through the introduction of innovative processes and practices, and facilitates the creation of new businesses built around the commercialisation of research.

The CRC Programme also addresses a market failure, particularly in environmental research, but also in agricultural research, that enables more attention to be given to the application of knowledge to reverse environmental degradation and biodiversity loss than would otherwise be the case.

[1] Minster for Science, announcing the first 15 CRCs, 14 March 1991 (emphasis added).

The CRC Programme is distinguished from a range of other public programmes designed to foster closer links between research users and research providers by the size of the Commonwealth payment – ranging from $12m to $30m – and the time-frame of commitment – typically seven years. The Programme also differs in that it requires the formation of a *managed* relationship between CRC participants in the form of a formal joint venture partnership. This differs from the *gift*-based (or unrequited) relationships that underlie many other research grant programmes.

There has been a profound change in Australia's research and innovation culture since the Programme was introduced. There has been, for example:

- A widespread recognition of the role of public-private research partnerships, based on the generation and utilisation of "applicable knowledge", in industrial innovation.
- In the context of the "knowledge economy", an acceptance of a role for the public sector in supporting new business development through the commercialisation of publicly funded research.
- A greater understanding of the contribution of science to the design and implementation of public programmes, particularly relating to the environment and public health.

The emergence of public-private research partnerships reflects a fundamental change in the way in which knowledge is generated and applied as well as changes in approaches to the management of industrial research and development. The CRC Programme sits well in the developing system of industrial research built around the production of "knowledge in application", or "applicable" knowledge.[2]

Research commercialisation has come into prominence with a realisation of the potential for the creation of new businesses based on knowledge assets. During the late 1990s venture capital came to be recognised as an asset class specifically designed to invest in these businesses. Moreover, the application of science in public programmes ensures that interventions are well directed and that there is a relationship between action and outcome.

To accommodate these changes it has been necessary to develop a capacity to carry out partnership-based research and innovation, business development based on research commercialisation, and for scientists to engage in public programme design and delivery. The CRC Programme has been an important contributor to that capacity building.

The CRC Programme, which started as a "bottom up" collaborative venture between researchers provided a strong basis for developing trust-based relationships between organisations. With increasing internal resource constraints and the need to set priorities, the Programme has now moved to the next level where collaboration between universities, publicly funded research agencies, business and government is being approached at a more strategic level. Moreover, with greater interest in returns

[2] See Michael Gibbons and others, *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies* (London: Sage, 1994), Michael Gibbons, "Higher Education Relevance in the 21st Century," in *UNESCO World Conference on Higher Education* (Paris: World Bank, 1998)

from Intellectual Property and commercial activity the management of a research joint venture is now a much more critical issue.

The CRC Programme has been reviewed several times over its lifetime. In commenting on these reviews, the Australian Chamber of Commerce and Industry (ACCI) concluded that the Programme is an extremely effective policy instrument, which has been recognised around the world for fostering collaboration between industry and researchers. Discussions and consultations during the Evaluation confirmed that most stakeholders agree with this sentiment. This has been a vanguard Programme that has tried to do new things in new ways. It has attracted international attention and has become one of the notable features on Australia's distinctive science and innovation landscape.

At the same time, however, CRC participants and stakeholders agree that it is now necessary for government to act decisively to build upon the strengths of the Programme *and* to adapt to some of the recent developments in the industrial research and the research commercialisation framework. There are criticisms, but these are generally *sympathetic criticisms* from those who stand to benefit from a more efficient and effective CRC Programme.

There was a view expressed by many stakeholders, particularly those in the private sector, that the Programme had been too focussed on research with an insufficient emphasis upon meeting industry and other end-user needs through attention to adoption and application of research results. Some, but by no means all, of this criticism is justified. It is in this context that the Evaluation recommends that the Programme should be clearly positioned as an "investment" vehicle in which research is seen as a means to an end ("an end use"), not an end in itself.

Consistent with the trends in research and innovation culture, the Evaluation finds that three distinct types of CRC have evolved with the implementation of the CRC Programme:

1. The delivery of *national benefits*, predominantly in relation to the conservation, repair and replenishment of Australia's *natural capital*, maintenance of biodiversity and promotion of public and environmental health.[3]

   CRCs that operate on these lines have a strong focus on *resource sustainability.*
2. The delivery of *collective industry benefits* through the creation of applicable knowledge to improve and/or enhance industry performance in the light of global competition and demands for increased quality.

   These outputs are delivered through what are effectively public-private industrial research partnerships, or *industrial research collaborations* and have a strong focus on *industry performance improvement.*
3. The delivery of commercial benefits through the expansion and creation of *new businesses* based on the transfer and/or sale of intellectual property rights and reflected in new products and services.

   CRCs that operate on these lines have a strong focus on business development and research *commercialisation*.

[3] Natural capital refers to the stock of productive soil, freshwater, vegetation, clean air, ocean and other resources that underpin the survival, health and prosperity of human communities.

The categories are not, of course, mutually exclusive. Commercial benefit, through the establishment of new businesses, has been realised in many national benefit and collective industry benefit CRCs. Substantial income streams have been realised through technology licensing and product marketing.

An estimate of the distribution of resources within the CRC Programme among these categories at four yearly intervals is indicated in Table 1.

Table 1: Distribution of CRC Expenditure within the CRC Programme

	1993/1994	1997/1998	2001/2002
National Benefits	14.0	16.0	20.1
Collective Industry Benefits	64.5	61.2	60.2
Business Development	21.6	22.8	19.8
	100.0	100.0	100.0

The data suggest that there has been a discernible trend towards a greater emphasis on national benefit CRCs over the life of the programme. Within each of these trajectories the Programme has recorded some major achievements. Some of these are listed in Figure 1 on page xix.

The increasing role of national benefit CRCs reflects the "demand pull" of research users involved in the application of scientific knowledge for resource sustainability. These include, predominantly, Government agencies involved in natural resource management, bio diversity and, more recently, biosecurity. In the area of collective industry benefit the CRC Programme has had a major impact in mature industries that have strong leadership, a production orientation, and a focus on global markets and international competitiveness. Collaboration tends to be "pre-competitive" and strongly directed towards innovation in industrial processes and business practices.

For businesses that are more strongly consumer oriented, where innovation is undertaken close to market in the form of rapid product re-development, design, and brand recognition, research collaboration tends to be approached on a single provider contract basis and working outside the collective approach of the CRC model. The level of involvement in the CRC Programme of companies in the "fast moving consumer goods"[4] sector, for example, is not high. These companies do, however, look beyond their boundaries for help with innovation – to customers, research companies, business partners and universities.[5]

During the 1990s companies that were traditionally production oriented have had to become much more consumer-oriented as a result of policy, regulatory and market changes that stimulated competition. Confronted with demands for increased shareholder value, and rejection of a "not-invented-here" culture, many of these companies have scaled back their internal R&D effort and now look to research collaboration and strategic alliances to source innovation. These arrangements can be established on a joint venture (managed) relationship or a purchaser-provider (market oriented) relationship. CRCs are essentially managed relationships.

[4] These companies include food processing, consumer electronics, consumer durables and some business products, where speed to market and continuous innovation in product development and presentation are major business drivers.

[5] A recent US study estimates that some retail companies source 90 percent of their innovation from external sources. The average for all firms in the study was 45 percent. See Jane C Linder, Sirkka Jarvenpaa, and Thomas Davenport, "Toward an Open Sourcing Strategy," *Sloan Management Review* 44, no. 4 (2003)

Companies that acquire R&D externally would like CRCs to undertake problem oriented research and often seek to negotiate contracts with specified researchers within the CRC (a form of market relationship). Reflecting this trend, some CRCs are evolving into "industrial research institutes" with substantial income from contract research. CRCs that create new businesses, in the form of "start-up" technology based companies, also address this emerging demand for sourcing industrial innovation by creating "options" for acquisition by technology intensive companies. This trend is associated with growing public policy interest in the commercialisation of publicly funded research.

CRCs have performed a vitally important role in transforming publicly funded discoveries and inventions into products and businesses that are "investment ready". A major challenge for current and potential CRCs is locating and connecting with companies prepared to be involved in the development and adoption of *disruptive* technologies. Venture capital seed investors are performing an important role by assisting with the creation and building of *new* "start-up" businesses based on these technologies. The shortage of seed and pre-seed funds is, however, a matter of major concern.

There is a number of "single user" CRCs based on both product development and business development in areas of new and emerging technologies, particularly in health care and medical devices. Many of these companies have been supported by venture capital investment.

The changes in structural conditions referred to above provide a clear indication of how the Programme can be strengthened in the future.

With that in mind, the Evaluation Team has no reservation about recommending that the Programme continue, albeit with modifications to objectives, design features and implementation arrangements. These changes will result in a more targeted and effective arrangement *for industrial research collaborations* and CRCs based on *creating businesses* through the commercialisation of discoveries and inventions in universities and public research organisations.

This Evaluation addresses the following principal questions:

- Do the Programme's outputs and outcomes demonstrate that it has been *effective* in meeting its objectives?
- Do the administrative arrangements for the Programme enable it to be delivered as *efficiently and flexibly* as possible?
- Do the Programme's objectives and key design features provide a clear and *appropriate* framework for achieving successful outcomes within the broader Australian science and innovation system in the medium and longer term?
- Are any changes needed to the objectives to strengthen the Programme in future and what implications would they have for Programme design and change management?

The Terms of Reference include a number of specific questions and issues to address in the Evaluation. The detailed Terms of Reference are located at Attachment 1. To address the Terms of Reference, the Evaluation was approached on a number of fronts:

- Analysis of existing documentary material and data collected by AusIndustry and the Department of Education, Science and Training in relation to the management of the Programme.[6]
- Research and analysis in relation to the role of cooperative research in national innovation systems and the increasing significance of that role.
- A very wide process of consultations with all categories of CRC stakeholder. Consultations included -
  - Approximately 100 one-on-one interviews with industry associations, business leaders, government departments and agencies, research organisations, university research managers and CRC senior managers.
  - A series of six workshops in each mainland capital city.
  - Submission of written comments in response to written invitations.
  - Attendance at meetings of Deputy Vice Chancellors and the Conference of the CRC Association.
- A structured questionnaire and *Outcomes Survey* managed by Orima Research to quantify opinion related to Programme outcomes.

The methodology is described in detail in Attachment 2.

The answers to each of the principal Evaluation questions, and to the subsidiary issues raised by the Terms of Reference are set out below. The body of the Report provides more material and supporting detail in relation to the findings reported.

Programme Effectiveness

In general terms, the CRC Programme's outputs and outcomes demonstrate that it has made substantial progress towards achieving its objective under the current design strategy.

There are areas of great strength, associated with the existence of strong established industry partners (such as in the mining, energy, agriculture and water sectors). There are also areas of strength in emerging technologies in which new businesses have been created as a result of the existence of the CRC and in providing 'public good' outcomes.

Responses to specific issues raised in the Terms of Reference documentation in relation to Programme effectiveness are as follows.

Contributing to Australia's economic growth, social well-being and environmental outcomes

In addressing this issue it is useful to draw a distinction between improving the *capacity* to carry out partnership-based research and innovation and how effectively this capacity has been *used*. Australia's *overall* capacity to carry out partnership-based industrial research and innovation has improved by virtue of "learning-by-doing" and "creation of knowledge in application" built around innovation at the interdisciplinary interface.

The CRC Programme has contributed to these developments, but as part of a more general trend. Consequently, the main return on the Commonwealth's investment in

[6] The CRC Programme was managed by AusIndustry in the Department of Industry, Science and Resources until late 2001 when responsibility was transferred to the Department of Education, Science and Training.

the CRC Programme lies in its contribution to this improved capacity to carry out partnership work in the *overall* science and innovation system.

Data from the *Outcomes Survey*, undertaken as part of the Evaluation, indicates that research outputs have been implemented and are expected to lead to economic and environmental benefits. Quantification of benefits, however, is difficult in the absence of a market transaction between research findings and end user application. This occurs particularly where research is applied in the form of improved environmental management or in improved industrial practices and processes, as in the mining and agriculture sectors.

Some CRCs have undertaken economic assessments, but these are not reported consistently. For example, the Australian Petroleum CRC reports that an independent economic analysis identified a net present value in excess of $300m from an $8m CRC investment.

The *potential* for substantial national economic benefits is generally reported by CRCs as being high, but demonstrated actual benefits are a little more difficult to come by. That said, the focus of the CRC Programme is on *long-term* research, and truly groundbreaking research may take many years to result in application. For example, examination of CRC individual Reports and submissions indicates:

- The CRC for Clean Power from Lignite estimates that implementation of the Centre's MTE technology for coal dewatering in existing Latrobe Valley power stations would save 15 million tonnes of CO_2 emissions per annum; at the expected range of emissions trading values this would amount to between $150m - $450m per annum (implementation costs are estimated to be $75m per annum).
- The CRC for Sustainable Production Forestry reports a potential pay-off of $194m from research leading to the improvement of genetic potential for eucalyptus from hardwood plantations.
- The CRC for Eye Research and Technology, which has developed a new type of contact lens that can be worn continuously for up to 30 days, and is now worn by more than 400,000 people, reports an enormous potential market among the 95 million people in the world wearing contact lenses.

The issue here is the capacity to realise *potential* economic, social and environment benefits through application and adoption by end users. At this stage, it may be too early to translate the potential benefits into application and adoption.

The difference between potential benefit and realisable benefit is reflected in the results of the *Outcomes Survey*, which indicates a substantial gap between the research user and CRC Manager views on research impacts. This is indicated in Table 2.

Table 2: Performance indicators: CRC research user and research provider views of research impact

Views concerning extent to which CRC research has impacted on	Research User[7] Rating High or Very High (%)	CRC Manager [8] Rating High or Very High (%)
Accelerating or improving existing research projects	48	74
Stimulating new research projects	48	78
Contributing to the development of IP	24	72
Introduction of new/improved products, processes	24	80
Improving business/industry profitability	28	64

The lower expectations of research users in relation to CRC research impact is also reflective of other motivations to be involved in a CRC – such as early warning and awareness on the development of new science and technologies and access to research students. It may also reflect an expectation and an understanding on the part of CRC Managers that adoption will occur in the form of *new* business relationships independently of the research users involved in the CRC (for example, commercialisation through licenses and start-up companies).

Data that allows the outputs generated by CRCs to be related to national outcomes is scarce and does not feature in the set of data collected by the Department of Education, Science and Training through the *Management Data Questionnaire* (MDQ). This issue highlights a main theme to arise from this Evaluation.

> *If technology-push is to be linked to demand-pull then the generation of the capacity to form and effectively manage partnerships with this end in mind is a necessary but not a sufficient condition for innovation and end-use to take place.*
>
> *The sufficient condition is that there must be investment in, detailed planning and knowledge of, the process that translates specific initiatives to innovate and to adopt into actual outcomes.*

The extent to which research is implemented in processes, products and public programmes varies considerably across CRCs.

Developing Australia's public and private research capacity in the areas of national need or global opportunity

The Evaluation has found that the CRC Programme has made a major contribution to the development of Australia's public sector research capacity in areas of national need and global opportunity.

- The environmental CRCs have not only carried out important and useful research on Australia's (often unique) environmental challenges, they are also viewed as having taken on a de-facto role in coordinating environmentally oriented research. Other CRCs have led the way in developing new technologies and in facilitating the commercialisation of these technologies.
- The agriculture CRCs have made substantial contributions to animal and plant production methods and processes that increase industry productivity and competitiveness in global markets as well as enhancing sustainability.

[7] Research users were asked about how CRC research has impacted on *them*.
[8] The sample included Managers in "public benefit" CRCs

- The high technology manufacturing CRCs have developed and applied material sciences for the aerospace industry and developed techniques for joining material with specialised welding techniques.
- The life sciences CRCs have been associated with biotechnology based drug discovery, and medical devices CRCs have been very successful in developing and marketing hearing implants and contact lenses.
- In information and communications technologies (ICT), the Photonics CRC has developed a range of communications technologies for which it has worldwide patents, and the Signals Processing CRC has created a number of radar related inventions.

The impact on private sector research capacity in general manufacturing is viewed as being less pronounced. This reflects in large part the relatively low level of commitment to industrial research in this sector.

Data from the *Outcomes Survey* provides an insight into a number of aspects of research capacity and capability. Seventy two percent of research users were either satisfied or highly satisfied with the way in which CRCs had facilitated access to facilities and equipment within the CRC environment, 72 percent with the way in which CRCs had built trust and confidence with the research community, and 76 percent with the contribution of the Programme to undertaking long term research.

There are, however, aspects of the Programme that limit the participation of small to medium businesses - particularly those in the category of new technology based firms (NTBFs) where established industry partners are either absent or unwilling to participate in a CRC. In this area, a business is quite often the *outcome* of research.

Producing research of an excellent standard that would not have been undertaken otherwise

This is a complex question to answer because of the degree of diversity within the CRC portfolio. On the one hand, the industry view that the Programme has become far too 'researcher' oriented suggests that the additionality of the CRC Programme may be relatively low from this end-user perspective. In this view, much CRC research might also have been possible using research funding from other sources.

On the other hand, CRCs are a vehicle for excellent research *of relevance to potential end-users*. In those cases where this system works well, the additionality of the CRC Programme in terms of research excellence of relevance is high. This tends to be associated with situations in which industry and government are able and willing to work in partnership with researchers (as in medical science and the environment).

Data from the *Outcomes Survey* indicated a very high level of user satisfaction with CRCs in relation to research scope, quality and relevance. Seventy two percent of research users were either satisfied or very satisfied with the scope of projects covered, 80 percent with the technical quality of the research, 76 percent with the innovation quality of the research, 56 percent with the relevance of the research to user needs and 68 percent to Australia's long term needs.

Adding to the nation's intellectual property and its commercialisation or utilisation

According to the MDQ database the CRCs currently maintain 114 Australian patents together with patent applications being processed. They maintain 549 overseas patents together with patent applications being processed. The preference for patenting overseas indicates that a global perspective is being adopted (and reflects good-practice in IP management strategies).

The level of patenting is not, however, very large given the overall scale of industrial research activities. The revenue stream from technology agreements between 1991-92 and 2000-01 is reported in the Department's database as $32m. However, income from this source has increased markedly in recent years and was reported as $7.7m in 2001-02.

The revenue from sales of CRC created start-up companies has been reported at $30.4m for the 2001-02. However, the projected sales of these companies is just under $1 billion, although the time frame for realisation is not clear.

Over the period 1998 to 2002 the total CRC allocation of cash resources to commercialisation/technology transfer and external communication averaged 13.6 percent of total cash commitments (and 9.9 percent of total cash and in-kind resource commitments). In contrast, 66.9 percent of cash resources were devoted to research (75.3 percent when cash and in-kind resources are combined).

Taken on face value these resource allocations support the view that the dominant focus of the CRC Programme has been on research and not upon commercialising and utilising intellectual property.

Enhancing collaboration among public and private researchers, and between public researchers and commercial or community interest

The capacity to collaborate largely resides in the cohorts of researchers who have passed through the CRC system. Their experience and training has exposed them to knowledge in different disciplines and sectors. It has also exposed them to a greater diversity of research problems than would otherwise have been the case.

Information from the Department of Education, Science and Training CRC Programme database indicates that there are 749 core participant organisations in the currently active CRCs. The distribution is: industry, 38 percent; universities, 30 percent; government, 28 percent; research institutes, four percent. There is a further 226 participants in a supporting role. Sixty one percent of these are from industry, 11 percent from universities and 14 percent from Government.

The enhanced capacity for inter-disciplinary and inter-sectoral work allows complementary intellectual assets to be brought together to do new things in new ways. This is the foundation both for leading-edge research and for successful innovation. It is also the most difficult outcome to quantify.

The *Outcomes Survey* provided very positive indications in relation to collaboration. In relation to specific outcomes, about half of the research users indicated that they obtained a high or very high level of value from the collaboration. It would appear that the CRC arrangements are regarded highly for the networking activities and opportunities of the researchers.

One issue that has emerged in recent years relates to the strategies of the large research-performing organisations (the research universities and the major Commonwealth research agencies). These organisations are reported to have adopted more strategic approaches to CRC involvement as the Programme has matured. This involves a greater 'top-down' influence on the nature and extent of involvement based upon alignment with the organisation's own strategic objectives.

The result is that the partnerships and collaboration associated with CRCs now have less of a 'bottom-up' element and there is a tendency to use CRC involvement as a means of supporting internal organisational objectives rather than supporting the inter-organisational partnership itself. Ongoing management of the CRC relationship is receiving much more attention in participant organisations.

With increasingly tight budgets and financial pressures, the resources available for open-ended collaboration are constrained. Networks and informal organisation only flourish in an environment where there is a substantial element of "organisational slack".

Increasing the proportion of public researchers who are commercially oriented

A major contribution of the CRC Programme has been to create a cohort of highly skilled industrial research managers who are able to deliver results under complex partnership arrangements involving large and powerful participant organisations. The 'matrix' structure of CRCs creates a management challenge of the highest order and places a premium on chief executive officers (CEO) who are: scientifically credible; have knowledge of Intellectual Property; and, have commercial and businesses acumen. This is in addition to strong leadership qualities.

One the most positive aspects of the CRC Programme has been the contribution to the training of PhD students. CRC based training of PhD students has an advantage in that these students develop a tacit knowledge of the importance of application and adoption of research and how to interact with industry. This positive externality will greatly assist in developing a culture of adoption and application within Australian industry and government. Unfortunately it is effectively impossible to measure its impact.

In 2001-02, 1,391 PhD full time equivalent (FTE) students were registered at CRCs, 208 FTE Masters degree research students and 9,124 undergraduates were recorded as taking part in CRC-run education courses. The proportion of CRC based PhD students in agriculture and natural resource management represents about 45 percent of enrolments in Australian universities.

From the *Outcomes Survey*, 72 percent of research users indicated that they were either satisfied of very satisfied with the qualities and capabilities of CRC researchers.

Upgrading the innovative capacities of Australian business enterprises

The main area in which innovative capacity in the private sector has been enhanced as a result of the CRC Programme is when new products and processes emerge as a result of the adoption of CRC research. In the agriculture, mining, and water industries businesses have adopted and implemented CRC developed technologies. Appli-

cation could go further with greater commitment to and investment in knowledge brokerage activities.

New technology-based companies have also been generated as a result of CRC research. This covers not only the transfer of technology into brand new businesses; it also covers new businesses created by graduates when they leave the CRC. This applies particularly in those industries where there is opportunity for the application of "disruptive technologies" and a comparatively low requirement for investment in "complementary assets" (machinery, buildings, other IP, etc).

New companies created from the CRC environment, together with start-up companies commencing from other sources, should eventually play a role in re-vitalising the nation's industrial fabric - but this is likely to be a long-term process that relies upon these companies growing in size and influence, being acquired, and/or building linkages through industry value chains. The skills and capabilities of venture capital investors in building businesses and linkages through (global) value chains is particularly important in this regard.

Administrative efficiency and flexibility

There is considerable scope for improvement in the administration of the Programme that would add to improved efficiency and flexibility. Specific opportunities are canvassed below.

Selection criteria and procedures

The successes that the Programme has generated have been due in large part to the flexibility of the selection criteria and the ability of individual CRCs to respond to changes in their operating environment. This 'permissive' approach has been important in introducing flexibility into the Programme and allowing CRCs to grow around new business development for example.

Although this flexibility is useful, the approach adopted by proponents to the application process is viewed as overly focused upon formulating proposals to fit eligibility criteria and assumed norms (such as the size of bid most likely to win funding). Professional advisors and consultants are frequently contracted to develop CRC proposals. This results in well-crafted proposals but introduces a level of conformity that may work against novelty and innovation.

The selection criteria have evolved over time and have become highly prescriptive in their orientation. The nine selection criteria are used not only in selection but also in the review and evaluation processes. Conversely, the Programme objectives have become more generic and all-embracing. There is a need to reverse this balance by encouraging Proposals to be developed around the Programme objectives rather than the selection criteria.

Funding arrangements

An important aspect of the CRC Programme has been to "leverage" industry funding for research and development. The extent of leverage is highly regarded in the application and assessment process. It has been reported widely in publicity and

promotion as an indicator of the "success" of the Programme in relation to stimulating expenditure on research and development.

Programme funding is seen by many CRC participants as "providing the glue" for collaborative research endeavours. This is the essence of the leverage arguments and applies particularly in the mining, energy, agriculture, and natural resource management sectors where participants have ongoing and substantial commitments to research.

At the same time, however, leverage makes it difficult for CRCs based on new business development in emerging industries to be competitive in the selection process due to the difficulty of finding existing industry partners and encouraging those partners to contribute significantly in cash and in kind. The extent of leverage required also makes it difficult for small to medium enterprises (SMEs) and non-government organisations (NGOs) to be major contributors to a CRC application.

By trying to increase the "leverage" of Commonwealth funding to make a bid look competitive, proposals in the established industries can also involve a large number of industry partners with relatively small commitments. These large CRCs can become unmanageable and non-viable.

The focus on leverage has resulted in an erosion of the relative value of core Commonwealth funding to individual CRCs and a risk that Programme funding is being spread too thinly. Whilst the leverage objective had validity in the early years of the Programme, it is of much less relevance now in stimulating industrial research – particularly in the area of research commercialisation. A greater investment focus for the CRC Programme will reduce the importance of the leverage expectation.

Departmental processes and procedures

Previous reviews have made recommendations that have increased departmental "oversight" and generated an increased reporting and compliance burden on CRCs. Whilst the objectives of the enhanced reporting requirements are to ensure accountability over the disposition of public funds, it is also important to ensure that the administration costs associated with operating a CRC do not continue to grow simply by virtue of these compliance requirements.

The general view expressed from within government, from universities and businesses is that the CRC Programme is "over-administered". In a devolved management environment much of the oversighting, monitoring and control should be in the hands of Boards – with Boards responsible and accountable for results and outcomes.

Despite this "over-administration" and fairly heavy reporting requirements via the Management Data Questionnaire (MDQ), no over-arching CRC performance measurement framework has evolved that is able to answer the key question: *what benefits has the CRC Programme achieved in terms of Australia's economic growth, social well-being and environmental outcomes?* The dominant emphasis is upon inputs and outputs not upon outcomes.

Accountability

The accountability framework for CRCs rests upon complying with a contract relating to often uncertain research and innovation processes over a seven year time-frame. The situation is complicated by the existence of two agreements – an Agreement with the Commonwealth and an Agreement among the participants.

Accountability for CRC performance should be placed more squarely with the Board of the CRC, with the Commonwealth monitoring results and outcomes and relying on annual financial returns, Audit Reports and CRC initiated Performance Audit Reports. The responsibilities of Boards, and their relationship with participants can be clarified by the creation, through legislation, of a special corporate vehicle to operate CRCs.

A special corporate vehicle would also have application in relation to other public-private industrial research partnerships, such as Major National Research Facilities (MNRF) and Centres of Excellence. Such an entity would clarify taxation and other corporate issues associated with CRCs and allow for a far less complex transition from a research organisation to a more commercially based business. It would allow for the resources currently spent on legal fees and taxation advice to be diverted into research and value adding activities.

The CRC Programme within the Broader Science and Innovation System

The CRC Programme occupies an important place in Australia's science and innovation system. However, the system has been evolving with consequent implications for the CRC Programme in the medium and longer term.

Clarity and appropriateness of the current objectives

The current Programme objectives have drifted significantly from those announced in 1991. The objectives have become more generic, but they are "supported" by nine selection criteria reflected in a comprehensive set of "rules" contained in *CRC Guidelines for Applicants 2002 Selection Round and General Principles of Centre Operations*. There is also a set of supporting documents relating to Reviews and Reporting based around the nine selection criteria.

As indicated above, it is important to restore the balance between the Programme's objectives and the Selection criteria. It is also important that the Programme be associated with an "overarching purpose" or "vision".

For the future, the CRC Programme should be promoted on the basis of an overarching purpose "to achieve closer linkages between science and the market by matching the technological capability provided by Australia's strong public research base with the requirements of industry and other research users".

In terms of objectives, it became apparent during the Evaluation that the tasks required were actually very clear statements of intent. It is therefore proposed that the objectives of the Programme be defined as:

- Contributing to Australia's economic growth, social well being and environmental outcomes.
- Developing Australia's public and private industrial research capacity in areas of national need or global opportunity.

- Producing applicable research that is of an excellent standard.
- Adding to the nation's intellectual property and promoting its adoption, application and use in businesses and public programmes.
- Producing graduates with skills, knowledge and experience in the application of research in a national, industry and/or business context.
- Enhancing collaboration among public and private researchers.
- Upgrading the innovative capacities of Australian business enterprises.

The objectives stated in these terms will allow for a more economical approach to be adopted in developing Guidelines (see below).

Within the framework of Programme purpose and objectives, and reflecting the industrial research focus of the Programme, the CRC Programme should be clearly positioned as an "investment" programme that is expected to deliver returns in the form of economic, social and environmental benefits to the nation. These benefits may be in the form of:

- Employment and profitability of new or existing technology based businesses as a result of the adoption, application and use of scientific discoveries and technological inventions.
- Improved international competitiveness of Australian industry.
- The adoption and implementation of programmes that are targeted at the conservation, repair and replenishment of the nation's natural capital, restoration of biodiversity and improving public and environmental health.

Selection criteria and procedures

The selection and renewal of CRCs should give preferential treatment to robust and compelling "investment propositions". These proposals should detail the path to market or other end-uses by quantifying, to the greatest extent possible the costs involved in attaining these objectives, the scope, extent and estimated value of benefits to be obtained, and the anticipated risks faced. The proposal should clearly identify the feasibility, desirability and practicality in relation to implementation – from an end user perspective.

Within this the basis of selection should be, first and foremost, an appraisal of the extent to which the proposal will achieve the objectives of the Programme. Beyond that, selection should be based on assessment of:

- The *Credibility* of the proposal in terms of methodology, approach, the significance of the problem and issues being addressed, the handling of risk and uncertainty, and the probability of success.
- The *Reputation* of the researchers in applicable research (including their track record in collaboration).
- The *Integrity* of the nominated Governing Board.
- The *Capacity* of the Board to identify and appoint a CEO with the necessary management and leadership capacities.
- The *Commitment* of all concerned to collaboration and achieving outcomes.

These criteria are consistent with investment appraisal criteria and focus on the skills, knowledge, experience and competency of the research team, and its backup, to deliver the results intended.

It is also envisaged that the selection process would involve two stages:

- A Preliminary proposal submitted in response to a general and public "Request for Proposals" and containing an outline and summary of the research, its importance and significance, indicative benefits, budget details and extent of end user involvement.
- A Full proposal, following CRC Committee review and invitation to submit a detailed proposition.

The selection process should be undertaken by expert panels with an industrial focus, with members having both academic research and industry credentials and experience in investment appraisal. The quality of the science would be a pre-requisite – as indicated by the academic and industry standing of the scientists. The panels would be formed for the following sectors: information technology and communication industries; pharmaceutical, health care and medical devices; environment/agriculture/water industries; mining and manufacturing.

Funding arrangements

In the revised framework there should be no specific guideline given concerning the level of funding for CRC proposals. However, the CRC portfolio should be structured in a way that there is an appropriate balance between CRCs requiring large, longer-term investments and those involving a lower level of investment over an initial shorter time frame, but a prospect of building up over time.

It is also proposed that the CRC Committee monitor and maintain what it considers to be an appropriate balance between investment in CRCs oriented towards national benefit, industrial performance improvement and business development. That balance would have regard to the investment climate and linkages and relationships with other Programmes relating to the creation and transfer of applicable knowledge. It is *not* suggested that the Programme be sub-divided into three "sub-Programmes" with earmarked allocations along these lines.

Given the changes in the industrial research and innovation culture referred to earlier, there would, however, be a strong expectation that more resources would be directed towards CRCs based on new business development involving the commercialisation of university and publicly funded research. Such re-direction would necessarily have regard to the quality of the "investment" proposals submitted.

Accountability framework

An "investment proposal" approach that stresses the intended return on investment and how this will be achieved would provide a suitable mechanism for enhancing industry and end-user confidence. This "business-like" approach would not only improve the effectiveness of the CRC Programme in delivering its intended 'headline' outcomes, it would also simplify the administration of the Programme.

The fundamental accountability criterion is that CRC Boards should be responsible and accountable for the performance of the CRC.

Conclusion

The success of the CRC Programme to date has been strongly influenced by the extent of the existing match between the technology-push from the research base and the demand-pull from potential research users. When this match is strong (as in the case of the environmental issues and the minerals industry) then CRCs have performed well in relation to research, education and collaboration outcomes. When there is little or no pre-existing capacity to match technology-push and demand-pull then the performance of CRCs has been more mixed.

In the area of research commercialisation, the CRC Programme has had some notable successes, but the track record is not yet strong. The change in orientation of the Programme towards a greater commitment to commercialisation and new business development should increase performance in this area. Success is, however, highly contingent on recognising the difficulty of finding established industry partners with the capacity to adopt and utilise disruptive technologies (and thus "leverage" Programme funding), and the availability of pre-seed funding and skilled and capable venture capital investors to "pull through" research into new products and businesses that have strong linkages though industry value chains.

The Evaluation highlights the importance of responding to and adapting to wider structural changes in the science and innovation system and differences in innovation pathways between and within industries and technologies. The Programme has, to date, not been designed to respond to these structural factors so much as to work within them.

Putting it another way, although the original objectives of the CRC Programme were related to the need to match technology-push with industry and other user demand-pull, the design of the Programme has, in practice, limited the extent to which it has been able to improve this match particularly in new areas of technology development. This job still needs to be done. A re-vitalised *investment-focused* CRC Programme with a greater emphasis on new business development would be better positioned to strengthen the match between technology-push and demand-pull.

On this basis it is recommended that the CRC Programme should continue, albeit with changes in design features and balance in the composition of CRCs.

Recommendation:

I - 1. The CRC Programme should continue, but with design modifications to reflect changes in the environment for public-private sector research collaboration and the creation of new business models for the commercialisation of publicly funded research, as identified and canvassed in this Report.

Structure of the Report

The Report is presented in two parts. Part I addresses the direct programme evaluation issues in Element 1 and Part II addresses the broader policy and strategic issues raised in Element 2.

Figure 1: Examples of CRC Successes Referred to in CRC Publications and Promotional Material

National Benefit CRCs

CRC for Aboriginal and Tropical Health - Discovered a new rapid test for detecting streptococcal B infections. The test is fast, non-invasive and easy to perform. This is a critical health issue for newborn infants.

CRC for Catchment Hydrology: Developed a short-term detailed forecasting system that enables more accurate predictions to be made of the precise level and location of rainfall during storms. Estimated to save Sydney Water around $20 million over the next 20 years.

CRC for Coastal Zone, Estuary and Waterway Management - Development of a regular comprehensive 'report card' for the Moreton Bay area to more accurately check the environmental health of the area.

CRC for Conservation and Management of Marsupials – Development of a contraceptive vaccine to control populations of possums and wallabies

CRC for the Great Barrier Reef World Heritage Area - Use of computer models to simulate cyclones on the reef to help engineers construct 'smarter' lighter tourist pontoons that minimise environmental impact and the chance of cyclone damage to the reef.

CRC for Weed Management - Successfully engaged the community to overcome an aggressive creeper introduced into Australia 150 years ago that was smothering Australian bushland.

Industrial Research Collaboration CRCs

Australian Telecommunications CRC – Patented a technology for real-time signal transfer over the Internet.

CRC for Advanced Composite Structures - Developed a patented process for the application of a thermoplastic skin to the surface of thermoset composite materials. The process attracted the interest of the major aerospace companies, Boeing and Airbus.

CRC for Clean Power from Lignite - Development of a laser plasma spectrometer; strategies for coal de-watering through Mechanical Thermal Expression.

CRC for Enterprise Distributed Systems Technology – Development of **GuideBeam**, a unique search tool designed to improve information access by helping the user formulate a precise description of their information need.

CRC for Mining Technology and Equipment - BHP Billiton has retrofitted a production dragline at the Peak Downs mine with the CRC's Universal Dig & Dump Technology (UDD). This innovation in open cut mining technology has increased productivity of the dragline by more than 25 percent.

CRC for Molecular Plant Breeding - The CRC's patents represent real innovation in the field of molecular plant breeding in the cereals and pastures areas; the patents are in various stages of certification for licensing, but are expected to deliver substantial commercial returns.

CRC for Quality Wheat – Development of WheatRite®, a test to determine the level of potential weather damage to wheat crops; expectations of sales of $4m by 2004.

CRC for Sensor Signal and Information Processing – Development of surface wave radar for coastal surveillance; development of an ultra wideband low frequency ground penetration radar.

CRC for Sustainable Rice Production – Developed models and software for understanding the movement of water and salt in relation to irrigation farming at both farm and irrigation-district levels.

CRC for Sustainable Sugar Production – Developed decision support models for onfarm water storage to maximise returns from supplementary irrigation.

CRC for Tropical Plant Protection - Contributed to the development of a test for disease in tropical fruits which is expected to save the industry over $21 million a year in managing this problem

CRC for Waste Management and Pollution Control - Development of a method for increasing the solid content of sewage sludge

CRC for Water Quality and Treatment - Developed a method of rapidly distinguishing toxic blue-green algae species from non-toxic species. The CRC has patented a test that uses genetic technology to identify two of the most toxic species within hours. This enables water resource managers to react more quickly to the potential health threats of algal blooms.

Business Development CRCs

Australian Photonics CRC – Creation of companies that: develop, make and sell applications specific optical fibres to component manufacturers; incorporates optical fibres in devices and components; developing optical circuits on a chip; incorporating new products into new wavelength management systems.

CRC for Cochlear Implant and Hearing Aid Innovation - Developed software for the tele-commerce sector that recognises and blocks 'acoustic shrieks' in phone lines. Expectations of earning around $5m a year, including a substantial export market; development of software to allow audiologists to vary the amplification at different frequencies by hearing devices.

CRC for Diagnostic Technologies – Developed and patented a technology (FNC) that allows rapid identification of variants of a specific gene at a molecular level; combination of FNC with gene chip technologies to make possible the speedy analysis of thousands of genes; technology has been acquired by US biotechnology company Affymetrix generating a royalty stream.

CRC for Eye Research and Technology – Developed continuous wear contact lenses. More than 400,000 people in over 40 countries now have contact lenses they can wear continuously for 30 days and nights.

CRC for International Food Manufacture and Packaging Science – Found ways of using plastics manufacturing systems to produce packaging materials that are biodegradable.

CRC for Satellite Systems - Development of the first all-Australian satellite in 30 years.

CRC for Tissue Growth and Repair - Developed Tendotrophin® for the treatment of horse tendon injuries, which is marketed by PrimeGRO Pty Ltd, a CRC start-up company established in 1999. Another CRC start-up is GroPep Ltd which achieved sales of $9.6 million in 2000-01.

CRC for Vaccine Technology- Developing a vaccine against glandular fever to stage of clinical testing. Potential market of 2.5 million vaccinations per annum

List of Recommendations

The Recommendations made as Part of the Evaluation are listed below. They are identified in relation to the Part of the Report in which they appear.

Part I: Programme Efficiency, Effectiveness and Flexibility

Part I: Report on Programme Effectiveness, Efficiency and Flexibility

1: The CRC Programme - Objectives and Profile

The CRC Programme was established in 1990 with the first CRCs being announced in 1991. It is the Government's major Programme for promoting collaborative research links between industry, research organisations, education institutions and government agencies. The Programme supports research and development and education activities that achieve real outcomes of national economic, environmental and social significance.

1.1 Objectives

The objectives for the CRC Programme are:

- To enhance the contribution of long-term scientific and technological research and innovation to Australia's sustainable economic and social development (the *research* objective).
- To enhance the transfer of research outputs into commercial or other outcomes of economic, environmental or social benefit to Australia.
- To enhance the value to Australia of graduate researchers.
- To enhance collaboration among researchers, between researchers and industry or other users, and to improve efficiency in the use of intellectual and other research resources.

The CRC Programme seeks to achieve these objectives by supporting applications to establish CRCs that bring together researchers and research groups from universities, government research laboratories (Federal, State and Territory), and the private sector, into long-term cooperative relationships. CRCs are expected to create strengthened research networks, and provide areas of research concentration to ensure that national resources are used more efficiently[9].

The active involvement of industry and users is a crucial aspect of the Programme. Industry and users are expected to be engaged in all key aspects of CRC operation, including: research programme design, management; monitoring and evaluation; commercialisation and utilisation of research outputs; and education and training of graduates and postgraduates. The active involvement of industry and users is intended to ensure that the long-term research undertaken in the CRC will have strategic relevance and that the research outputs will be used to produce outcomes of economic, environmental or social benefit to Australia[10].

The Programme also seeks to stimulate a broader education and training experience for graduate and postgraduate students to enhance their employment prospects. It is expected that CRC students will have the opportunity to participate in cooperative user oriented research programmes and work with researchers from outside the higher education system.

[9] Australia. AusIndustry, *CRC Guidelines for Applicants 2002 Selection Round and General Principles of Centre Operations* (2001)
[10] Ibid.

It is important to note that while the Programme encourages long term research, it is not an objective of the CRC Programme to establish permanent research institutions supported indefinitely using Programme funds. Programme funding is for a maximum of seven years. It is expected that participants will come to recognise the benefits of collaboration and user involvement in long-term research and will continue to collaborate when CRC funding ceases.

The amount of funding provided to CRCs in Round seven, announced in 2000, ranged between $1.6 million and $3.14 million per annum, averaging $2.45 million per annum. Additional funding provided under *Backing Australia's Ability* for the expansion of the CRC Programme enabled an increase in grant size. In the *Guidelines for Applicants 2002 Selection Round* AusIndustry indicated that the average level of Centre funding would be around $3 million per annum, but the existing flexibility in size and duration would be maintained[11].

The Department of Education, Science and Training is responsible for the administration of the Programme since it was transferred from the Department of Industry, Science and Resources in late 2001. These responsibilities include, monitoring, review and assessment of CRC applications. The Department also supports the CRC Committee and its Expert Panels and is responsible for providing policy advice to Ministers on the CRC Programme.

The purpose of the evaluation is to ensure that the Programme's objectives and design are kept up to date and that it is well positioned to deliver beneficial outcomes into the future.

1.2 Origins

The CRC Programme was established in 1990 (with the first selection round CRCs announced in 1991) in response to a number of perceived weaknesses in the institutional framework for Australia's R&D effort. These weaknesses were identified as[12]:

- Australia's combined scientific and technological resources were quite substantial, but they were dispersed both geographically and institutionally. This separation made it difficult to build strong research teams and led to unnecessary duplication of facilities, and difficulty in ensuring that they were world class.
- Existing funding arrangements were seen as contributors to the problem. As most research funding in Australia was from institutional sources and was distributed through administrative channels to operational units and individual researchers, it was difficult to build large integrated research. Competitive funding sources, such as the Australian Research Council, the National Health and Medical Research Council and the Rural Research funding bodies had, with few exceptions, difficulty in building such teams.
- Corporate R&D was not well developed in most Australian industry sectors. There was limited capacity for corporate and other research users to benefit fully from the skills and information in the Universities and government re-

[11] Ibid.
[12] Ralph O Slatyer, "Cooperative Research Centres - A Retrospective View," in *The Annual Meeting of the CRC Association* (Brisbane: 2000)

search organisations. It was well known that information and technology are transferred most effectively when there is a similar level of knowledge in both parties - the lack of in-house R&D capability was seen as an important liability.

- Graduate programs in Australian Universities provided mainly traditional academic training, involving research only and a single supervisor. This did not prepare students well for jobs outside the academic world as well as denying students access to the skills and experience of many of Australia's best researchers, and researchers the stimulus of interaction with students.

The vision for a Cooperative Research Centre was a "One Stop Shop" for innovation, consisting of a cooperative team of researchers and research users, drawn from various organisations and of adequate size and composition to have a real and continuing impact in the sector where it was located. It was envisaged that:

- Research organisation participants would undertake mainly long term strategic research (work at the R end of the R&D spectrum) and research users would work mainly at the "D" end.
- All user participants would have access to the research in the Centre, so the competitive challenge for individual firms would be to utilise the research results in-house, ahead of others.
- More than one firm would be associated with each Centre so that it would not become the research arm of a particular firm and opportunities for commercial joint ventures would be more likely to arise.

Embedded in the concept was an objective that the Centres would demonstrate the benefits of greater cooperation to the whole Australian research, and research user, community and thus enhance the overall national R&D effort.

It was also envisaged that a combination of location, funding and leadership would achieve a level of cooperation that had been lacking in the past. Centres would be located on or adjacent to University campuses wherever possible, so as to encourage precinct development around each campus, with innovative, R&D intensive firms regarding Universities as the logical place to locate part of their R&D effort.

There was an expectation that some of the participants could be co-located in the same buildings and facilities - building more space if necessary. In this way, truly cooperative teams, sharing the same laboratories, could be established and opportunities taken for non-University staff to participate fully in educational programs. In this way the institutional origins of the participating groups could become more blurred and the Centres themselves could more readily develop an identity.

Given the geographical dispersion of Australian research groups, however, it was evident that the degree of co-location would seldom be achieved in the new Program. It was therefore hoped that funding flexibility would lead to imaginative building programs and that effective networking would do much to overcome the "tyranny of distance".

1.3 Subsequent developments

Over the last ten years the Programme has evolved through adaptation and initiatives following decisions by Government and Ministers. The key points in that evolution are summarised in Figure 2.

Figure 2: Evolution of the CRC Programme

Year	Event	Outcome
1990 – 1991	Review of CSIRO suggests co-location of CSIRO research Divisions with Universities or some kind of programme to foster cross fertilisation of research.	Labor Government election commitment to a new programme with linkages to industry to foster research excellence. Cabinet submission results in new programme funding for 50 centres at $2m per centre, per annum (total $100m per annum).
1991	Programme launched, first call for applications, implementation group located in Department of Prime Minister and Cabinet	Programme commenced. Minister's Statement – "Australia must match the technology push provided by its strong research base with the demand pull of industry and other research users, and these centres will make an important contribution to this goal" CRC programme announced 25 centres funded for 7 years with a strong focus on research excellence.
1995	Rupert Myers Report *Changing Research Culture* to Senator the Hon Peter Cook	Concluded the Programme has encouraged industry to become involved with longer-term research, has improved researcher linkages, and cooperation and has focussed education and, finally is beginning to improve overall research management. Recommended that programme continue and that successive rounds be open to competition for places from new proposals and from existing or modified centre proposals. This did not constitute an expansion of the program.
1997	Stocker Review, *Priority Matters*[13]	Endorsed pluralistic system of S&T research where priorities are largely determined at the sectoral level "close to the action". CRCs acknowledged as having their own priority setting methodologies in this context. Noted strong contribution of CRCs in changing the culture of research, promoting the value of research in industry, promoting research interaction with industry in higher education. The CRC programme application processes are a strong example of priority setting involving researchers and users. Recommended that the CRC Committee should amend the CRC Programme guidelines to ensure that the legitimate place for "public good" centres is made explicit.
1997	Mortimer Review, *Going for Growth: Business Programs for Innovation, Investment and Export*[14]	Recommended termination of funding of those CRCs for which there is predominantly a private benefit and limit funding to $20m per annum for new CRCs with predominantly "public good" collaborative scientific programs. Articulated dichotomy between "public good" and "private good" activities. Created strong reaction.

[13] Australia. Chief Scientist (Dr John Stocker), *Priority Matters* (Canberra: Department of Industry, Science and Tourism, 1997)
[14] Australia. Review of Business Programs, *Going for Growth: Business Programs for Investment, Innovation and Export (David Mortimer, Chair)* (Canberra: Australian Government Publishing Service, 1997)

Year	Event	Outcome
1997	*Investing for Growth, the Howard Government's Plan for Australian Industry*[15] announces a Programme Review	Don Mercer commissioned to undertake review. …*which may recommend structural change to the programme. The review's recommendations will focus on enhancing the commercial and economic benefits of research within CRCs.*
1998	Mercer-Stocker Report, *Review of the Greater Commercialisation and Self Funding in the Cooperative Research Centres Programme*[16]	Confirmed the role of the Programme in enhancing collaborative activities between research providers and industry and the significance of effective linking mechanisms in the national innovation system. Made a number of recommendations to improve the management of centres within the Program. Recommended that overall Programme balance of effort in different sectors should be reviewed and the scope of more CRCs in the services sectors, in general, and the 'information industries' in particular, should be assessed.
1999	AusIndustry internal Review	Changes to objectives and focus of the CRC programme – more closely oriented to "user needs" with an emphasis on commercialisation. Programme included in AusIndustry "suite" of Innovation Programs and marketed to industry.

While the historical evolution of the Programme is of interest from the point of view of changes and adaptations in the science and innovation policy environment, the present policy position and objectives are taken as given in this Report.

1.4 CRCs approved

The main focus of this Evaluation is on CRCs approved up to and including Round 7 (undertaken during 2000). CRCs approved in Round 8 (2002) are scheduled to commence operations from July 2003.

Over the life of the Programme, a total of 158 CRC applications, including renewal and supplementary applications, have been supported from a total of 529 applications. A profile of successful and unsuccessful applications by selection round is shown in Table 3.

Table 3: CRC Applications - Successful and Unsuccessful

Year (round)	1991 (1)	1991 (2)	1992 (3)	1994 (4)	1996 (5)	1998 (6)	2000 (7)	*2002 (8)*	Total
Successful applications									
New	15	19	17	11	6	4	11	*12*	95
Existing					10	22	8	*9*	49
Supplementary			2	2	1			*9*	14
	15	19	19	13	17	26	19	*30*	158
Unsuccessful applications									
New	105	55	52	45	19	18	26	*14*	334
Existing						12	3	*5*	20
Supplementary			3	1	1	3	1	*8*	17
	105	55	55	46	20	33	30	*27*	371
Total no of applications	120	74	74	59	37	59	49	*57*	529

Successful applications according to selection round and industry/research sector, are listed in Table 4.

[15] Australia. Prime Minister, *Investing For Growth: The Howard Government's Plan for Australian Industry* (Canberra: Department of Industry, Science and Resources, 1997)

[16] Australia. Department of Industry Science and Tourism, *Review of Greater Commercial and Self Funding in The Cooperative Research Centres Programme: Report of the Steering Committee (Mr Don Mercer, Dr John Stocker)* (Canberra: AusInfo, 1998)

Table 4: CRC Successful Applications (Number)

Industry/Research Categories	1991 (1)	1991 (2)	1992 (3)	1994 (4)	1996 (5)	1998 (6)	2000 (7)	2002 (8)	Total
Agriculture and Rural Based Manufacturing	3	4	5	4	3	4	4	6	33
Environment	3	2	4	3	3	7	4	11	37
Information and Communication Technology	2	3	3		2	4	2	4	20
Manufacturing Technology	1	5	2	2	1	6	4	1	22
Medical Science and Technology	3	3	1	1	5	3	2	4	22
Mining and Energy	3	2	4	3	3	2	3	4	24
Total Successful	*15*	*19*	*19*	*13*	*17*	*26*	*19*	*30*	*158*

The highest number of CRCs has been approved in the Agriculture and Rural Based Manufacturing and the Environment industry/research categories, accounting for a total of 70 or 44 percent of all CRCs approved. The lowest number of successful applications has been in the Information and Communications Technology category

The success rate for CRC applications has varied markedly across industry/research categories. This is indicated in Table 5 below.

Table 5: Success Rates for CRC Applications

Industry/Research Categories	1991 (1)	1991 (2)	1992 (3)	1994 (4)	1996 (5)	1998 (6)	2000 (7)	2002 (8)	Total
Agriculture and Rural Based Manufacturing	15.0	26.7	29.4	50.0	42.9	36.4	40.0	50.0	33.0
Environment	17.6	11.8	36.4	30.0	42.9	70.0	44.4	73.3	38.5
Information and Communication Technology	11.8	37.5	21.4	0.0	50.0	50.0	28.6	57.1	26.3
Manufacturing Technology	5.9	26.3	14.3	28.6	14.3	66.7	30.8	14.3	23.7
Medical Science and Technology	12.5	30.0	8.3	7.7	62.5	21.4	28.6	40.0	22.4
Mining and Energy	25.0	40.0	66.7	30.0	75.0	28.6	100.0	66.7	45.3
Total All CRCs	12.5	25.7	25.7	22.0	45.9	44.1	38.8	52.6	29.9

The overall success rate for CRC applications for the life of the Programme is just under 30 percent. For Round 8, the success rate was 52.6 percent. The highest success rate has been in Mining and Energy and the lowest in Manufacturing Technologies. CRC applications from sectors associated with emerging technologies and generally a shortage of established industry partners (ICT and medical science and technology) increased from a very low success rate (28.6 percent) in Round 7 to higher rates in Round 8, but not to the levels of the Mining and Environment CRCs.

1.5 Support for the CRC Programme

The Commonwealth Government has been the major supporter of the CRC Programme since its inception in 1991, providing a total of $1,147m in Programme funding. Universities have been the second highest contributor, but their contributions have been mainly in-kind. Industry has contributed 16.5 percent of the resources, of which 41 percent has been in cash.

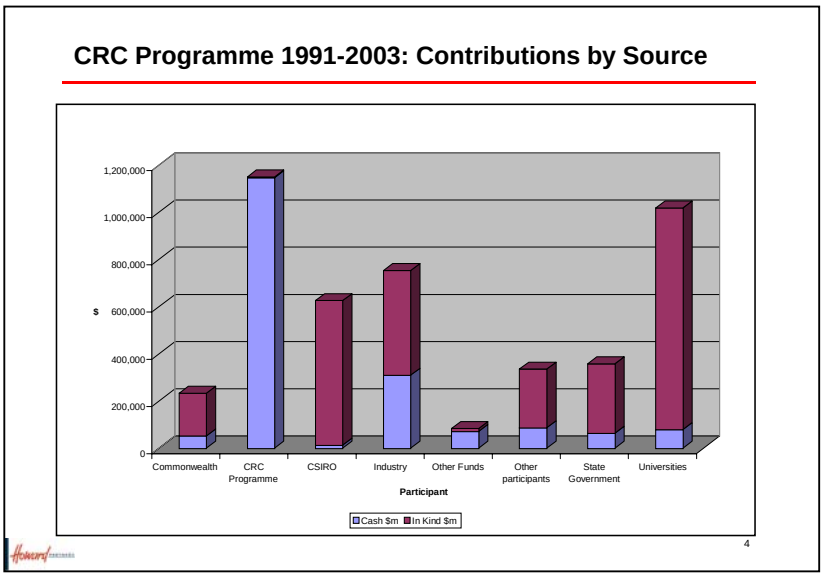
Data from the Department of Education, Science and Training CRC database indicating the level of contribution is illustrated in Table 6 below.

Table 6: CRC Programme - Resource contributions 1991-92 - 2001-02

	Cash $m	In Kind $m	Total $m	Proportion Cash (%)	Proportion Total Resources (%)
CRC Programme	1,146.9	2.5	1,149.4	99.8	25.2
Universities	79.9	939.1	1,019.0	7.8	22.3
CSIRO	13.7	612.4	626.1	2.2	13.7
Industry	310.0	443.6	753.7	41.1	16.5
State Government	63.9	294.2	358.1	17.8	7.9
Other Commonwealth	52.4	181.3	233.8	22.4	5.1
Other participants	87.5	248.0	335.5	26.1	7.4
Other Funds	72.0	12.0	84.0	85.7	1.8
Total	1,826.2	2,733.1	4,559.4	40.1	100.0

On the basis of the data in Table 6, the observation is often made that the Commonwealth's contribution of $1,149.4m has resulted in a total of $4,559.4m in collaborative industrial research – a ratio of 3:1

In the last several years universities have been increasing their level of cash contributions as a way of making applications "competitive". The overall profile is reflected in the following chart.



1.6 Current allocation of resource commitment

The purpose of this brief Section is to give an overview of resources allocated under the CRC Programme in order to provide context for subsequent discussion. Further analysis of resources allocated is provided in other relevant sections of the Report

Resource allocation data classified according to the five programme areas is only available from Department of Education, Science and Training sources for the years since 1998-99. This coincides with the commencement of Round 5 CRCs and the introduction of Guidelines following the Myers Review.[17]

Between 1998-99 and 2001-02 a total of $835m in cash was allocated to CRC purposes. Two thirds of this was allocated to research and 12.5 percent to Administration. The allocation to technology transfer was 10.6 percent. This is indicated in Table 7.

[17] Australia. Department of Industry Science and Technology, *Cooperative Research Centres Programme Evaluation: Changing Research Culture, Australia - 1995 (Sir Rupert Myers, Chair)* (Canberra: Australian Government Publishing Service, 1995)

Table 7: CRC Resource Allocation - 1998-99 - 2001-02 Cash (Total)

	1998/1999 $'000	1999/2000 $'000	2000/2001 $'000	2001/2002 $'000	Average $'000	Proportion (%)
Research	125,576.0	120,036.0	148,800.0	164,710.0	139,780.5	66.9
Education	12,521.0	13,097.0	16,579.0	16,977.0	14,793.5	7.1
Commercialisation/Tech Transfer	15,329.0	16,127.0	25,164.0	31,645.0	22,066.3	10.6
External Communication	5,128.0	4,661.0	6,742.0	8,744.0	6,318.8	3.0
Administration	23,711.0	21,787.0	25,394.0	33,236.0	26,032.0	12.5
	182,265.0	175,708.0	222,679.0	255,312.0	208,991.0	100.0

The level of in-kind resourcing of research over the same time period was over 80 percent. This is indicated in Table 8.

Table 8: CRC Resource Allocation - 1998-99 - 2001-02 In Kind (Total)

	1998/1999 $'000	1999/2000 $'000	2000/2001 $'000	2001/2002 $'000	Average $'000	Proportion (%)
Research	225,114.0	236,798.0	279,519.0	362,092.0	275,880.8	80.5
Education	17,373.0	17,480.0	21,623.0	26,776.0	20,813.0	6.1
Commercialisation/Tech Transfer	18,019.0	21,458.0	24,273.0	19,479.0	20,807.3	6.1
External Communication	4,575.0	5,227.0	4,837.0	5,885.0	5,131.0	1.5
Administration	16,542.0	15,985.0	24,239.0	24,188.0	20,238.5	5.9
Total In-kind	281,623.0	296,948.0	354,491.0	438,420.0	342,870.5	100.0

Overall, the level of resourcing for research amounts to three quarters of CRC resources. The allocation for Technology Transfer is less than eight percent and the amount allocated to Communication is approximately two and a half percent. These allocations are indicated in Table 9.

Table 9: CRC Resource Allocation - 1998-99 - 2001-02 Cash and In Kind (Total)

	1998/1999 $'000	1999/2000 $'000	2000/2001 $'000	2001/2002 $'000	Average $m	Proportion (%)
Research	350,690.0	356,834.0	428,319.0	526,802.0	415,661.3	75.3
Education	29,894.0	30,577.0	38,202.0	43,753.0	35,606.5	6.5
Commercialisation/Tech Transfer	33,348.0	37,585.0	49,437.0	51,124.0	42,873.5	7.8
External Communication	9,703.0	9,888.0	11,579.0	14,629.0	11,449.8	2.1
Administration	40,253.0	37,772.0	49,633.0	57,424.0	46,270.5	8.4
Total Cash & In-kind	463,888.0	472,656.0	577,170.0	693,732.0	551,861.5	100.0

The resource allocation data suggest, from an overall perspective, a very high commitment to research and a comparatively low level of commitment to the commercialisation and communication of research outcomes.

Over the last three rounds there has been a perceptible shift in the emphasis of the Programme towards commercialisation. This follows from changes and adjustments to the CRC Guidelines. Successful applicants from the 2002 Round will be required to develop a Commercialisation Plan. The change in the distribution of expenditure among CRCs in Rounds 5-7 is indicated in Table 10.

Table 10: Distribution of Total CRC Expenditure Across Functions - Rounds 5-7

	Research	Education	Tech Transfer/ Commercialisation	Ext Communication	Administration	Total
	%	%	%	%	%	%
Round 5 (1996)	77.1	5.4	8.2	1.2	8.2	100.0
Round 6 (1998)	73.5	6.5	9.7	2.9	7.4	100.0
Round 7 (2000)	75.7	7.4	2.9	0.7	13.4	100.0
Total Rounds 5-7	75.3	6.1	8.5	2.0	8.2	100.0

The proportions in Table 10 show an increase of 1.5 percentage points in commercialisation expenditure and 1.7 percentage points in external communication expenditure between Rounds 5 and 6. Together with an increase in expenditure on education

there has been a reduction of 3.6 percentage points in research expenditure over the same period.

The distribution of expenditure for Round 7 CRCs reflects the commitment to commencement, with 13.4 percent of expenditure allocated to administration – and a very low level of commitment to commercialisation. The high level of expenditure on administration would also reflect the costs of negotiating Centre Agreements and the high cost of legal advice associated with that activity.

1.7 CRCs in the Science and Innovation System

The CRC Programme performs an important role in the public research system, and particularly in the university sector. The significance of the Programme in relation to total expenditure on Research and Experimental Development is indicated in Table 11. The data are not strictly comparable with Table 7 due to recoding differences.

Table 11: CRC Expenditure in Relation to Total R&D Expenditure 2000-2001

Socio-economic objective	*CRC Expenditure*	Higher Ed Expenditure on R&D	Government Expenditure on R&D	Business & Other Expenditure on R&D	Total Exp on R&D
	$'m	$m	$m	$m	$m
Economic Development					
Animal Production and Animal Primary Products	*10.5*	64.5	297.8	55.5	417.8
Plant Production and Plant Primary Products	*37.2*	108.6	392.5	46.8	547.9
Mineral Resources (excluding energy)	*20.6*	42.1	81.9	317.2	441.2
Energy Resources	*9.8*	32.4	65.3	103.6	201.3
Energy Supply	*10.0*	31.1	28.3	121.8	181.2
Manufacturing	*45.2*	140.7	232.8	1,949.8	2,323.2
Construction	*0.9*	54.1	33.2	60.0	147.4
Transport	*0.7*	22.8	20.3	80.6	123.7
Information and Communication Services	*29.3*	127.7	53.0	1,368.7	1,549.4
Economic Framework	*4.4*	130.9	158.7	8.0	297.6
Commercial Services & Tourism	*0*	40.4	11.4	211.0	262.9
	168.8	795.3	1,375.0	4,323.2	6,493.6
Environment					
Environmental Management	*50.7*	134.9	380.9	62.1	577.9
Environmental Policy Frameworks	*0*	10.6	50.2	27.5	88.3
Society					
Health	*25.1*	744.3	213.0	532.9	1,490.2
Advancement of Knowledge	*7.2*	691.7	33.8	7.0	732.5
Other	*0*	397.7	315.4	155.8	868.9
	251.9	2,774.6	2,368.4	5,108.5	10,251.4

According to the data in Table 11, the CRC Programme is quite small in relation to overall expenditure on research and development - amounting to $251m in a total of $10 billion in 2000-01. However, the significance of the Programme is apparent in relation to expenditure on research and development in the higher education sector, particularly in the economic development and environment socio-economic groupings.

2: CRCs and their Current Operating Environment

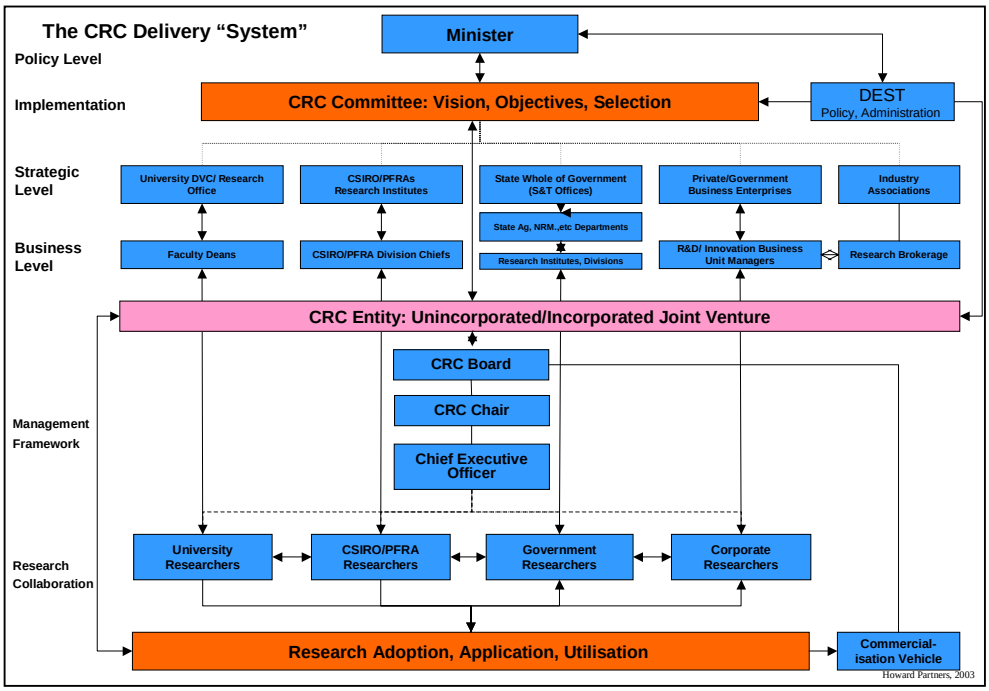
The purpose of this Section of the Report is to outline and discuss the arrangements for the implementation of the CRC Programme. As with all public programmes, the successful implementation and achievement of objectives is determined by the efficiency and effectiveness of the organisation and management arrangements that have been put in place and the practices and procedures that have evolved over time.

2.1 Overall framework

The CRC system started as a "bottom up" system with a strong focus on collaboration at the researcher level. Over the years there has been an increasing level of involvement at the institutional level. This involvement has increased as a direct result of pressures and constraints on resources available to support research and tighter priority setting and an increased focus upon achieving outcomes.

Over the life of the Programme more rules and guidelines have been instituted in an endeavour to ensure that CRC activities are directed towards achieving Programme objectives. Arguably, and in the opinion of stakeholders, the overall effect has been to create a heavy superstructure and the system has become heavily top down.

As a result, the CRC Programme operates within a complex institutional, organisational and management system. It operates at several levels, which are depicted below:



The framework suggests that a CRC is a "matrix" organisation, with researchers responsible and accountable to *both* their host institutions as well as to the CRC

entity. Although some researchers are directly employed by CRCs this is not common.

Responsibility for managing the organisation on a day-to-day basis falls to the CEO. A great deal of reliance is placed in the Board to appoint a person with the appropriate qualities and competencies to manage in this very complex environment. It is of interest that in most applications for CRC grants the identity of the CEO is not known – however the CEO must be approved by the Commonwealth.

Specific comments on each of the "layers" in the matrix follow.

2.2 The Minister for Science

At the policy level, the Minister for Science is responsible for setting the direction for the Programme, endorsing objectives, and approving applications for CRC funding. The Minister for Education, Science and Training has overall portfolio responsibility.

The Minister for Science decides which CRCs will be funded and the conditions of any funding offer made under the Programme.

2.3 The CRC Committee

The Minister has appointed the CRC Committee to oversight the selection of new CRCs by assessing all applications and recommending applications for funding together with any terms or conditions that should be applied for successful applicants. It also provides overall advice in relation to the management of the Programme. The Committee takes an active role in the performance evaluation of individual CRCs during their period of operation.

Dr Geoffrey Vaughan is the Chair of the CRC Committee.

Upon direction from the Minister the Committee may invite an application at any time, or call for applications in specific research areas.

The CRC Committee may, from time to time, appoint Expert Panels to assist in reviewing CRCs and assessing applications. There are currently two Expert Panels of nine members each:

- The Life Sciences Panel provides advice covering the natural sciences including medical and rural research, biological aspects of environmental research, and other topics with a predominantly biological orientation.
- The Physical Sciences and Engineering Panel provides advice covering manufacturing, the physical and chemical sciences, mineral and earth sciences, information technology, physical aspects of the environmental sciences, and all engineering fields.

Other advisory panels are appointed as required.

2.4 CRC participants

At the strategic level are executive managers of the organisations and institutions that participate in CRCs and who make decisions about the form and level of commitment to CRCs. They include university Deputy Vice Chancellors (Research), Corporate R&D Executives, Heads of Publicly Funded Research Agencies.

Drawing on data in the Department of Education, Science and Training database, a profile of participation in CRCs can be derived. In Table 12 the number of organisations participating in each CRC is listed, indicating that "industry" represents 37.7 percent of core participants, universities represent 30 percent, Commonwealth Publicly Funded Research Agencies 12 percent and State Government just under 13 percent.

Table 12: CRC Participant profiles

	Core Participants					Other Participants	
	Core Role		Supporting Role	Total		Supporting Role	
	No	%	No	No	%	No	%
Industry							
Industry Association/Organisation	33	4.4	2	37	3.8	13	5.8
Rural RDC	11	1.5	5	16	1.7	2	0.9
Businesses – Private	197	26.3	16	213	22.1	123	54.4
Business – Public	41	5.5	1	42	4.4		0.0
	282	37.7	24	308	32.0	138	61.1
University							
University – Australia	225	30.0	153	378	39.3	16	7.1
University – Overseas						8	3.5
TAFE/School	1	0.1		1	0.1	2	0.9
	226	30.2	153	379	39.4	26	11.5
Government							
Commonwealth Publicly Funded Research Agency	89	11.9	9	98	10.2		0.0
Government – Commonwealth (Other)	21	2.8	2	24	2.5	2	0.9
Government – State	96	12.8	15	111	11.5	29	12.8
	206	27.5	26	233	24.2	31	13.7
Research Institutes	*33*	*4.4*	*8*	*41*	*4.3*	*25*	*11.1*
NGO	*2*	*0.3*		*2*	*0.2*	*6*	*2.7*
	749	100.0	211	963	100.0	226	100.0

Source: Department of Education, Science and Training , CRC Management Data Questionnaire Database

Table 12 does not provide any indication of the *scale or extent* of CRC participation, although it does provide an indication of the scope of participation.

In the past the level of strategic commitment from participant organisations to the CRCs has been "permissive" rather than "strategic". Support was generally based on agreement to "bottom up" research proposals and the attractiveness of leveraging Commonwealth funds. However, during the course of the Evaluation, universities, the CSIRO, State Government agencies, and public and private enterprise research divisions indicated they would be taking a more deliberative approach to their involvement in CRCs in the future, and in particular, how CRCs related to their overall research priorities and directions.

At the business levels are the people who plan and manage the resource budgets (funds, staff, property) that form the basis of participation in CRCs. They include the Faculty Deans, Heads of Research Divisions, Corporate Research managers. As resources become tighter, business managers are looking more closely at the scope of their commitments, including their investments in CRCs, in terms of the value they contribute to their research strategies, priorities and directions.

2.5 CRC entities

The CRC "entity" is the vehicle for the delivery of CRC outcomes. It is generally an unincorporated joint venture, formalised through a "centre agreement". In a few cases, the entity is a company incorporated under the provisions of the Corporations Law.

Under the 2002 CRC *Guidelines for Applicants 2002 Selection Round and General Principles of Centre Operations*, new CRCs are strongly encouraged to be incorporated, or adopt an incorporated structure for selected aspects of their operations, such as commercialisation of intellectual property and new business development.

CRCs are effectively small enterprises created to "achieve real outcomes of national economic, environmental and social significance".

Based on data relating to resource contributions, the "average" CRC has an annual budget in the region of $12m and 52 professional full time equivalent staff (FTE) and 10 non-professional staff FTEs. The actual number of staff involved in a CRC may be considerably higher, depending on the size and scope of the fractional allocations.

Based upon the CRCs currently in existence, the annual cash budget managed by the average CRC is in the region of $4.6m. From a commercial perspective, this is a *very small* business operation. However, over the seven year life of the CRC, the level of commitment amounts to a total of $32m – or $84m including in-kind contributions.

From a management perspective there is a paradox in that a CRC is created for a defined period of time (up to seven years) to deliver agreed outputs and outcomes specified in a contract with the Commonwealth, but is structured and managed in a corporate and taxation environment as if it were a going concern with an infinite life - without the Commonwealth being party to the structural agreement.

There are no pre-defined management and organisational structures for CRCs – or more generally, for any joint venture arrangements once established. The issue of partnership relationship management in joint venture arrangements is now receiving increased attention in the management literature. A recent study concludes that in order to maximise a joint venture's potential over the course of its life, participants "must pay more attention to the impact of partner relations on the performance of their offspring".[18]

The linkage between relationship management and joint venture success, as indicated by achieving the results intended by participants, is now recognised as a subject worthy of serious study.[19] The experience of CRCs over the last 12 years provides important insights and experience relevant to the development of best practice in joint venture relationship management not only in research collaboration but more gener-

[18] Bettina Buchel, "Managing Partner Relations in Joint Ventures," *Sloan Management Review* 44, no. 4 (2003)

[19] Ibid.. There have been many studies that canvass issues in relationship management, and particularly the potential to create value through collaboration; but the matter of *how* this is done and the management skills and capabilities required in managing the joint venture has received much less attention. See for example Yves L Doz and Gary Hamel, *Alliance Advantage: The Art of Creating Value Through Partnering* (Boston: Harvard Business School Press, 1998) and Robert E Spekman and Lynn A Isabella, *Alliance Competence: Maximizing the Value of Your Partnerships* (New York: Wiley, 2000) For a study relevant to the Department of Education, Science and Training, see Howard Partners and ACIIC, *A Case Study of a Strategic Alliance* (Canberra: Department of Education, Training and Youth Affairs, 1999)

ally in joint venture arrangements within and between the public, private and non-government sectors.

The comments that follow provide a description of basic CRC joint venture management arrangements. Comments on performance and the scope for improvement are made at various points later in the Report.

2.6 The CRC Board

The Board of the CRC is responsible for the overall direction of the CRC. Where the CRC is incorporated as a company, the responsibilities of the Board and its directors are relatively clear. Where a CRC is a joint venture, in the form of a "strategic alliance" or partnership there is a "flow through" relationship between the participants and the researchers.

The 2002 CRC *Guidelines for Applicants 2002 Selection Round and General Principles of Centre Operations* provide that:

> CRCs should adopt a structure headed by a governing board. Boards must have independent chairs. Board members should include nominees of the main participating research organisations in the CRC, but the majority of Board members should be drawn from the industry or user participants, or be independent members, ie external to the contributing parties.
>
> The Board is accountable for the management of the CRC and setting overall policies, research directions, for utilisation, technology transfer, commercialisation and budgets and for overseeing the executive.

The formation, structure, and operation of CRC Boards was raised as a major issue during the Evaluation.

2.7 The Chief Executive Officer

The actual management of a CRC is generally the responsibility of a Chief Executive Officer, who reports to a CRC Chair and to the Board. The Chief Executive Officer is the lynchpin in the CRC system.

The 2002 CRC *Guidelines for Applicants 2002 Selection Round and General Principles of Centre Operations* provide that:

> The application should nominate a Chief Executive Officer (CEO) for the proposed CRC, or state as clearly as possible the procedure to be adopted for appointing the CEO. Ideally, the CEO should be an experienced and highly regarded research manager, who will lead and manage the activities of the CRC.
>
> The CEO has the responsibility for the provision of research leadership, the day-to-day management of the CRC, and the effective and efficient implementation of the Board's decisions.
>
> The CEO must have the authority of the Board to manage the combined resources committed to the CRC in order to meet the objectives of the CRC.
>
> The CEO should generally be a full time, or close to full time, appointment.

The CEO role has becoming increasingly important as the system has evolved. In the past, when most CRCs have had their origins in a group of academics seeking funding to support their research, the "Chief Researcher" role paralleled that of a research

project team leader. The most important attribute was credibility in science and research.

CRCs require first-class leadership. Credibility in science and technology, together with competency in intellectual property, business, and project management, and an ability to operate joint ventures in a climate of ambiguity, has been found to be an essential pre-requisite.

The matrix structure of the CRC Programme creates fundamental and far-reaching challenges for management – at all levels. This management challenge has a major impact on the success and potential for achievements of the Programme. Those CRCs that are well managed tend to be associated with high levels of success, whilst those that find the structure difficult have been associated with significant problems for participants and researchers.

Matrix organisations are associated with a high level of decision-making power delegated to a CEO, together with a high level of formal coordination and a high cost of coordination. In business, the matrix form of organisation is required for demanding strategic tasks. Because matrix structures violate many of the classic principles of management - especially "unity of command" – they require top level support and commitment.

In fact, one of the major achievements of the CRC Programme has been to develop a cadre of industrial research managers who can manage effectively in the "matrix" environment of cooperative research and link the cultures of research providers and research users.

2.8 Researchers

Finally, there are the researchers and research users, who initially came together to create the collaborative arrangement that becomes a CRC. They are the people who have the task of undertaking and executing the research activities to achieve the Centre and the Programme outcomes.

The 2002 CRC *Guidelines for Applicants 2002 Selection Round and General Principles of Centre Operations* provide that:

> It is expected that a number of key individuals will make all or almost all of their time available to the CRC. Large numbers of low time commitments have presented management difficulties for CRCs in the past, and are of concern to the CRC Committee.

In the contemporary management environment people are finding it necessary to work in several organisation structures at the same time, depending on the tasks being undertaken. This of course creates significant personal challenges.

From discussions during the Evaluation, it was seen as essential that the key researchers provide a substantial proportion of their time to the CRC. From a mining industry perspective for example, this proportion should be at least 60 percent and preferably 100 percent - particularly programme managers; smaller amounts, particularly the 10-20 percent range, as often allocated by senior researchers, are seen to be inadequate.

University staff working in CRCs may spend only a proportion of their time involved in the specific tasks associated with the project. This can cause significant difficulties

when staff members employed in part-time capacities, are constantly required to change tasks.

Where the CRC commitment represents only a small proportion of the employee's time, and when a number of staff are employed on this basis, there can be some loss of *esprit de corps* and management problems ensue from this fragmentation of effort. *Trust is an essential component of the process.*

2.9 Conclusion

A CRC represents a special and unique form of *managed relationship* between research providers and research users. They are temporary, but relatively long term organisations that involve a substantial commitment of resources to achieve a common goal.

A managed relationship differs from a *market relationship* in which knowledge products (often represented as intellectual property) are "traded" between research providers and users through contracts and other forms of commercial agreement. The *knowledge market* generally involves a range of intermediaries, such as technology transfer offices, licensing executives, technology marketers and venture investors[20].

Universities and Publicly Funded Research Agencies are extensively involved in market type relationships in undertaking contract research in various forms of research agreement. They also seek to "commercialise" the results of research work through licensing and sale of intellectual property rights and the formation of new businesses with the assistance of venture capital investors. CRCs are increasingly being involved in these transactions.

CRCs are not "virtual organisations", or "cross functional teams" that imply an absence of management: management is essential to organise the resources of the CRC and to ensure that the intended results are achieved. The task is centred not on control and direction, but on leadership.

The management goal in a CRC is to make productive the specific strengths and knowledge of each researcher in the CRC.

Difficulties arise in the CRC environment where managed and market relationships overlap, intersect and conflict: that is a CRC may be involved in managing an industrial research partnership but may also be involved in marketing knowledge to users outside the CRC. Many CRCs attempt to resolve this by working in a joint venture relationship for their collaborative relationships and an incorporated company arrangement for their market relationships.

Many CRC participants are looking for market relationships within a CRC framework. That is, participants want to enter into specific contracts with researchers and institutions within the CRC, but at the same time leverage the Commonwealth funding. Conversely, some participants become concerned when a research partnership is involved in the creation of new business ventures in which they have little interest and see no benefit.

[20] Market and managed relationships differ from academic "gift" relationships where knowledge is "given" in expectation of recognition, prestige, status and "eminence" . This relationship may also conflict with market and managed relationships

There has also been a trend towards defining the CRC structure in terms of legal obligations in a formal agreement rather than as a *partnership* of organisations that are linked with a common purpose. Large players, such as the CSIRO and large corporations have sought to take dominant positions in many CRCs, from the point of negotiating the joint venture agreement to the conduct and governance of the centre. This arises where one party has ownership of foundation IP and/or some major facilities and seeks to establish a dominant position. This has been a major issue and concern for CRC Managers and other participants.

Successful collaborations are based on a partnership of equals, not on the dependence or control of one or more of the participants.

The requirements of the Corporations Law and the Taxation Law also work towards creating a very cumbersome vehicle for CRCs where IP and the transfer of IP is involved – either in or out of the CRC. This problem arises where there is an expectation that use and creation of IP will generate substantial financial returns for the CRC. Accordingly, negotiating Centre Agreements has involved substantial costs in legal and taxation advice and has diverted time and resources away from achieving the results of the CRC.

These observations suggest a need to clearly differentiate between CRCs that are built around managed relationships in an industrial research partnership framework, and CRCs that want to enter into market relationships and generate substantial financial returns through business development based on the licensing and sale of Intellectual Property and the creation of new business ventures.

The Report recommends, in Part II, that a special CRC entity structure be created under legislation that will reduce the costs and complexity associated with operation of CRCs as unincorporated joint venture arrangements and the uncertainties associated with the provisions of the Taxation Law. The entity would give specific recognition of a CRC as a *public-private industrial research partnership.* CRCs established with the specific purpose of developing a business involving the commercialisation of research should be established as incorporated entities.

3: General Views on the Success of the CRC Programme

Views about the success of the CRC Programme vary considerably among stakeholders. In this Section, the views from stakeholder categories are presented. The difference in views reflects in large measure a lack of clarity, and some inconsistency, in interpreting and applying the objectives of the Programme.

3.1 Overall perspectives

The following observations have been distilled from the consultations process:

- Over the time frame of its operation the CRC Programme has injected new funds into what was at the time a declining commitment to public sector research support ($2 billion over period 1990-91 – 2001-02).
- There is widespread support and agreement about the success of the CRC Programme – but most will add a "but . . ." caveat.
- Major contributions were seen as:
  - Encouraged a number of "public good" issues to be addressed on a national basis; substantial leverage in environment CRCs
  - Allowed industry to "gain a seat at the table" in designing research programmes.
  - Allowed universities to "channel passion" for research into a framework that has national/industry impact – a framework for professional research management; scientists being oriented towards solving problems.
  - A powerful change agent in research culture – away from the "ivory tower" culture of universities.
- The CRC movement has aided the translation of *thinking* about transfer of research outcomes into an industrial application, into *action;* it is no longer a question of *why* but one of *how.*
- Research entities need managing once created; it takes time to ramp up and achieve results.
- The CRC system needs to prosper and adapt – but now in a much more complex, dynamic and contingent environment – effectively – "we want to keep the CRC system, but we want it to work better for us".
- There is strong support for broadening the Programme to include greater involvement of social sciences and humanities directly and indirectly; however, social sciences and humanities need to work in areas of interest to government and research priority.
- There is a need to maintain a genuine inter- and cross-disciplinary focus - balance between science based and engineering based innovation – and the relationship between the two.
- Flexibility and responsiveness are key design features – responding to emerging threats and opportunities eg Bushfires, Tourism.
- There is an uneasy and unclear fit in the new and emerging research funding landscape.

The views of the key participants in the CRC system are canvassed below.

3.2 Research providers

3.2.1 University perspectives

The Programme is highly valued by universities in building research capacity and capability; they see value in access to researchers and facilities in Commonwealth and State publicly funded research facilities.

Universities are operating in an environment where there is increased funding pressure resulting in greater commitment to prioritise, manage and coordinate their research efforts. Strategies to achieve this include generating research clusters or groups with critical mass, defining and supporting institutional areas of research strength and aligning those areas with National Research Priorities. The long term support provided by the CRC Programme is regarded as an important means for coordinating and prioritising research effort and has a significant influence on research direction and the longer term research horizon.[21]

More specific comments in relation to the involvement of universities are presented from the perspective of predominantly research universities, the technology oriented universities and the regional universities.

Research universities

The Group of Eight Universities, which collectively participate in most CRCs, see the Programme in the following terms:

> In general terms the Programme is seen as an important element of Australia's research and development landscape. A pioneer of public-private research engagement, the Programme has created a successful model of commercialisation and technology transfer which is recognised both nationally and internationally. Strengths of the Programme include the long-term investment in innovation, the development of greater cultural understanding between universities, public sector research agencies and business, and research training success. Collaborative arrangements are critical to the development of a culture of innovation which is in turn fundamental to Australia's competitive position in the global economy of knowledge.[22]

The major strengths of the Programme, from a University perspective are broadly as follows:

- *Long term, big picture, significant research programmes:* Seven years with a possibility of extension and with support generally much larger than other sources (such as ARC, NH&MRC); there are very few other programmes where such long term, large investment commitment can be obtained; the funding is sufficient to allow large research teams to be assembled and the possibility of tackling "big" research questions.
- *Technology transfer:* CRCs facilitate technology transfer from research organisations to industry and to the wider community; universities receive substantial kudos from successful commercialisation outcomes and CRCs are seen as iden-

[21] Submission, The University of Sydney
[22] Submission, The Group of Eight Universities

tifiable mechanisms for technology transfer into the commercial, applied research arena.

- *Research performance indicators:* CRC income contributes directly to Category 4 research income; research contracts and consultancies contribute to Category 3 research income. This means that there is a downstream impact on the Research Block Grant (about 30-40 cents for every $ that the University derives from involvement in a CRC).
- *External salary support for staff*: CRCs provide some direct salary support to researchers involved in CRCs through significant consultancies in the short term and royalty flows in the longer term.
- *Research critical mass:* CRCs coordinate and focus research critical mass through additional postdoctoral research staff, research associates, post graduate students, equipment and support for infrastructure; they also create networks, research contacts and collaborations outside the university.
- *Postgraduate students:* Scholarship support; opportunities to work on well-focussed research programmes, usually as part of a "high flying" research team. Opportunity to gain experience working with industry – including working to deadlines, milestones, a working knowledge of issues associated with IP protection. Providing postgraduate coursework programmes – including delivery of courses or modules with a University post graduate course work programme.
- *Commercial returns:* Some CRCs have provided a stream of revenue to a university.

Universities have identified a number of weaknesses in the CRC system, mainly relating to administration and management. These matters are addressed in Part II.

Technology universities

The commencement of the CRC Programme coincided with the introduction of the unified national system for higher education. It provided an opportunity for the newly formed "technology universities" to become involved in CRCs.

The Technology universities value the CRC system in terms of the opportunity to work with industrial partners on a continuing basis and to offer extended education programmes that provide, among other things, opportunities for PhD candidates to develop management and leadership skills.[23]

Technology universities see opportunities to further develop education programmes by exploring some of the other technical and personal skills domains.

Regional and smaller universities

The CRC system has been an important factor in enabling regional and smaller universities to establish research capability and to develop specialisations in research

[23] Submission, Curtin University

areas. The Programme has also assisted in securing the leadership role of universities in regional economic development.[24]

Regional universities are major participants in the CRC Programme in terms of the relationship to overall research funding. For example, James Cook University argues that on a per capita basis its involvement in the CRC Programme is one of the largest amongst the Australian universities. All regional universities report in their *Research Management and Research Training Plans* that the CRC Programme is a major contributor to their areas of research strength.

Regional and smaller universities argue that by being strategic in their approach to CRCs they can become major players, such as in the Antarctic, Aquafin and Forestry CRCs.[25] The system also provides a vehicle for researchers in all universities to adopt a national focus and develop links with researchers in the larger institutions.

CRCs have been particularly important in developing research capability and application in agriculture and natural resource management (NRM) in regional universities. For example, the University of New England noted in its submission that:

> . . . a major achievement of the CRC initiatives has been to allow regional universities like UNE to showcase R&D initiatives that otherwise would be more difficult to promote. There are several spinoffs from this during a period when regional development is a significant issue for both federal and state governments: the creation of high tech centres (such as the International Livestock Research and Information Centre in Armidale, leveraging off CRC knowledge bases), economic contribution to regional economies (through expenditure and personnel), and service to local industries (especially beef and sheep in the New England context). In regional areas, simply, CRCs have an extremely important capacity building function not necessarily apparent in metropolitan settings.
>
> . . . UNE has found that as a regional university, a major benefit from the CRCs has been in postgraduate students coming to the centres. In light of national research trends and priority setting, enhancement of that contribution from postgraduate students would be an excellent investment not only in the specific industries, but also in the investment in human capital. That will enable institutions like UNE to retain global significance in areas like quantitative genetics, so central to the genome project more widely.

The UNE argues that CRCs allow institutions as a whole to become involved in constructive networks tackling the "big" problems. The $32 million Progeny Testing Programme in the Beef CRC provides an important and significant example: it has inestimable value for the industry but could not be tackled by single agencies alone. The Programme has facilitated James Cook University involvement in issues of global significance to the tropics.

Emerging pressures

The "bottom up" (researcher driven) nature of the Programme has developed to a situation where individual universities, and universities in the system as a whole, are coming under increasing pressure to find the overall level of resources required for

[24] In the United States and Europe the role of universities in leading economic and industry development is well understood. See Mary L Walshok and others, "Building Regional Innovation Capacity: the San Diego Experience," *Industry and Higher Education* 16, no. 1 (2002)

[25] Submission, University of Tasmania

participation. As a result, universities are giving closer attention and more careful management to their involvement than in the past. This follows from both the management and organisational issues referred to above and the increasingly tight funding situation being encountered. Universities are committed to ongoing involvement in CRCs.

A substantial amount of that pressure arises because most university researchers also have teaching responsibilities. Consequently, if a researcher joins a CRC fulltime, someone will have to fill in for them when they join the CRC. In view of the continuous rise in the student/staff ratios this could cause major problems in some faculties. This situation does not apply to government agencies such as Geoscience Australia or CSIRO because their staff are usually fulltime researchers.

Part of the problem arises when university researchers commit at levels below that which would require consideration by a Dean of "back filling" a position. That would arise when the time commitment was below, say, 25 percent. With time commitment of ten percent (half a day a week), as is occurring across the system, that time would be seen as either marginal to ongoing research effort and is likely to be provided without adjustment to other commitments. Alternatively, researchers may find that they have to commit more time, and place themselves under considerable pressure to provide a meaningful contribution to the research programme.

Universities are also concerned about the requirement to commit cash in submitting CRC applications, that is, to become a research funder. There is a view that this is inconsistent with their role as research providers. The level of cash contributions from universities has become quite significant, particularly in the last three Rounds. Despite the pressure on university resources, the cash contribution has continued to rise and is becoming unsustainable.[26]

The Group of Eight Universities submitted that:

> Due to the tied nature of most Commonwealth university funding there is little discretionary funding which the universities can draw on to fund their contribution to programmes such as the CRC Programme. This is even more the case since the introduction of *Backing Australia's Ability* (BAA) through which additional Commonwealth funding for a number of programmes, such as Federation Fellowships, also leverage university funding on a matching basis. The Government's higher education reform package announced in the 2003-04 Budget, whilst generally welcome, does not directly address this issue, as research funding is to be addressed separately in the context of the future of the *Backing Australia's Ability* Programme. In the meantime the Group of Eight Universities will find it increasingly difficult to provide cash support for the CRC Programme.

More specifically, The University of Sydney advised:

> The University of Sydney will continue to invest strongly in CRCs. However we have made the strategic decision for all new CRCs that we will not directly invest cash. In some cases the University has received very poor returns from CRCs and in general The University is much better off investing "in house" to boost up the personnel and research infrastructure directly supporting the CRCs.[27]

[26] Submission, the Group of Eight
[27] Submission, The University of Sydney

The regional and smaller universities also raised concerns about the cost of involvement in CRCs and the need to take a more strategic approach. In its submission the University of Tasmania commented that:

> We have adopted the view that we prefer to contribute substantially to fewer CRCs rather than in a small way to a larger number. It is important to note that the administrative costs of CRCs are reasonably high. Like all organisations, we need to evaluate the returns from the investments we make in staff and student-time, infrastructure and cash to CRCs.[28]

The overall conclusion is that Universities have valued their involvement in CRCs in terms of building research capability, adopting a national approach to research, broadening the focus of research training and postgraduate education, and providing an opportunity for the smaller and regional universities to develop specialist capabilities in areas such as agriculture and natural resource management. They are becoming concerned about the growing cost of involvement and are looking towards adopting a more strategic involvement.

Many universities have reviewed their involvement in and commitment to research centres and are looking for a "steady state" arrangement where they are involved in CRCs at various stages of development (new, developing, mature, windup). A number of universities have developed specific policies and protocols for involvement in research centres generally.

3.2.2 Publicly Funded Research Agencies

The role, performance and behaviours of Publicly Funded Research Agencies (PFRAs) in the CRC Programme was a major topic in discussions and consultations during the Review. In many respects, these comments reflect tensions between the "bottom up" logic of the CRC Programme and the corporate financial and institutional pressures that exist with those organisations. Comments from the major PFRAs about the Programme follow.

CSIRO

CSIRO has been active in the Programme since its inception and remains a strong supporter of the Programme. It has participated in 95 of the 123 CRCs which have commenced or renewed since 1990. Of the 64 CRCs active at June 30 2002, CSIRO was in 46, with a multi-year financial commitment totaling $315m. CSIRO is a core or supporting participant in 16 of the 21 new Round 8 CRCs announced in December 2002.

CSIRO has indicated that where it is a major player, its commitments comprise, on average, 27 percent of the equity in the CRC. This amounts to 11 per cent of CSIRO resources.

The CRC Programme has been an important vehicle for CSIRO's collaboration with universities. Thirty-three universities had worked with CSIRO to put together the 46 CRCs in which CSIRO was participating in June 2002 and individual universities

[28] Submission, University of Tasmania

were working with CSIRO in up to 10 separate centres. CSIRO had played a leading role in developing some of these CRCs.

CSIRO considers that CRC collaborations between universities, CSIRO, industry and other organisations have in many cases led to the coordination of Australia's national research effort in particular fields and helped achieve very significant research and commercial outcomes.

In late 2002 the CSIRO Board asked CSIRO to review its participation in the CRC Programme. In response to this request, CSIRO commissioned an external consulting firm to conduct a stocktake to assess and evaluate the value CSIRO has created from CRCs and to report on the findings from that assessment and their potential implications for CSIRO.

The stocktake found that:

- The CRCs in which CSIRO participated had been successful overall and that CSIRO's participation had created value for Australia, for research clients and for itself.
- CSIRO had made significant contributions to its CRCs, though its interactions with other CRC participants sometimes suffered from disparate agendas and overt competition.
- CSIRO's value creation from CRCs related to the nature of the CRC and the quality of CSIRO's interactions with other participants.
- To maximise future value from its participation in the Programme, CSIRO should address the strategy it uses to select the CRCs in which it will participate and the management of its participation.

The stocktake also indicated:

- CSIRO is perceived as a difficult, but necessary partner by many CRCs.
- Overlap between CRC objectives and CSIRO's areas of research has led to friction – each side seeing the other as a threat.
- Apart from research overlap, CSIRO is perceived as too tough on legal, commercial and governance issues, and most of this concern is aimed at CSIRO's corporate and legal staff.

These comments were reiterated and reinforced throughout the discussion and consultations aspects of the Evaluation.

As a result of the stocktake, CSIRO is working to improve its processes and skills for involvement in CRCs and to increase communication with the Department of Education, Science and Training and CRCs. It is also working to implement a CSIRO CRC secretariat with a broad charter to ensure it works effectively within the Organisation to achieve the maximum return for all participants from the changes that have taken place in Australia's national innovation system since the introduction of the CRC Programme.

The CSIRO Executive has decided to implement a number of specific changes in its approach to CRCs:

- Set and share objectives for CSIRO involvement in CRCs at programme and individual CRC level.
- Ensure approval to negotiate and enter is sought before committing to new CRCs.
- Introduce formal performance evaluation for CSIRO involvement in CRCs.

Defence Science and Technology Organisation (DSTO)

DSTO currently has the lead responsibility within the Defence Department for overall management of its involvement in the CRC Programme. This is based on DSTO being the primary research organisation within Defence, and the need to ensure that various legal obligations are complied with, such as financial reporting requirements or the need to provide aggregate reporting to the Minister.

For DSTO to have joined a CRC demonstrates that it is seen to meet a range of collaborative objectives, which include:

- Providing science and technology advice to the ADF
- Increasing opportunities for DSTO to transfer the results of Defence research and development to the Defence industry
- Providing access for industry and other agencies to DSTO's research facilities and expertise
- Providing improved relations with industry/customers
- Conferring a multiplier effect on defence research through DSTO's collaboration with research agencies.

For DSTO, joining a specific CRC must also meet the following criteria:

- The broad DSTO requirements for collaboration are satisfied (contribution to national wealth creation, leveraging R&D, technology transfer and sharing research risks and benefits)
- Research undertaken for the CRC would have been a formal part of the DSTO planned programme of research (given the availability of the necessary resources), even if the CRC had not existed
- The area of research and development task work is a DSTO task, or part of a DSTO task, and subject to the same review procedures as other DSTO tasks.

In summary, DSTO is therefore only involved in collaborative research like CRCs, where there is a clear benefit to developing or supporting critical Defence capability. An example of this is the CRC for Advanced Composite Structures, which is perceived to have had a moderate impact at a National level in terms of an increased capability to manufacture advanced composite structures, particularly those manufactured using liquid moulding techniques.

Defence has been involved in the CRC Programme since the first CRCs were established with both cash and in-kind contributions. Including both expended and committed funding from 1991-1992 through to 2005-2006, Defence's overall involvement in the CRC Programme is predicted to come to over $66 million, of which 96 percent is DSTO sponsored.

Defence is continuing to develop a global picture of its financial commitments to CRCs. Although it has stated the agreed cash and in-kind contributions as part of its CRC membership obligations, mechanisms to capture the full extent of DSTO/Defence contribution to CRCs are still being developed and refined.

Although Defence has a range of international engagements with allied nations, the nature of these government-to-government agreements often exclude commercial use of the information generated on the grounds of national security.

From Defence's perspective, there is greater benefit in investigating increased collaboration with international research networks and civilian international science and technology cooperation programmes, eg the U.K. Towers of Excellence Programme, as a mechanism for extending CRC interaction, a process DSTO continues to explore.

3.3 Research users

The views of industry vary across sectors. The views of key industry representatives are captured in the following paragraphs.

3.3.1 Agriculture

State Departments of Agriculture are major participants and users of CRC research in the interests of primary producers and the broader objective of sustainable agriculture.

NSW Agriculture believes that the CRC Programme fills an important niche in the Australian research landscape, allowing focussing of scattered resources on achieving common goals, particularly in the agricultural sphere. The Department notes:

> The relatively long duration of CRCs allows real communities of interest to develop between researchers and industry, and outcomes have been enormous. The basic framework of the Programme is very sound and a great deal of experience has now been amassed nationally in how to make them work.

The Department adds that commercialisation of outcomes in agricultural CRCs has come about almost entirely through the rapid dissemination of CRC findings to "well-primed industry participants, who are waiting eagerly to adopt the results of the research which they asked for". This leads to behaviour change on farms, with joint improvements in economic and environmental benefits, and consequent social benefits. The Department states:

> It is critical that the government recognise this and not expect major returns from patents, royalties etc in these largely public good CRCs.
>
> Increasing environmental pressures mean that the need for these agricultural CRCs will increase. Their merit is their joint focus on profitability and sustainability, which hopefully will be more effective at mobilising private dollars from land managers to help with environmental remediation.

The Queensland Department of Primary Industries pointed out in a submission that CRCs provide a forum for establishing a strategic approach to a broad research topic across the leading research organisations that make up the core and supporting partners. The Department adds:

> In general, the CRC Programme has facilitated useful collaborations with a wide range of other research organisations. Collaboration has, for example, permitted access to intellectual property held in other organisations and the IP has been used to

> enhance DPI's own capabilities. The creation of a CRC however, does not necessarily automatically deliver collaboration benefits, as a successful networking outcome depends very much on the people involved in the directorate and the management committees, particularly with respect to personalities and attitudes. Australian science is in general poorly funded, and consequently very competitive. Poor funding can impact on collaboration. When funds are scarce, there is a strong tendency for scientists to use available funds for their own units (to ensure their capacity to deliver) in the first instance, and secondarily for collaborative ventures. *Collaboration is much easier when funding is ample.*[29]

The Queensland DPI submitted that it has developed closer links with universities and postgraduate students and this has enhanced the creativity of research being undertaken. This view was confirmed in discussions with the West Australian Department of Agriculture.

Consistent with the concerns of other agencies, the Queensland DPI notes that the financial inputs that partners are required to make (in both cash and in kind) is high and the funding injected into CRCs into the projects of partner organisations is sometimes less than the partner organisations can obtain through other sources.

The Western Australian Department of Agriculture informed the Evaluation that it has had:

> … a largely positive experience from its involvement in the CRC Programme which has provided either valuable scientific support to our existing R&D activities or has brought additional resources to important areas where we have limited or no capacity.[30]

The Department noted concerns about the costs associated with bid preparation and the start-up and operational phases of CRCs and that "Industry expectations have not been met in many cases as the long-term and basic nature of much of the research has yet to deliver implementable outputs".

Consistent with other comments, the Department added:

> DAWA expects to support involvement in the Programme into the future but must consider very carefully commitments to new CRCs given an ever increasing demand on shrinking resources, and the significant management costs associated with CRCs. Future involvement will depend increasingly on clear, shared objectives and confidence that outputs of value to the industries we serve and the State of Western Australia will flow and have a genuine impact.

3.3.2 Environmental and natural resource management agencies

A significant amount of CRC activity relates to activities in the environment and natural resource management arenas. The major research users in this category are State Departments of natural resources.

The Queensland Department of Natural Resources and Mines pointed out in a submission to the Evaluation that:

[29] Submission, Queensland Department of Primary Industries. Emphasis added. Management and organisation literature points to the existence of "organisational slack" as a pre-condition for problem solving activity and innovation.
[30] Submission, Department of Agriculture - Western Australia.

> The CRC Programme has substantially raised the profile of natural resource and environmental R&D in Queensland and nationally, and is providing an improved scientific basis to support natural resource management decisions.
>
> Much of this R&D would not have been otherwise undertaken or if it had been, knowledge of its existence would have been restricted, or it would have been undertaken by a single organisation in isolation without the benefits of networked science.

The Department pointed out, however that:

> The CRC Programme has not, however, contributed to the development of private research capacity in the natural resource/environmental area. This R&D area is still – and likely to continue to be – funded publicly, as this is essentially public science that contributes to natural resource management planning, policy and decision-making by governments and community groups and resource users.

In areas such as water allocation, landscape management for salinity and water contamination, clean coal research, and greenhouse gas emissions, the Queensland Department of Natural Resources and Mines considers that CRCs have provided State agencies with a link to a broader set of skills than currently resides within agencies. In return, agencies have provided practical on-ground experience and often extensive data sets that could be used by the combined research group.

The CRC Programme is also seen by the Department to provide a useful framework for better integration of social and economic dimensions into biophysical and other 'pure' research, which in turn enhances the relevance and likelihood of uptake of R&D results. This is especially the case when the desired outcomes involve attitudinal or behavioural change on the part of members of the general community.

The Department also notes that collaboration with community groups has only occurred when a CRC has put the resources and effort into making it happen. With the increasing devolvement of decision-making to regional or catchment bodies, as is now required under the Natural Heritage Trust Programme (NHT2), this is an area where there is certainly a need for greater CRC collaborative linkages.

3.3.3 Information and communications industries

The information and communications technology (ICT) sector has experienced highly volatile industry conditions over the last decade which has impacted in CRC participation and performance.

Globally rapid growth and sudden down turn from about 2000-2001 onwards is mirrored by the earlier rounds of CRCs being well represented in basic applied ICT research areas such as CRCs in Photonics, Telecommunications, Satellite Systems, Enterprise Distributed Systems Technology, and Sensor Signal and Information Processing. In more recent rounds there has been a change towards market-specific and applications driven CRCs, such as that for Technology Enabled Capital Markets and Smart Internet Technology.

Executives in this industry when consulted indicated the major limiting factors in relation to participation in CRCs to be as follows:

- The global ICT industry downturn with flow on consequences such as the loss of local capability and investment (for example, the recent closure of Ericsson

AsiaPacificLab R&D centre in Australia, and the departure of other major firms and their commitments to CRCs)

- The challenge for photonics to realise the rate of growth initially anticipated, despite successfully raising significant venture capital and spinning-off a small group of new companies
- The diffuse leadership and lack of an overarching vision for the Australian ICT industry over the last decade
- The huge divide in resources/capability/global reach of major multinationals in this sector and the many much smaller local software development companies, too small to get effectively engaged in CRCs.

Seven year CRC contracts (with one year notice of resignation) in such an uncertain business climate has led in the past to minor disputes on the terms for early departure of CRC participants. Participants now seek far greater flexibility in CRC contract tenure.

There have been a number of recent initiatives to address these problems, including:

- Industry Action Agendas in Electronics (2001-02); Information Industries (2000-01); Spatial Information Industry (2000-01); Digital Broadcasting (2000-01)
- The publication of the *ICT Framework for the Future* (comprising various and multiple reports and statistical maps of the industry) by the Commonwealth in April 2003, and summarising current national ICT R&D in this sector[31]
- Formation of the ICT Centre of Excellence, National ICT Australia (NICTA).

Whilst NICTA has been welcomed by the industry executives consulted, it was also raised as a concern about national R&D coordination in the ICT sector, especially the relationship with CRCs.[32]

The process leading to the establishment of NICTA involved inputs from many stakeholders in government, research sectors and industry who all considered that Australia's capacity for world-class ICT R&D and its commercialisation was comparatively weak. It was weak in part because of Australia's industry structure which includes no large indigenous ICT firms other than Telstra and because very few Australian public sector research groups were able to mount critical masses of leading researchers.[33]

A Council of ICT CRCs has recently been created and CRCs will be involved in the research outlook forum being jointly organised by NICTA, CSIRO and DSTO for September 2003.

A recurring theme amongst the CRCs, businesses and publicly funded research institutions is the need for flexibility. Specific comments related to:

- Mechanisms to allow adjustments to agreements to reflect the changing environment and new opportunities that may arise

[31] Australia. Framework for the Future Steering Committee, *Enabling Our Future: A Framework for the Information and Communications Technology Industry* (Canberra: Department of Communications, Information Technology and the Arts, 2003)
[32] Ibid. pp. 27-33.
[33] Submission, Department of Communications, Information Technology and the Arts

- Merging of ICT into other CRC industry sectors as an 'enabler' as it focussed on an industry need
- Trying to commercialise some 'mini-project/concept' in an environment where major corporate participants did not want 'smart little bits of technology'.

Industry executives indicated a preference for bilateral relationships with quality and trusted university academics that could deliver on industry needs, rather than going with the complexity of a CRC joint venture.

There is, of course the view that the appropriate path to market for innovations in ICT CRCs is less through adoption by an industry participant but more through new business creation in the form of a start-up company. This issue is taken up again later in the Report.

3.3.4 Manufacturing and services

The CRC Programme was initiated with a major focus on improving Australia's industrial base, including advanced manufacturing and drawing on the emerging fields of material science. There are currently several CRCs in this area, including the CRCs for Advanced Composite Structures, CAST Metals Manufacturing, Polymers and Welded Structures.

There have been fewer CRCs in those areas of manufacturing where innovation occurs close to market, for example in food processing where there have been only two CRCs - despite food processing being one of Australia's largest manufacturing segments.[34]

In a submission the Australian Chamber of Commerce and Industry pointed out that the CRC Programme is "an effective cross sectoral approach developed for promoting more effective linkages between research and commercial organisations, and for promoting specific, outcomes-focussed research and commercialisation in the longer term" and that it "is a serious attempt to:

- Bring together research providers with research users
- Change the culture of university researchers and researchers in bodies such as CSIRO towards more commercial outcomes
- Promote business focussed R&D."

ACCI notes that:

> In general, public R&D has had less than optimal benefit to the majority of business enterprises because frequently it lacks commercial application. Over the last few years there has been an objective that public R&D be more commercially focussed and business oriented. On the other hand, business R&D in Australia has been limited compared to comparable developed countries. There has been recognition of the need to promote greater focus in the private sector on innovation and R&D, and commercialisation within Australia of that R&D.
>
> In industry's view, the CRC Programme has been far more successful than the old model of public institutions doing the research and the private sector commercialising it into products. Universities and CSIRO have made efforts to improve their co-

[34] The newly created National Food Industry Strategy Limited is supporting the creation of Centres of Excellence in Food Processing as part of the Food Industry Action Agenda

> operative efforts with industry in the last few years, but in general are still less effective and user friendly than the CRCs. Indeed, an important spin-off of the CRC Programme is the cultural change that it is promoting in these organisations more broadly.

ACCI believes that the CRC Programme is an effective policy instrument but there is potential to streamline the operation of the Programme. It suggests that one of the major challenges for the Programme is to achieve long-term business support, particularly from SMEs, to the CRC process. It notes, however, that as businesses constantly evolve through mergers, takeovers and other changes, difficulties arise in maintaining continuity of business involvement.

The Australian Industry Group (AiG) has undertaken an extensive study of manufacturer's use of CRCs as part of its study into *R&D Expenditures and Drivers.*[35] It found that CRCs have little engagement with the manufacturing sector. The study reported that only four percent of manufacturers engaged in R&D had used a CRC as part of this activity, the vast majority of these firms being large companies employing more than 500 people.

The AiG suggested that the finding reflects the broader findings of both the AiG and OECD research into business R&D activity in that Australia's R&D effort compared to other OECD countries is disproportionately focussed on public research, which lacks strong commercial benefits and results in weaker spillover effects to the broader economy. The Group notes that all other countries (with the exception of New Zealand) put the balance of their R&D into private (businesses) rather than public R&D.[36]

3.3.5 Mining and energy

The CRC Programme is well established in the mining and energy sector. CRCs have taken over much of the research previously undertaken by individual companies.[37] They are seen as an effective method of providing focussed, applied research when collaboration is needed between industry, Government and community. The Queensland Department of Natural Resources and Mines submitted that:

> The networking and joint R&D which the CRC process provides has resulted in collaborative, high quality R&D which is generally accessible. It has also added to Queensland's and the nation's intellectual property and capability on natural resource management, and has driven the research dollar further through the shared resources (cash and in-kind) and the combination of intellectual and enterprise talents.

In the mining sector the industry input (both involvement and financial commitment), and particularly at the small to medium enterprise level, is seen as a significant strength of CRCs. It has allowed research to be focussed on specific priority areas and local issues that require practical solutions. The networking has also resulted in organisations such as universities and CSIRO becoming more aware of the industry priorities for natural resource management and putting R&D resources into these activities.

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[35] Australian Industry Group, *Research and Development: Expenditure Drivers in Australian Manufacturing* (Sydney: Australian Industry Group, 2002).
[36] Submission, AiG,
[37] Submission, Queensland Department of Natural Resources and Mines

Much of the involvement of the mining industry occurs through AMIRA, an industry association which manages collaborative research for members operating in a global minerals industry. The Association considers that by taking a partnership approach to research and development that is managed by AMIRA, members enhance their competitive position through access to leading edge technology.

AMIRA is a supporter of the CRC Programme on the basis that much good research is done using contestable 'soft' funding. Many of the Mining CRCs generate substantial amounts of revenue from contract research. However, a concern was raised in a submission that some of the mining CRCs are "crowding out" private sector contract research.

3.3.6 Pharmaceuticals and biotechnology

The CRC Programme supports a number of CRCs that focus on research that aims to deliver new drugs and apply biotechnology in clinical processes and procedures.

Research in pharmaceuticals/biotechnology is associated with high costs and considerable technical and market risk. It is difficult for research groups who may discover a new compound to take the product to market as a "start-up" for these reasons. Within the industry there has been significant consolidation and mergers of small biotechnology companies over the past decade essentially to gain access to "promising pipelines".

In a submission to the Evaluation GlaxcoSmithKline argued that:

> . . .it is important to view CRCs as providing an additional means of encouraging collaboration in addition to its own activities. Government support provides important facilitory support. Similarly, the pharmaceutical industry has a long record of collaborative research, particularly with Australia's publicly and privately funded health research institutes. The CRC for Asthma represents a continuation of this willingness to continue to invest in Australian health research and plays an important role in forging stronger links between the research sector and industry.[38]

From a GSK perspective the collaborative nature of the CRC Programme has allowed an effective exchange of information and expertise between industry and the academic research community. This is seen to be of particular importance given the rapid pace of change and enormous costs of development which can inhibit the ability of many smaller companies and academia to keep up with latest developments. Therefore having membership of large global companies such as GSK provides improved access to developments and resources.

GSK points out that the collaborative nature of CRCs, their focus on developing partnerships and commercialisation and the broader involvement of industry partners assists in ensuring that the research expertise and experience that exists within industry better informs academic research. This is also seen to be dependent on an effective administrative structure that establishes the committee/advisory bodies that allows the true interflow of feedback and directions between industry and academia.

The company makes an important and useful comment on the relationship between "public benefit" and "commercial" orientation of CRCs:

[38] Submission, GlaxcoSmithKline

> One of the key aims of the CRC Programme is to deliver both research of public benefit and that which enhances the transfer of research outputs into commercial outcomes. Similarly, the CRC for Asthma aims to improve the understanding of the causes of asthma and its treatment as well as commercialise its research outcomes. These aims should not be seen as competing with one another as they are often complementary.

In relation to commercialisation, GSK suggests that:

> While CRCs are most effective at ensuring collaboration in research, participants should understand that the challenge of commercialising research is often more effective through utilising other resources and government programmes. Therefore the CRC structure needs to be closely aligned with other Government research programmes.

The GSK experience with the CRC Asthma has been positive. This reflects on the membership and administrative structure.

3.3.7 Medical devices

There is a number of CRCs that focus on research in relation to medical devices. They include the Cochlear and Vision CRCs.

In these areas CRC industry involvement is often associated with one business – as that business largely constitutes the industry. Moreover, as with ICT, the path to market is often through the creation of new start-up companies rather than through take up with an established industrial organisation.

3.3.8 Water industry

The water industry and associated utilities have interests in four CRCs: Catchment Hydrology, Freshwater Ecology, Water Quality and Treatment, and Coastal Zone, Estuary and Waterway Management. These CRCs have established research platforms spanning the entire length of Australian waterways. The industry participants constitute a mix of both urban and rural/regional water management authorities and State Departments typically covering all aspects of water resource management.

Melbourne Water advised the Evaluation Team that:

> Melbourne Water has been a strong supporter of the CRC Programme, having been a member of three CRCs, Catchment Hydrology, Freshwater Ecology and Water Quality and Treatment since their formation.
>
> Each of these CRCs has been highly successful and has received strong support from industry.
>
> The CRC for Water Quality and Treatment has developed excellent global linkages with international research agencies through the Global Research Coalition. It has had a major influence in the adoption of a new risk based framework for ensuring drinking water quality in both the WHO and Australian drinking water guidelines.
>
> Melbourne Water made a strategic decision in the early 1990s to outsource R&D to ensure that the organisation could access world-leading research in a cost effective way. This has been supported by Melbourne water's skill based Board and they have given strong endorsement to the organisation's involvement in the CRC Programme.[39]

[39] Submission, Melbourne Water

Discussions with CEOs of the water CRCs and with technology transfer "knowledge brokers" working with Melbourne Water indicate that the general experience of end user water authorities and utilities towards CRCs is positive and is similar to views held by State agricultural agencies. These CRCs as a group have established a reputation for consulting on major national water projects.

The CEOs of water CRCs meet periodically, and there are some R&D programmes spanning them, but no coherent or consistently applied enviro-economic analysis of their combined national benefit has ever been made across the group.

3.4 Other stakeholder views

3.4.1 The Department of Industry, Tourism and Resources

The Department of Industry, Tourism and Resources submitted that:

> The Programme continues to offer a combination of features that are not found elsewhere in the Australian innovation system. These include: scale of project-focussed funding; an emphasis on collaboration between research groups; and the certainty of funding over a longer time frame than most other programmes.

The Department notes:

> ITR has had positive interaction with particular CRCs. In the CRCs where the ITR portfolio agency Geoscience Australia has been involved, the Programme has enhanced collaboration between government agencies at both Commonwealth and State level and the universities to focus on topics of public interest and concern. This would not have happened under an ARC Centre of Excellence Model because the resources deployed in the average CRC and the disciplinary range is significantly higher than can be realised in ARC Centres.
>
> CRCs are used by Invest Australia to promote Australian capabilities in ICT, Biotechnology, and Nanotechnology. They demonstrate the interconnectedness of R&D in Australia and offer useful examples of cutting edge R&D, with multi-national involvement/investment and international linkages.
>
> The CRC for Tourism provides a crucial research role for industry which is not provided by any other organisation. This CRC has a strong commitment to expanding the commercialisation of its research, having established three spin-off companies. While the industry is dominated by resource limited SMEs, the CRC is actively pursuing the involvement of these businesses in its Programme. Engagement with SMEs is largely through industry associations as full or associate participants. This CRC is also very active in developing international links.

3.4.2 The Department of Agriculture, Fisheries and Forestry

The Department of Agriculture, Fisheries and Forestry has an interest in the outcomes of a number of CRCs in the agriculture and natural resource management areas. It advised the Evaluation that:

> CRCs form a part of the research infrastructure underpinning the Department's industries . . . a significant proportion of CRCs in each funding round are focussed on our portfolio industries and associated technologies or on environmental concerns of importance to our portfolio industries.[40]

[40] Submission, Department of Agriculture, Fisheries and Forestry

Much of the involvement of the Department is through the Rural Research and Development Corporations that participate directly in a number of CRCs. The Department's Bureau of Resource Sciences is also involved in some CRCs. The Department is also a direct participant in the new Biosecurity CRC.

3.4.3 The Department of Communications, Information Technology and the Arts

The Department of Communications, Information Technology and the Arts made the following general comments in relation to the Programme:

- From an ICT perspective, the CRC Programme has encouraged increased cooperation between universities and industry and this cooperation has been successful in producing some significant research and commercial outcomes.
- The Programme has not only provided a boost to the research expenditure in the ICT area, but has been influential in building a substantial body of planned research focussed around particular research issues and practical problems.
- The Programme has been influential in encouraging cross-and multi-disciplinary research. One of the significant emerging trends in the research conducted in OECD countries is the rise in multi-disciplinary research.
- The CRC Programme has also encouraged a greater focus on commercialisation and the transfer of knowledge to industry; 16 ICT companies have been formed between 1992 and 2001 in the 7 ICT CRCs established to January 2003.
- Many postgraduate students from the ICT CRCs have found jobs with industry.
- All the ICT CRCs have established technology transfer companies to encourage the transfer of CRC tacit knowledge.

The Department considers that the increase in overall ICT research expertise and activity provides a substantial opportunity for the ICT CRCs by expanding the scale of possible research and deepening the pool of research expertise. Taking full advantage of this opportunity requires the ICT CRCs to take the opportunity for greater collaboration between them and also with other relevant programmes and institutions. The Department suggests that the design of the CRC Programme be refined to encourage and give greater reward for collaborative efforts.

3.4.4 Environment Australia

The Department provided detailed information about the way in which the outputs of several of the CRCs associated with the portfolio have been reflected in public policy and programmes. For example:

- The CRC for Catchment Hydrology is developing catchment models and decision-support tools that will form the basis to coastal, catchment and regional water quality management and protection in Australia. These are vital tools, the need for which is demonstrated in the Commonwealth's *Framework for Marine and Estuarine Water Quality Protection*, applied through the Coastal Catchments Initiative.
- CRC Catchment Hydrology tools are critical for developing management strategies to address, for example, water quality in the Great Barrier Reef. These tools are currently being implemented for Port Phillip Bay, Moreton Bay and will underpin implementation of the Coastal Catchments Initiative and any likely national approach to implementing UNEP's Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA).

The Australian Greenhouse Office submitted that:

> The AGO supports the contention that the CRC Programme has contributed to Australia's economic growth, social well-being, and environmental outcomes. In the case of the environment-based CRCs, the opportunities, and indeed the intent, for immediate economic benefit may not be the prime driver for the CRC. Rather it is intended and fully understood that the benefits of research in the environmentally-based CRCs need a longer pay-back time, often beyond the lifespan of the CRC. The AGO supports the current mix of commercially-driven and public-good CRCs in the overall Programme.
>
> . . .
>
> The AGO is concerned about the declining capacity in Australia for world-leading research and development. Of course there are bright spots, but criteria such as citation indices, and R&D as a proportion of GDP are clear warning signs. The AGO believes that within this context, the CRC Programme has continued to encourage as much as possible an excellent standard of research.

3.4.5 The Australian Academy of Science

The Australian Academy of Science is a supporter of the Programme, but is concerned that the contribution of the CRC Programme may be constrained if CRC selection criteria "… prejudice the development of CRCs in key areas in which current Australian industry participation is weak":

> CRCs have a role in developing emergent industries. The Australian Photonics CRC is an excellent example of a CRC that has promoted an emergent Australian industry and, in the process, generated several SMEs." An over reliance on the existence of industry partners would limit the effectiveness of this Programme and hence its ability to stimulate new emerging industries in Australia. A whole-of-government approach would provide a means of ensuring that Programme-specific investment selection criteria align with a forward strategy for Australian economic development, and consequently avoid such problems.

3.4.6 Federation of Australian Scientific and Technology Societies

The Federation of Australian Scientific and Technology Societies (FASTS) advised in a submission to the Evaluation that:

> FASTS overwhelmingly believes that the CRC scheme has been a most useful additional mechanism to promote cooperative research in Australia and has conferred many cultural benefits both in the conduct of research and in the capture of innovation since its introduction in 1991. It is now widely accepted by the public and private research sectors and is seen by Australian industry as a way of ensuring that pre-competitive research is conducted, interesting developments are tracked, and innovations likely to benefit Australian industry are captured and applied.

FASTS considers that CRCs have greatly assisted in encouraging R&D networking within Australian industry and have provided both academics and research students with a much better understanding of motivating factors for industry in the pursuit of R&D and in implementing innovation.

FASTS also considers that there are some features that merit further refinement, with the view of ensuring that the Programme achieves its full potential as an important element in research and innovation activity in Australia.

3.4.7 Australian Geoscience Council

The Australian Geoscience Council pointed out in a submission that one of the issues that needs further refinement in the Programme is the extent to which researchers in CRCs form new research partnerships that transcend organisational barriers. There is a strong view that the Programme has effected substantial cultural change in this regard:

> One of CRCs' most important impacts has been to effect a real culture change in the different science and technology sectors within Australia. Barriers between industry, academia and government research agencies have been broken down and scientists have been encouraged to get out of his/her laboratory and actively cooperate with other colleagues in different agencies.
>
> In the future, the most worthwhile outputs from the SET sector are most likely to come from multidisciplinary teams, and the CRCs are excellent vehicles to foster this interaction. [41]

This view is widely shared within both the university sector and in industry.

3.4.8 State Governments

State governments are heavily involved in CRCs as both research funders and research users. Their involvement is strongest in the agriculture, natural resource management and water CRCs.

State development agencies have taken an interest in CRC investment as part of their State based science and innovation strategies. However, the role of State governments in the CRC process is extremely varied. Some State governments, such as Queensland, Victoria and Western Australia have a highly structured process for supporting CRC bids involving State institutions and provide funding for the preparation of the bid. Others have mechanisms for providing financial support in specific areas of interest.

Most State governments support and assist consortia from their State in the preparation of CRC proposals. States advise that they are interested in fostering partners with an interest in the application of research, not the research itself, and involving partners who are actively involved in the project and with the capabilities to take up the technology.

3.5 Conclusion

This summary of the views of the various stakeholders in the CRC Programme reveals a range of different, though largely positive, perspectives. These perspectives largely reflect the different experience of the effectiveness of particular CRCs. The different types of universities and publicly funded research agencies have used the CRC Programme in different ways appropriate to their capabilities, strategies and objectives.

Similarly the experience is quite different in the different sectors of application. In the traditional sectors of agriculture, mining and energy, where there is a long experience of jointly funded research performed by publicly funded research agencies, the CRC

[41] Submission, Australian Geoscience Council

Programme has provided an important resource to supplement these collaborations and provide a focus on adoption.

In the areas of the environment and natural resource management, the CRC Programme has played a powerful role in building collaborative research teams on a sufficient scale to make a considerable impact. In contrast, there has been only a limited involvement of major manufacturing firms in the CRC Programme, and for various reasons, some of them quite unconnected with the Programme, that involvement appears to be declining. This is most notable in the case of the global downturn of the ICT industry.

It is also worth mentioning that, while the great majority of submissions and contributions were positive, they provide little relatively hard evidence of outcomes and achievements.

The comments in this Section of the Report are reflected in conclusions and recommendations later in the document.

4: Identifying and Defining CRC Outcomes

The purpose of this Section is to outline a framework for the collection of information relating to CRC outcomes. A number of issues are canvassed concerning measurement, followed by a discussion of definitions and concepts. It is argued that *adoption* by CRC participants should be seen as the main outcome indicator of the CRC Programme.

4.1 Issues

The CRC Programme is highly regulated and the reporting process is well established. The Programme requires the tracking of inputs consumed by CRCs such as grant income, research staff numbers and the amount of time spent on various projects etc.

Output tracking, however, is generally limited to such things as the number of papers, PhDs and patents generated, being the tangible results of the research effort. There is no existing procedure for tracking other outputs such as benefits to industry partners, or more widely, the economic, environmental or social outcomes of the CRCs. Although the contracts for 2002 round CRCs do ask for performance indicators to be provided, in practice these often require further development.

The *Management Data Questionnaire* collects some information relating to market based transactions – such as commercialisation agreements - but it does not report the impact or results of those transactions in terms of the contribution to the business or performance of the acquirer. Some CRC *Annual Reports* provide good information relating to the results and impact of research from an end user perspective, but the information is relatively inaccessible and inconsistent as to quality across all CRCs.

It is therefore difficult to assess the success of the Programme against its objectives when the Programme does not comprehensively measure the very thing it is trying to achieve.

The results of the Programme are closely related to the objectives of the participants when they enter into the joint venture arrangement. It follows that the success of the CRC, and the Programme as a whole, must be addressed from the perspective of the participants – and particularly the end users of the research and education services provided by a CRC.

The task of measuring the impact of publicly funded research, without taking into account the way in which users choose to adopt and apply the research, is notoriously difficult and complex - and there are no easy solutions. For this reason, the focus of the Evaluation has been on obtaining and assessing user views in relation to CRC research, education, commercialisation and collaboration outcomes. In this regard, the main area of interest relates to *adoption, application and use*.

4.2 Definitions and concepts

The expected outcomes from the collaborative research, research training and education activities of the CRC Programme can be identified at three levels:

- *National economic, social and environmental benefits* – often referred to as the "public good" benefit, and which are general in their application and difficult, if not impossible, to measure in an objective sense; they relate to the capacity for wealth creation, the quality of life (for example, in terms of social well being and health status), and the conservation, repair and replenishment of natural capital.[42]
- *Collective industry benefit* – represented as broad industry benefit, intended to improve the performance, profitability and competitiveness of an industry through improved practices and processes; this is particularly relevant to commodity oriented and other industries that compete on a global basis (mining, agriculture, tourism, and some segments of manufacturing).
- *Private business benefit* – reflected in business investment in new processes and products that embody the results of research outputs, either by existing businesses (industry partners) or the creation of new businesses (start-ups); this outcome is generally referred to as "commercialisation" and is particularly relevant to biotechnology, medical, information and communication technologies.

The categories are not, of course, mutually exclusive. For example, many of the successful outcomes of CRCs in the mining, agriculture and tourism sectors involve the development of applications software for broad industry adoption. Biotechnology has major applications in the agriculture sector. However, each category has differing implications in relation to the generation, protection, licensing and sale of intellectual property rights. In all cases, however, the critical issue as far as the CRC Programme is concerned is the level of adoption, application and use of research results in a general, industry or specific business sense.

The nature and extent of capacity-building is also important (critical mass, enhanced workforce skills etc). However, in the long-run this capacity-building is only useful if the enhanced capacities are actually *exploited*.

In submissions, discussions and consultations during the Evaluation there were a wide variety of views expressed concerning the importance and significance of each outcome. There is a very strong view that the CRC Programme is (or should be) strongly focussed on commercialisation outcomes with the implication that business take-up of research outcomes will result in the generation of national economic benefits through wealth creation represented by increases in employment, profits, sales and exports. There is also another view that the CRC Programme should continue to include a focus on the generation of "public good" outcomes.

Whatever the category of outcome, adoption carries with it the necessity for clarity in the *path to adoption*. The path to adoption necessarily involves an instrument for implementation. These include:

- An existing or new business/businesses (private or public enterprise) - commercialisation.
- An existing or new *public programme* – a public policy initiative or programme.

[42] Natural capital refers to the stock of productive soil, fresh water, vegetation, clean air, ocean and other resources that underpin the survival, health and prosperity of human communities.

- A strategy for changing attitudes and behaviours by businesses, governments and citizens – a targeted communication strategy.
- Ensuring that researchers have the skills, capabilities and experience to apply new knowledge as an essential component of management practice in a business organisation or government agency.

To achieve these outcomes it is necessary for research to be not only of a world class standard, it also has to be *relevant* to a commercial and/or public policy context. The R&D should enable businesses to address commercial opportunities or enable governments to resolve public policy issues. This is a technology transfer problem – research outcomes have to be presented in ways that are useful to the target end-users.

4.3 Adoption: the critical factor in CRC success

The focus of the CRC Programme is on adoption. This involves the application and utilisation of research by "industry" either in new processes or new products – or new ways of doing business. Industry can be defined narrowly to include only private enterprise businesses, or can be taken to include public enterprise (for example, water authorities and electricity utilities). In the contemporary context of the CRC Programme, "industry" also includes government agencies with responsibility for the planning, organisation and delivery of public programmes that impact on an industry sector, or where that sector impacts on social, community and environmental outcomes.

Professor Trevor Cole, Executive Director of The Warren Centre for Advanced Engineering, observed in a note to the Evaluation Team that:

> A reasonable expectation to place on CRCs is clear identification of the need and/or opportunity being addressed by the CRC and a capacity to articulate both the opportunity and the practical pathway to its realisation.
>
> That is, if CRCs are to contribute to commercialisation or utilisation, then the technology being produced must be relevant to commercial outcomes and there must be a pathway through the much more expensive and risky process of implementation and application.

A Report prepared by the Victorian Department of Industry, Innovation and Regional Development concluded that:

> The CRC Programme is failing to achieve its objectives in cases where CRCs develop technologies that are not pursued beyond the laboratory. CRCs should focus effort on pursuing projects that are actively supported by a partner or an external client, who maintains ongoing involvement in the project. The research plan for these projects should outline how the transfer of technology or the commercialisation of the technology is to take place. The commercialisation plan should be embedded in the research planning process at the outset, rather than developed as an afterthought to the technology development efforts.[43]

Discussions and consultations during the Evaluation pointed to the difficult distinction between "commercial" and "public good" CRCs. The basis of the distinction appears to be that "commercial" CRCs produce products and services for a market, while

[43] Submission, Department of Industry Innovation and Regional Development, Victoria. A requirement for Commercialisation Plans was covered in the 2002 Selection Round

"public good" CRCs produce knowledge that is universally available for application and use. Such a distinction overlooks the possibility that "commercial" CRCs may fail to produce commercially sustainable products while "public good" CRCs may have a major impact on wealth generation through broad adoption of new practices and processes within industry.

As indicated elsewhere in this Report, the role of so-called "public good" CRCs in the Programme was a matter of considerable concern. There was, in particular a concern that if the Programme had a greater "industry" focus and looked for the immediate and obvious economic returns, mechanisms would be needed to address aspects of the National Research Priorities in relation to environment, health, and a secure Australia that may not find a ready industry partner. The University of Tasmania observed:

> Tasks like the repair of major river systems, and overcoming salinity and acidity are of crucial importance and clearly in the national interest. Harnessing the research capability of the nation via the CRC process to address these matters seems to me to be sensible.

There is also a tendency to regard CRCs currently classified as "environment" as being essentially "public benefit". However, and as indicated in Section 3.3.8 public enterprises in the water industry are major participants in CRCs and have a high regard for the quality, applicability and utility of the research.

Public good CRCs can, and do, deliver substantial and direct national economic and industry benefits. Many of the CRCs are clearly focussed on adoption through their own communication programmes or through take up in public policy and programmes. However, without a *commitment* to the adoption, application and use of research results proposals should not be supported by the CRC Programme – they should be funded from other sources.

4.4 Defining pathways to adoption, application and use

It is important to bear in mind in relation to both public good, and commercially oriented CRCs, that research outputs do not automatically flow into application and use. Publication of research papers and reports, filing patents and building prototypes will not necessarily result in adoption. Whatever the intentions and aspirations of scientists and researchers, adoption will not occur unless there is an end user need or want that is available to be satisfied. This applies to all categories of CRC. Interestingly, of course, adoption may occur in situations and circumstances that are least expected or quite unplanned.

One dilemma for Expert Panels is that it is often easier to assess adoption and path to use for a commercially oriented CRC proposal than for a public benefit proposal. That is, commercial criteria relating to production and marketability are easier to grasp and assess than the economic, social or environmental impact of a discovery or invention. Financial projections of benefits may be impressive - but are totally unrealisable unless there is a vehicle for implementation. In a commercial context,

this may be a new or existing company; in a public good context, this might be a new public programme – but these outcomes are much harder to establish up front.[44]

There is generally a need for an intermediary to interpret research results into a form that can be understood and used by businesses in a commercial setting or by programme managers in a public policy setting. The "gap" between the community of science and the commercial and policy settings are well known and the arguments well rehearsed. It is not a matter of simply exhorting scientists and researchers to be more entrepreneurial or commercial, or for business people and policy makers to be more attuned to using research.

The "transfer" of research outputs to application in a commercial or public policy setting occurs along a number of "pathways". Navigation of these pathways invariably involves the intermediation of a range of brokers, advisers and communicators. These agents may rely on market signals or opportunities or they may "manage" the relationship between the providers and the users of research. As a Cooperative Research Centre is a special form of managed relationship it follows that an important aspect of its success relies on the effectiveness of its management leadership.

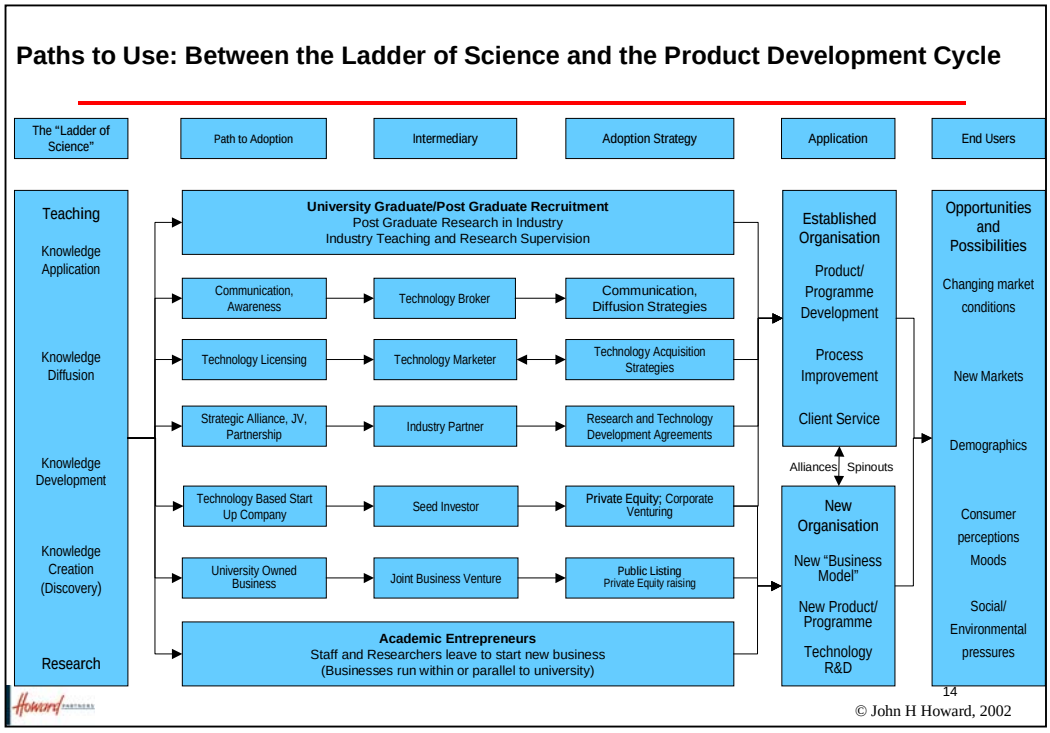
In some instances a CRC may have to substitute market relationships for managed relationships. This is likely to occur where the CRC does not include a research user who is interested in, or capable of adopting, research outcomes. In such cases, research outcomes are marketed through a technology license or spin-out company. These *business development* CRCs tend to occur in those industries where businesses acquire their technologies through acquisition of technology-based start-up companies. Venture capital investors perform a critical role in this area: their task is to create new businesses and to help them to grow.

The greater the level of technical risk in the scientific discovery or technological invention, the higher the market risk in terms of attractiveness to potential end users, and the greater the need for intermediation to manage the risks involved. Venture capital investors perform this role in business. Increasingly, large businesses are acquiring and accessing research and development outcomes through acquisition of technology via taking stakes in or buying start-up companies rather than investing directly in industrial research projects. The trend is particularly apparent in information and communications technologies, and in pharmaceuticals.

4.5 Pathways to adoption: a framework

It is possible to identify a number of pathways from invention and discovery in the research environment to application and utilisation in a customer/client service environment. A framework for considering paths to application and use is illustrated below. The paths identified are not mutually exclusive. They are, however, relevant to the CRC environment.

[44] In discussions about the involvement of social sciences and the humanities in CRCs the contribution of policy analysts in designing and advocating public programmes should not be overlooked.



Whilst the pathways tend to have a commercial orientation, they are also relevant to the translation of applications into adoption in a public policy or public programme environment. The pathways relevant to the CRC environment are addressed below.

4.5.1 Research training and education

The most common form of application of research outputs is the training and subsequent employment of university graduates in industry. The CRC Programme has a major role in research training with the objective of preparing people for the application of research in a business or public policy environment. This pathway is particularly apparent in commercial and public organisations that have large research facilities and there is a career path in industrial research. In technology intensive companies, experienced researchers also move from research to product development, marketing and general management roles.

The main issue from a CRC perspective is that researchers-in-training may be precluded, or constrained in publishing or disseminating the results of their research in an academic environment.

The Group of Eight Universities submitted that:

> . . . in the main, the research training outcomes have been excellent. Research students are given the opportunity to work on focused projects, to engage with business and industry and to receive scholarships and other financial rewards. Students do encounter some difficulties when their publishing and public presentation activities are

> restricted because of commercial-in-confidence considerations and this concern needs to be resolved.[45]

IP created by the student in a university setting generally belongs to the student. The situation can be different in a CRC setting where participants may claim ownership of IP created.

4.5.2 Communication: changing attitudes and behaviours

Communication is sometimes referred to as "technology diffusion". In a research environment the essential task is to encourage people and organisations to adopt the research in a way that improves business performance or achieves desired economic, social and environmental outcomes.

The CRC Programme generates a vast amount of information contained in Annual Reports, Brochures, Booklets, Success Stories and Press Releases. While "communication campaigns" targeted at end users to create awareness as a basis for change have an important place for CRCs, it is not enough to simply publish or report research results in the expectation that users will locate and use them. *Publication is not the same as communication.*

The problem in the adoption of research outcomes may not be a problem of information availability, but a problem of getting *the attention* of the people and organisations who are in a position to make decisions that affect economic, social and environmental outcomes.

4.5.3 Application: take up in industry practice and public programmes

The processes and procedures through which research from CRCs translates into industrial processes and public programmes and policies are variable. Generally, it requires close collaboration between research provider and research user. CRCs that operate as "industrial research consortia", undertaking research on a pre-competitive collective basis tend to adopt a project-based focus on research with adoption and application strongly in mind. Projects may form part of a longer-term research agenda.

Several CRCs have appointed technology marketers to translate the results of research into a form that is understood by decision makers in both business and government. Much of this work involves one-on-one communication – explaining the way in which research results can be adopted and applied *from the perspective of the user*. This involves developing an understanding of the target end user's operating environment and how the research results may contribute to achieving overall business or policy goals. The water industry CRCs have made a strong commitment in this area.

In the case of agriculture CRCs, research outcomes are applied by State Agriculture Departments in programmes directed towards improving productivity, returns and competitiveness. However, in natural resource management, the processes are often more complex. Translating research findings into public programmes and actions may require a very high degree of advocacy. Increasingly, however, actions and

[45] Submission, Group of Eight

agendas in natural resource management require a sound science base. The basis for action in restoration and repair of wetlands provides a contemporary example.

The *Outcomes Survey*, undertaken as part of the Evaluation, specifically asked questions relating to impact in terms of adoption and use of research results in new or changed public programmes. The results of the Survey are reported in Sections 5-9 of the Report

4.5.4 Commercialisation: new processes, new products and new businesses

In the area of emerging technologies, particularly in information and communications technologies and biotechnology, the path to adoption is often through "commercialisation". Commercialisation involves the creation of new and improved products or processes and/or new business models. It involves one or more of the following strategies:

- Technology Licensing to existing or new businesses.
- Entering into strategic alliances, joint ventures, partnerships.
- Creating new technology based start up companies.

The skills required to implement and deliver commercialisation outcomes from public science and technology are complex and scarce. Moreover, there are many who claim to have skills in this area but delivery fails to match up to promise and expectations. Commercialisation is not only about securing intellectual property rights and creating governance structures for a start-up enterprise: it is about creating viable and sustainable businesses. This issue is raised again in Part II.

4.6 Evidence of adoption of CRC outcomes

The Evaluation Team endeavoured to identify and report CRC outcomes in a systematic way. This was approached by reviewing CRC Reports, Periodic Reviews and other documentation in order to identify the actual outcomes of the investments in these organisations in terms of relevance for industrial application and *actual utilisation*.

Regrettably, the most common practice still is to report *potential* benefits rather than demonstrate actual benefits. The Evaluation Team had a concern that there may be a gap between what many CRCs report they have achieved, or could achieve, and what they have actually achieved in terms of take up by end users.

Publicity about *potential* use and application is of interest and makes good news stories, but for the purposes of evaluation evidence is required about implementation and take up. It is difficult in the existing CRC promotional material to differentiate between what has been adopted and what has the potential to be adopted. There is far too much emphasis on "good news" as opposed to "good content".

The CRCs referred to in Figure 3 have clearly demonstrated that research outputs have been applied and have made, and will continue to make, major impacts. It is also important to know what were the factors underlying and driving the successful

outcomes.[46] Moreover, since implementation generally involves a commitment to continual and ongoing innovation for sustained success, it is important to know how this is being done. This information should be more readily available.

Figure 3: Sample of CRC Achievements

CRC	Achievements
AJ Parker CRC for Hydrometallurgy:	Developing a thiosulfate process for gold extraction - Thiosulfate is seen as an environmentally friendly alternative to cyanide. As part of its work towards producing a viable thiosulfate process for gold extraction, the AJ Parker CRC for Hydrometallurgy has developed a recovery method which uses resins to recover gold from solution after the gold is leached with thiosulfate. The gold attaches to the resin surface. A simple method for selectively retrieving gold from the resins has also been developed.
Australian Cotton CRC:	A combination of ecological and economic research by the CRC with grower groups has documented the economic value of Integrated Pest Management (IPM) approaches to pest management. The CRC has also identified two new, potentially more attractive blends of plant volatile chemicals as potential attractants for Helicoverpa, the main insect pest of cotton. A provisional patent application covering formulation of the most attractive blends has been lodged with the Australian Patent Office.
Australian Telecommunica-tions CRC:	An ATCRC patent is pending for increasing mobile phone tower capacity. The invention has the potential to alter the landscape of Australian cities. It could result in a 41% increase in mobile phone tower (basestation) capacity in a power limited environment, thus allowing more users per basestation.
CRC for Aboriginal & Tropical Health:	The CRC is assessing the effect of pneumococcal vaccine Prevenar® on rates of pneumococcal diseases in Northern Territory children. Central Australian children suffer the highest reported incidence of invasive pneumococcal disease in the world. Pneumococcal disease is caused by Streptococcus pneumoniae bacteria and infections with this bacterium can cause serious meningitis, pneumonia, septicemia and middle ear infections.
CRC for Advanced Composite Structures	The CRC has developed a new process, "pullforming", for making parts for aeroplanes - a simple, low-cost, automated procedure for pulling and forming composite materials into shape through a die. In one application alone, it has reduced labour by 30% with a potential saving of $500,000 over 5 years and also made the customer providing the product for Boeing much more competitive through easily meeting a target for a reduction in costs of 20%. The CRC with its participant, Boeing-Hawker de Havilland, devised a new approach to the lamination of a selected number of aeroplane parts which were particularly expensive to produce. The time-saving achieved by the new process allows as many as five to ten parts to be made by the same amount of labour as would be required for just one part, using lamination by hand. Potential savings on one current assembly are around $100,000 per year.
CRC for Cast Metals Manufactur-ing (CAST).	CAST has developed and patented new technology for an environmentally friendly melt protection system to prevent molten magnesium from burning in air. The promising new melt protection system uses the hydrofluorocarbon gas HFC-134a, replacing the potent greenhouse gas sulphur hexafluoride (SF6), which is the currently used industry standard. The new technology has the potential to eliminate green house gas emissions by the world's magnesium industry equivalent to over 5 million tonnes of carbon dioxide per annum.
CRC for Cattle & Beef Quality	Researchers working in the CRC have recently discovered the world's first gene marker for beef tenderness. This complements the world's first and only other gene marker test for a production trait, the TG5 marbling gene. A provisional patent has been lodged, and Genetic Solutions Pty Ltd (Commercial Partner of the CRC for Cattle and Beef Quality) expects to market the gene marker test to Australian beef breeders within 6 months.
CRC for Cochlear Implant & Hearing Aid Innovation:	Collaborative research with one of the CRC's core participants, Cochlear Limited, has led to the development of the Australian and US award-winning Contour electrode array as well as to the new ESPrit ear-level speech processor. These devices greatly improve the benefits to adults and children with hearing loss. The NAL-NL1 fitting software, developed by the CRC and Australian Hearing, has been licensed by most hearing aid and audiology test equipment companies for their products. NAL-NL1 allows non-linear hearing aids to be adjusted for maximum performance and increased speech intelligibly. The major international advance ensures optimum fitting to improve speech recognition for hearing-impaired people.
CRC for Eye Research & Technology:	The CRC, in collaboration with CIBA Vision, has developed a breakthrough soft contact lens that can be worn continuously night and day for up to 30 days, and which sets a new industry standard for oxygen permeability. The Focus Night & Day® lens has now been launched internationally. The lens is expected to earn a multi-million dollar income, with predictions that the new generation of extended wear lenses will capture at least half of the current contact lens market. It is also expected that the convenience of this

[46] This material is summarised from CRC Association reports and profiles.

CRC	Achievements
	lens will entice spectacle wearers to contact lenses, triggering further growth in the market. CRC researchers have found that tears may indicate if people have certain types of cancer. In a world-first discovery, researchers at CRCERT and the Proteome Analysis Facility at Macquarie University, have found tears of patients with certain forms of cancer contain a marker protein.
CRC for Interna-tional Food Manufacturing & Packaging Science:	The CRC developed fourteen industry-ready technologies, four of which have already been adopted by industry. Four spin-off companies have been established and two global licenses are pending in breathable films and the grape packaging system. The CRC also holds 7 patents/applications in Australia and 40 overseas. The return on total investment in this CRC is expected within 10 years from innovations already delivered to its industry partners.
CRC for Mining Technology & Equipment (CMTE):	Three software programmes developed by the CRC for Mining Technology and Equipment (CMTE) are enabling mines to make use of powerful geosensing techniques. By providing a cheap and easy way to process and interpret data, SeisWin, LogTrans and ImageWin are removing impediments to the use of tools that provide much greater geological certainty.
CRC for Molecular Plant Breeding:	The CRC has developed germplasm that captures new molecular techniques in a product that can be used directly by breeders. An example in the cereals area is the development of highly transformable lines of wheat named 'MPB Bobwhite'. These lines grown under appropriate conditions can give transformation efficiencies of up to 60%.
CRC for Sensor, Signal & Information Processing (CSSIP):	Over-the-horizon-radar: Sponsored by Telstra Applied Technologies, and in collaboration with DSTO, CSSIP has developed the receive and processing subsystems of a HF surface wave radar. This has been built and deployed in two locations in Northern Australia for experimental evaluation. The system performed exceptionally well in these trials and was able to detect targets out to several hundred kilometres. Further work to produce an operational system based on this work is being initiated.
CRC for Tissue Growth & Repair:	A new South Australian biotechnology company has been established which builds on the successes of the CRC for Tissue Growth and Repair to achieve self-sufficiency. TGR BioSciences Pty Ltd is a unique strategic research and development enterprise with a proven track record in identifying discoveries, capturing intellectual property and creating commercial value in bioscience. The focus of TGR Biosciences is on novel bioactives for treatment of gut, topical wound, bone and tendon disorders. The applications of this research include the pharmaceutical, nutriceutical and dairy industries. There is a major emphasis on topical applications for gut disorders and wounds, as well as growth factors targeted for local action in bone and tendon repair. The company is establishing a platform discovery programme based on high-throughput screening assays and proteomics to identify novel bioactive factors, with particular input from the expertise of one of its shareholders, the Australian Proteome Analysis Facility at Macquarie University.
CRC for Waste Management & Pollution Control Limited	Scientists have used advanced microscopy techniques to study the surface characteristics of the pathogen, Cryptosporidium, the organism that triggered the 1998 Sydney water incident. The knowledge they have gained will assist researchers understand why Cryptosporidium can pass through sand filters and help improve water treatment. The CRC has announced an agreement to sell its subsidiary, Waste Technologies of Australia to Zeolite Limited in a three-stage $20 million deal.
CRC for Water Quality & Treatment:	Developed computer models that describe the build up of biofilms, coliform growth and chlorine decay within the water distribution system. These models will help water suppliers design chlorination disinfection systems that remain effective throughout the distribution system, while keeping chlorine dose rates as low as possible.
Quality Wheat CRC Ltd:	A protocol showing how to blend grists and flours for specific quality was developed (in a contract from the Grains Research and Development Corporation) so that outcomes could be predicted with greater certainty.

The achievements identified above are substantial and convey a very positive result of the CRC Programme. However, the information is incomplete and the material that is publicly available does not always indicate *how* success was secured and the extent of commitment and the nature of the skills applied from implementation.

It would be useful to have more consistent information about how the outputs of CRCs have been subsequently *used and applied* by industry, government and the community. This point applies to situations in which a CRC has closed down and/or the knowledge has been exploited by a third party. Comprehensively tracing these wider subsequent impacts is a potential role for the CRC Association.

Recommendation

I - 2. CRCs, through the CRC Association, prepare a series of detailed case studies, across all CRCs, describing paths to adoption, application and use of research. The case studies should identify the factors that lay behind and drove the successful outcome and how this was done.

These concerns were the basis of designing the performance information framework and undertaking a survey of CRC Managers and business participants in CRCs in order to identify the level of adoption, application and use of CRC outputs. This framework is discussed below.

4.7 Performance indicators and performance information framework

From a policy and management perspective there are a number of desirable characteristics of a performance monitoring and reporting system. They include.

- Being specifically geared to the setting and monitoring of policy and programme objectives and performance targets.
- Being able to provide information on both resource usage (inputs) and on outputs and outcomes, measured against historical trends (and future targets), by programme and programme element, region, research field, etc.
  - Reporting against trend and actual performance against planned (expected) performance, in sufficient detail to give an overall picture of the performance of the Programme.
  - Flagging the need for management and/or policy intervention in particular areas where trends move outside specific "tolerance" limits.
- Being able to produce timely reports, in readily comprehensible formats – and should be sufficiently flexible to allow non-specialists to interrogate the system.
- Being able to answer "what if" questions about broad demand for Programme services, or about the implications for outputs/outcomes based on alternative futures.
- Being focussed on regular presentation of a small number of key indicators, which portray the Programme's overall performance against short term budget and/or standards oriented targets and against long term strategic plans.
- Being cost effective: it should not be developed beyond the stage where the costs of further data collection, maintenance and reporting, exceed the benefits resulting from the additional effort.

These characteristics are often lost sight of when attention turns to what is technically possible and feasible as distinct from what is desirable from a policy, management and operational perspective.

The previous Department responsible for the CRC Programme, the Department of Industry, Tourism and Resources, invested considerable resources in the present Management Data System – a performance information system. That system can provide a substantial amount of performance information relating to programme resource usage (inputs) and programme outputs. This information can be presented in terms of both trend and actual performance. It does not, however, easily provide outcome information. It is our understanding that the Department of Education, Science and Training intends to revise the Management Data System.

Outcome information typically comes from outside the Programme administration framework and requires separate collection procedures and analysis. Some information relating to outcomes is included in the 2nd and 5th Year Review Reports and in the Annual Reports. This information is structured around assessments of the extent to

which Centres are achieving results in relation to the Centre selection criteria. The information is not, however, presented in a way that facilitates compilation and analysis.

A number of government programme evaluations currently underway are attempting to define net economic benefit outcomes (R&D Tax Concession, R&D Start, Biotechnology Innovation Fund). The CRC Programme should also provide indications on return to government funds where this can be realistically calculated. However, this information can only be prepared by the individual CRCs that have the knowledge of the research and how it might be adopted. Assigning this responsibility is difficult if CRCs have been wound up.

The task of defining net economic benefit necessarily involves tracking the adoption of research through to application and use. This can be done in those situations where research is adopted by an existing or new business and products and services are sold in a market environment. It can also be done in situations in which public sector departments or agencies adopt or use CRC-developed knowledge. But the interpretation and meaning of future net economic benefit for long-term research is at best speculative where reliance has to be placed on "potential" application and use and there is no clear responsibility for implementation and take-up.

Nonetheless, CRCs should be encouraged to undertake such economic analyses where useful and meaningful results can be derived.

Estimates of "potential application, if research is adopted" have been found in many studies to be vague and unreliable. Researchers are fond of claiming "immense" economic benefits as a result of their discoveries. However, the path to application and use, resulting in realisable economic returns involves numerous business decisions that are virtually impossible to predict, let alone estimate. Without a clearly articulated investment strategy it is difficult to discern whether outcomes have occurred as a result of the intervention or as a result of other events.

Thus, mapping out the potential paths, key decision points, complementary investments, expected take-up, together with the costs and risks involved should be central to a CRC application – in the form of an "investment" proposal. When costs and risks are estimated with rigour and reality, the realisable "net present value" of the investment tends to be lower, but more plausible. Research *attractiveness* should not be confused with investment *feasibility*. The requirement for CRC applications to be submitted as "investment" proposals is a key recommendation of this Evaluation.

Data are presented later in the Report in relation to financial returns relating to progress in achieving commercial outcomes from CRC activity. Examples of commercial outcomes include technology transfer consultancy services,[47] licence revenue, the creation of start-up companies and the sale of commercial offshoots. But this only represents a partial picture, and "counting start-ups" represents only a partial representation of the path to adoption, application and use.

[47] For example services in the improvement to firms manufacturing process are cited in the Annual Report of the CRC for Cast Metal Manufacturing.

Nonetheless, the start-up route to research adoption is an important aspect of contemporary industrial innovation, particularly in technology intensive industries. Start-up companies, as "New Technology Based Firms" (NTBFs) are important in the technology acquisition strategies of larger corporations – either as direct acquisition or through strategic alliance arrangement – particularly in the setting of a "knowledge cluster".

4.8 Approach adopted in the evaluation

The challenge for the Evaluation was to identify the set of *performance indicators* that meets the needs of policy advisers and programme managers that portray the Programme's overall performance in relation to its objectives.

A framework for performance monitoring and reporting for the CRC Programme was prepared during the Evaluation and is included in the project Working Papers. The framework has been developed on the basis of the information that already exists in the current MDQ System and other readily available data sources and information. Outcome information can only realistically be obtained directly from the research users and research providers.

For the purposes of the Evaluation, comprehensive outcome information relating to the impact of the Programme in the areas of research, education, adoption/commercialisation and collaboration was obtained through a structured survey of CRC research user participants, CRC managers and businesses that have not participated in CRCs. The methodology for this *Outcomes Survey* is described in Attachment 2. The performance information is reported in Sections 5-8 that follow.

While the *Outcomes Survey* task was undertaken as a "one off" project in this Evaluation, it should be undertaken as a regular study to inform policy advisers and decision makers about the impact of the Programme and where adjustment might be required.

Recommendation

I - 3. The performance information framework, and the related Outcomes Survey, developed during the Evaluation be adapted to reflect the proposed revised Programme objectives and used on a continuing basis for the identification of, and reporting on, CRC outputs and outcomes.

5: Research Outputs and Outcomes

This Section of the Report addresses what we have termed the CRC "Research" objective – that is:

> To enhance the contribution of long term scientific and technological research and innovation to Australia's sustainable economic and social development

The objective, as stated, clearly relates to the *utilisation* of research by pointing to the contribution to sustainable economic and social development.

The Terms of Reference that relate to this objective required consideration of the extent to which the CRC Programme was:

- Contributing to Australia's economic growth, social well-being and environmental outcomes.
- Developing Australia's public and private research capacity in the areas of national need or global opportunity.
- Producing research of an excellent standard that would not have been undertaken otherwise.

The performance indicators that were identified in the *Performance Monitoring Framework* for the Evaluation are as follows.

Path to Adoption	Output Indicators		Outcome Indicators	
	Indicator	**Source**	**Indicator**	**Source**
Creation of knowledge that can be applied in: new and existing businesses; the formulation of public policy; programme implementation/delivery. Furthers objectives of equity, social justice and environmental sustainability.	Research publications in refereed /peer reviewed international journals or monographs. Patent registrations	CRC Annual Reports MDQ Data Base	Extent to which research outcomes have impacted on industry and/or public programme delivery through: . Accelerated or improved existing research projects . Stimulated new research projects . Contributed to the development of IP . The introduction of new and/or improved products, production processes, supply chain practice and public programmes . Improved business and/or industry profitability and public programme performance	Survey of businesses/ industry/ government organisations involved in CRCs
Creation of knowledge that is aligned with national research priorities and areas where Australia has competitive advantage	Projects that are consistent with and contribute to knowledge in priority areas	CRC Annual Reports	Research user satisfaction with: . Technical quality of the research . Innovative quality of the research	Survey of businesses/ industry/ government organisations involved in CRCs
Achieving "critical mass" and "seamless" (cross-institutional) approaches to research management.	Jointly authored publications	CRC Annual Reports	Extent to which CRC has created opportunities for researchers to: . Obtain greater access to facilities and equipment . Build trust and confidence . Obtain promotion, recognition	Survey of CRC CEOs and researchers

Findings in relation to the outputs and outcomes in these areas follow. In a number of output categories, the information was either not available or inadequately reported in many CRC *Annual Reports* with the result that it is not possible to provide information that can be relied upon to indicate performance of the CRC Programme in aggregate.

5.1 Resources allocated

Data collected by the Department of Education, Science and Training indicate that, overall, CRCs have allocated $1,224.5m or 73 percent of their resources to research in the period 1998-99 – 2001-02. Seventeen CRCs allocate over 80 percent of resources to research activity and six CRCs allocate over 85 percent.

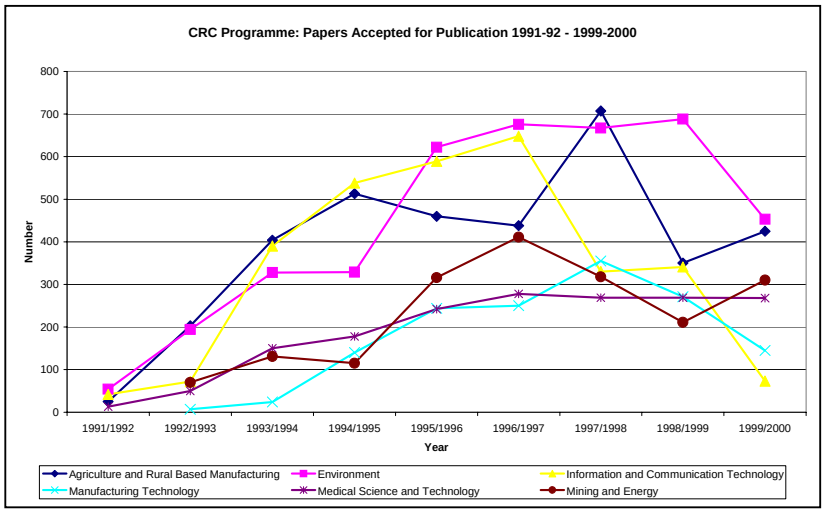
While research provides the basis on which CRCs are established, there is also an objective to transfer research results into application. A commitment of 80 percent means that there are only 20 percent of resources available for technology transfer and communication.

5.2 Creation of new applicable knowledge

In terms of the discussion in previous Sections of the Report, the contribution of research to social well-being and environmental outcomes will be through the production of *applicable* knowledge.

5.2.1 Output data

The Management Data Questionnaire collects information in relation to a number of research activities and outputs. Over the life of the Programme, the MDQ reports that a total of 15,839 papers prepared by CRC researchers have been accepted for publication. The overall trend in papers accepted for publication from CRC researchers over the years 1991-92 to 1999-2000 is illustrated below.



The data indicate an overall fall off in publication activity since 1997-98. The data also indicate a much higher level of publication activity in the environment and agriculture CRCs. While this may reflect a stronger academic research orientation, it also reflects the strong science orientation in addressing problems and canvassing solutions in relation to the preservation, repair and restoration of natural capital resources and in agricultural and farming practices.

More detailed CRC production information, collected over the last two years, is contained in Table 13.

Table 13: CRC Programme Outputs – Research – 2000-01 - 2001-02 (Total)

	Total
Number of book chapters published	602
Total number of books published	222
Number of full written conference papers published in refereed proceedings	3,082
Total number of papers/journal articles published	3,511
Total number of research projects carried out by Centres during the reporting period	3,638

The information in Table 13 points to a significant volume of activity and output. These indicators would be useful in assessing the performance of individual researchers, and the relative performance of individual CRCs, but as a CRC *Programme* indicator they merely state that a large amount of material has been produced. The time frame to assess or comment on trends in the above categories of publication is too short.

A complication in interpreting the data in Table 13 is that it is not known whether some of the output identified above (books, papers, etc) has been produced while a researcher has been working in a CRC or produced as part of other academic/industrial research activities.

A more specific indicator of generation of applicable knowledge is reflected in patents generated. Information relating to patenting activity over the years 1996-97 to 2001-02 is provided in Table 14. The data are reported as submitted by CRCs to the Department of Education, Science and Training. It is emphasised that patents are an indicator of research output – not adoption or research commercialisation.

Table 14: Number of patents and applications maintained in Australia

	1996/1997	1997/1998	1998/1999	1999/2000	2000/2001	2001/2002
Mining and Energy	14	15	10	18	10	11
Manufacturing Technology	47	71	32	30	32	32
Information and Communication Technology	18	53	41	8	58	104
Agriculture and Rural Based Manufacturing	31	26	15	24	19	14
Environment	9	4	9	18	16	18
Medical Science and Technology	53	72	88	59	68	82
Number of patents and patent applications maintained in Australia	172	102	112	100	102	114

Table 14 indicates that the CRCs with the highest level of patenting activity are in the ICT sector (predominantly the Photonics CRC) and in the Medical Science and Technology category. The CRC for Waste Management and Pollution Control has also a significant number of patents in the Environment sector.

International patenting is an indication of relevance and significance of a CRC. Information on patents and patent applications made overseas is listed in Table 15.

Table 15: Number of patents and patent applications made overseas

	2000/2001	2001/2002
Mining and Energy	18	61
Manufacturing Technology	70	24
Information and Communication Technology	46	209
Agriculture and Rural Based Manufacturing	16	19
Environment	76	87
Medical Science and Technology	108	149
	334	549

The data in Table 15 indicates a preference for CRCs to undertake patenting overseas. It also points to the extensive patent portfolio of the Photonics CRC, the CMTE, the CRC for Waste Management and Pollution Control and the medical/life sciences CRCs.

5.2.2 Outcome data

The *Outcomes Survey* sought to identify the success of the CRC Programme in terms of the extent to which research had impacted business development and growth.

From the research user perspective, the highest impact has been in relation to "accelerating or improving existing research projects". The impact was lowest in relation to contributing to the development of intellectual property and improving business or industry profitability. The results are presented in Table 16.

Table 16: Performance indicators: Research user views of research impact

As a CRC Participant, to what extent so you think the research of CRCs has impacted on	Very High %	High %	Moderate %	Low %	Very Low %	Not Sure %	Total %
Accelerating or improving existing research projects	12	36	24	12	8	8	100
Stimulating new research projects	8	40	28	16	8	0	100
Contributing to the development of IP	4	20	32	28	8	8	100
Introduction of new/improved products, processes	4	40	16	20	16	4	100
Improving business/industry profitability	12	16	24	28	8	12	100

Given the focus of the CRC Programme on long-term research, business perceptions of impact on research is a good outcome. Research users also indicated that the impact had been high in terms of introducing new products and processes, but of much less impact in contributing to profitability. This follows from earlier discussion about the motivation of users to participate in CRCs.

CRC Managers were asked a similar question, but they were asked to think about both the actual and potential impact. In this regard, their perceptions are highly optimistic, reflecting the interest in research outcome *potential* as discussed earlier. Eighty percent of CRC Managers believed that there is a high to very high prospect of research leading to the introduction of new and/or improved products. This is reflected in Table 17.

Table 17: Performance indicators: CRC Manager views of research impact

To what extent do you think the research of your CRCs has had or will have impact:	Very High %	High %	Moderate %	Low %	Very Low %	Not Sure/ NA %	Total %
Accelerating or improving existing research projects	32	42	16	4	-	6	100
Stimulating new research projects in industry	32	46	12	6	-	4	100
Contributing to the development of IP	26	36	26	6	-	6	100
Introduction of new/improved products, processes	28	52	10	2	-	8	100
Improving business/industry profitability	16	38	26	10	-	10	100
Improving public programme/policy performance	26	14	26	10	2	22	100

The higher rating of CRC Managers would also reflect the longer-term perspectives and time horizons in relation to research activity and outcomes.

5.3 Creation of knowledge that is aligned with national research priorities and areas where Australia has competitive advantage

Under current arrangements, there is no specific requirement for CRCs to commit to projects that reflect the recently announced National Research Priorities. However, an analysis undertaken in the Department of Education, Science and Training indicates that all CRCs fall within the National Research Priority categories. It is planned to require CRC application and selection to have regard to Priorities in the next round.

From a global perspective, Australia has a competitive advantage in what are commonly regarded as the commodity industries of agriculture, mining and energy. These

industries are well represented in the current CRC portfolio. In these industries businesses are seeking to differentiate by developing a "product" focus and to build and retain market share by reducing costs, increasing productivity through application of technology and aggressively targeting customer needs through quality and service. The Beef CRC has been particularly successful in this area with its "tender gene".

In a number of other industries, particularly manufacturing, Australia has the opportunity to become globally competitive in small, specialised, niche markets.[48] For example, Australia performs well in the areas of manufacture of mining equipment, and medical devices – including hearing technologies and contact lens research and application. All of these areas are associated with CRCs.

There is also a relationship between CRCs and industry Action Agendas in terms of CRCs being involved in implementation of specific initiatives. The Department of Education, Science and Training seeks information from other government agencies in relation to Action Agendas as part of the selection process.

The recently released Report *Enabling Our Future: A Framework for the Information and Communications Technology Industry* recommended that NICTA, CSIRO and DSTO should coordinate the establishment of major publicly funded research groups, including IT related CRCs and appropriate larger groups to:

- Develop an implementation plan setting out actions to respond to recommendations in the report.
- Work together to more fully integrate and embed private sector R&D facilities into the Australian ICT R&D community.[49]

As a way of assessing CRC research in terms of its relevance to industry and business needs, CRC research user participants in CRCs were asked in the *Outcomes Survey* about their level of satisfaction with CRC research in relation to research scope, focus and quality. These may be taken as indicators of research relevance. The responses are contained in Table 18.

Table 18: Performance Indicators: Research user satisfaction with research scope, quality and relevance

As a CRC Participant, how satisfied are you with the following in relation to your CRC	Very satisfied %	Satisfied %	Neither Satisfied or Dissatisfied %	Dissatisfied %	Not sure %	Total %
The scope of projects covered	16	56	4	24	0	100
The focus of projects covered	24	40	12	28	0	100
The technical quality of the research	28	52	16	4	0	100
Innovation quality of the research	24	52	12	8	4	100
Relevance of the research to your needs	16	40	20	20	4	100
Relevance to Australia's long term needs	16	52	28	4	0	100

In general, research users are satisfied, or highly satisfied in relation to indicators of research relevance. There are, however, indications that some research users are not satisfied with the relevance of the research, particularly in relation to scope and focus.

[48] See Howard Partners and ACIIC, *Securing Our Manufacturing Future: Small Business Manufacturing to 2015 and Beyond* (Sydney: Small Business Development Corporation, 2001)

[49] Australia. Framework for the Future Steering Committee, *Enabling Our Future: A Framework for the Information and Communications Technology Industry*

There is, at the same time, a very high level of satisfaction with research quality and the relevance to Australia's *long-term* needs.

5.4 Achieving "critical mass" and "seamless" (cross-institutional) approaches to research management

Comments in discussions and consultations during the Evaluation, and in submissions, indicated that both research providers and research users were satisfied with the way in which the CRC Programme had built critical mass. Critical mass is indicated by enhanced access to research facilities and equipment, increased trust among researchers, opportunities for career advancement and capacity to undertake long-term research.

Achievements in this area are substantially impacted by the way in which a CRC is managed, and in particular the working of the Board and the skills, knowledge and experience of the CEO.

Information from the *Outcomes Survey* relating to research user satisfaction with the "critical mass" indicators is contained in Table 19. The strongest indicators are in the areas of access to facilities and equipment within the CRC framework. Significantly, over 70 percent of research users are satisfied or highly satisfied with the CRC in building trust.

Table 19: Performance indicators: Research User satisfaction with the extent to which the CRC has created opportunities for "critical mass"

How satisfied are you with the extent to which the CRC has created opportunities for researchers to:	Very satisfied %	Satisfied %	Neither Satisfied or Dissatisfied %	Dissatisfied %	Not sure %	Total %
Obtaining access to f&e within the CRC	24	48	20	4	4	100
Obtaining access to f&e outside the CRC	8	40	24	4	24	100
Build trust and confidence within the research community	12	60	16	4	8	100
Build trust and confidence within your industry	12	40	28	16	4	100
Obtain career advancement/recognition	16	28	40	4	12	100
Undertake and commit to undertaking long term research	48	28	12	12	0	100

The high proportion of "unsure" in relation to access to facilities and equipment outside the CRC might suggest that CRCs do not often go outside their collaborative arrangement, and the importance of CSIRO facilities for the Programme.

The levels of satisfaction with the "critical mass" indicators are even higher from the perspective of CRC Managers. This is reflected in Table 20.

Table 20: Performance indicators: CRC Manager satisfaction with the extent to which the CRC has created opportunities for "critical mass"

How satisfied are you with the extent to which your CRC has created opportunities for researchers to:	Very satisfied %	Satisfied %	Neither Satisfied or Dissatisfied %	Dissatisfied %	Not sure %	Total %
Obtain access to f&e of the CRC participants	36	52	6	4	2	100
Obtaining access to f&e outside of the CRC participants	8	34	46	2	10	100
Build trust and confidence within the research community	36	42	14	4	4	100
Build trust and confidence with industry	38	44	12	4	2	100
Obtain career advancement/recognition	26	40	20	4	10	100
Undertake and commit to undertaking long term research	42	40	10	6	2	100

The CRC Managers are also very happy with the levels of trust and confidence that has been established within the research community and within industry, as well as prospects for career advancement and to undertake longer-term research.

These findings in relation to critical mass must be regarded as a highly positive impact of the Programme.

5.5 Conclusion

The following broad *generalisations* may be drawn from the outputs and the *Outcomes Survey* data that provides quantitative and qualitative perspectives of the views of participants in CRCs.

5.5.1 Research output

The volume of research output from CRCs is considerable, as reflected in the numbers of publications and patents. Publication is particularly strong in the environment and agriculture sector. Publication in these sectors is an important way of communicating research results to users in government and non-government organisations involved in restoration of natural capital and improved agricultural practices.

Patenting has been particularly strong in the pharmaceutical and medical related CRCs. However, in CRCs related to mining and energy, patenting is less important than adoption by industry users.

5.5.2 Research outcomes

With some exceptions, most CRC participants regard the research being undertaken as being at least satisfactory to their interests in terms of business impact, and more satisfactory in regards to its quality, and the technical capability of the people doing the work. Most participants see research as relevant to their business.

Compared with the CRC research users, the views of the CRC Managers are significantly more positive - rating far higher the impact of CRC research, and in stimulating new research projects in industry, new products and IP, improving industry profitability and building community capacity. This group viewed the impact of the CRCs' research as considerably greater than CRC research users when asked the same questions. This reflects the broader perspective of CRC Managers and their focus on broader and environmental economic benefits and potential benefits rather than direct business benefit.

CRC Managers are slightly more satisfied that their CRCs have created a climate of trust and confidence with users that will lead to long-term commitment to undertake research. The divergence of views is not as extreme as differences in perceived impact of R&D. Managers are also marginally more confident in believing that CRC outcomes have resulted in both business and government developing new products, processes and supply chain practices.

6: Education Outputs and Outcomes

The "Education" objective for the CRC Programme is:

> To enhance the value to Australia of graduate researchers.

The Terms of Reference require consideration of the following:

- Increasing the proportion of public researchers who are commercially oriented.

The performance indicators that were identified in the *Performance Monitoring Framework* for the Evaluation are as follows.

Path to Adoption	Output Indicators	Source	Outcome Indicators	Source
Graduates with relevant and applicable industry knowledge	PhD and Masters Degree Graduates	MDQ Data CRC Annual Reports	Industry/business/user satisfaction with: . Qualities and capabilities of CRC graduates Industry willingness/ preparedness to: . Recruit CRC graduates in preference to other graduates	Survey of businesses/ industry/ government organisations involved in CRCs

Information collected in relation to these indicators is provided in this Section.

6.1 Resources allocated

According to Department of Education, Science and Training data, CRCs have allocated 6.5 percent of their resources to education in the period 1998-99 to 2001-02. Only nine CRCs allocated more than ten percent of their resources to education. These CRCs are spread across all industry and technology categories.

Expenditure on Education does not include the full cost of education and research training, as many students are on scholarships and awards. The data will include additional payments to students over and above an award remuneration.

Universities indicated during the Evaluation that establishing specifically designed education programmes, such as course-work masters and short courses, within CRCs involved high costs and often attracted little interest from end user organisations. The market for short course education programmes is also highly contested.

6.2 Graduates with relevant and applicable industry knowledge

6.2.1 Output information

Between 1991-92 and 2001-02, the MDQ data indicates that 2,621 students have commenced work on a PhD in a CRC and that 1,426 PhDs have been awarded. In addition, there have been 1,423 Masters Research students commencing and 1,022 completions. The number of students enrolled in formal postgraduate coursework qualifications totals 527 for the period. There have been a total of 327 coursework Masters degrees awarded.

The number of undergraduates taking part in education courses has been recorded as 62,519.

The numbers of full time equivalent (FTE) students in CRCs over the life of the Programme is provided in Table 21. The table indicates a fall off in enrolments in 1998-99, picking up again in 2000-01.

Table 21: PhD, Masters and Undergraduate Students - 1991-92 - 2001-02

	1991-92 No.	1992-93 No.	1993-94 No.	1994-95 No.	1995-96 No.	1996-97 No.	1997-98 No.	1998-99 No.	1999-00 No.	2000-01 No.	2001-02 No.
Full time equivalent PhD students	94	425	783	1,006	1,158	1,277	1,248	1,111	1,003	1,253	1,391
Full time equivalent masters research students	53	172	292	318	340	350	377	254	383	179	208
Full time equivalent numbers of postgraduate coursework students										296	451
Undergraduates taking part in Education courses	*708*	*3,576*	*3,028*	*4,203*	*6,561*	*5,546*	*n.a.*	*5,976*	*4,774*	*7,733*	*9,124*

For the purposes of comparison, information relating to the total number of PhD and Masters students in Australian universities at June 2002 is provided in Table 22.

Table 22: PhD and Masters Students in Australian universities June 2002

Field of Education	Doctorate by Research	Doctorate by Coursework	Master's by Research	Master's by Coursework
Natural and Physical Sciences	6,553	7	1,081	1,690
Information Technology	1,000	30	301	12,707
Engineering and Related Technologies	3,374	0	1,228	4,706
Architecture and Building	425	0	267	1,351
Agriculture, Environmental and Related Studies	1,517	1	461	1,352
Health	4,663	55	1,216	7,573
	17,532	93	4,554	29,379
Other	16,508	1,401	5,615	82,663
Total (a)	34,040	1,494	10,169	112,042

Overall, CRC PhDs amount to about eight percent of all PhDs enrolled in science, technology and innovation-related fields of education. However, the involvement of CRCs in PhD education varies significantly across these fields. To gain a perspective of the relative concentration of PhD students, information concerning CRC PhD enrolments according to industry and technology category is provided in Table 23.

Table 23: CRC PhD enrolments according to industry and technology

	1998/1999	1999/2000	2000/2001	2001/2002
Agriculture and Rural Based Manufacturing	207	216	261	256
Environment	377	350	405	424
Information and Communication Technology	164	99	188	242
Manufacturing Technology	88	60	119	146
Medical Science and Technology	94	113	136	157
Mining and Energy	181	165	144	166
	1,111	992	1,232	1,356

The data in Table 23 suggest that CRCs account for about 25 percent of the ICT candidates, 45 percent of agriculture and environment candidates and approximately 10 percent of candidates in the engineering and minerals areas.

From the data available, it would appear that the CRC Programme has made a major contribution to the education of researchers in the areas of agriculture and the environment, and to a lesser extent in the ICT area.

A further indicator of the contribution of the CRC Programme to educating graduates with relevant and applicable industry knowledge relates to employment following graduation. Information on CRC graduates obtaining jobs in industry following completion over the last four years is provided in Table 24.

Table 24: Number of students from CRCs taking up employment with industry/end users

	1998/1999	1999/2000	2000/2001	2001/2002	Total
Agriculture and Rural Based Manufacturing	33	62	38	35	168
Environment	67	73	67	82	289
Information and Communication Technology	26	11	46	24	107
Manufacturing Technology	23	18	36	22	99
Medical Science and Technology	24	39	49	41	153
Mining and Energy	48	59	44	34	185
	394	465	523	455	1,655

Many graduates take up employment with a CRC participant organisation. Consistent with the data on enrolments, the highest levels of employment for CRC PhDs related to the environment - and particularly the Antarctic CRC.

6.2.2 Outcome information

The *Outcomes Survey* indicated that 72 percent of research users were either satisfied or very satisfied with the qualities and capabilities of CRC graduates. Thirty six percent indicated a high to very high willingness to recruit CRC graduates in preference to other graduates. [50]

CRC Managers rated their perception of the satisfaction of employers with the capabilities of CRC graduates at 82 percent (25 percent satisfied and 58 percent very satisfied). They also rated highly (30 percent) or very highly (44 percent) the preference of employers to recruit CRC graduates in preference to other graduates. This apparent discrepancy may be associated with the high proportion of PhDs in agriculture and environment and their career path to public research organisations.

6.3 Supervisors with relevant industry knowledge

The number of non university staff supervising post graduates provides an additional indicator of the role of CRCs in the creation of industry relevant knowledge. This is provided in Table 25

Table 25: Number of non-university staff supervising research postgraduates in CRCs

	1996/1997	1997/1998	1998/1999	1999/2000	2000/2001	2001/2002
Agriculture and Rural Based Manufacturing	200	218	136	158	138	159
Environment	164	216	189	149	146	141
Information and Communication Technology	31	27	20	8	60	37
Manufacturing Technology	48	68	50	30	23	43
Medical Science and Technology	59	54	50	63	74	52
Mining and Energy	71	100	89	97	60	60
	573	683	534	505	501	492

The data indicate a decline in the level of commitment over the years since 1998-99. This would reflect the changing mix of CRCs as older ones wind up and newer ones come on stream.

From the *Outcomes Survey*, the data indicate that 40 percent of research users rated the contribution of postgraduate supervisors from industry as being high or very high. The equivalent rating from CRC Managers was 56 percent.

[50] This may reflects a sampling bias as government agencies as users were not extensively sampled. This may have to be addressed – particularly in the light of the inconsistency with CRC Manager views.

6.4 Conclusion

It is clear from the output data that CRCs are having a major influence in education relating to the agriculture and the natural resource management sectors. By contrast, the influence is low in manufacturing.

Based on the *Outcome Survey* evidence, industry participants have a positive to very positive view as to the CRC graduates and students, showing significant preference for employing CRC graduates over others and have positive views about the influence of industry supervisors in their education.

CRC Managers believe employers are overwhelmingly very satisfied or satisfied with their graduates and were significantly preferred over graduates from other courses. The extent of their belief was even greater than the positive views held by industry partners. They also rated the influence of industry supervisors positively.

Consultations and submissions suggested that there is an unrealised opportunity for CRCs to add considerable extra value through education programmes that go beyond the current offerings of the partners. The Deputy Vice Chancellor, Research, at Curtin University commented:

> I would judge most present education programmes as very competent, usually embracing sizeable PhD programmes, scholarships, visiting fellows, workshops, conferences, annual reviews and coursework programmes (some of which even involve links between institutions).
>
> The research-based PhD programme was introduced in Australia in the late 1940's to address the weakness in its science and technology base exposed during the Second World War. Today, most higher degree work in the science/engineering/technology sector is still carried out by research, despite repeated calls for graduates with a better mix of skills in areas such as communication, ability to learn, capacity for cooperative teamwork and capacity to make decisions and solve problems.

Some Australian universities have implemented additional coursework studies to extend the learning opportunities for PhD students and their supervisors in areas such as commercialisation, entrepreneurship, leadership, and project management.

7: Commercialisation/Technology Transfer Outputs and Outcomes

The "Commercialisation/Technology Transfer" objective of the CRC Programme is:

> To enhance the transfer of research outputs into commercial or other outcomes of economic, environmental or social benefit.

The Terms of Reference in this area refer to:

- Adding to the nation's intellectual property and its commercialisation or utilisation.
- Upgrading the innovative capacities of Australian business enterprises.
- Improving the basis for public policy formulation and Programme delivery.

The performance indicators that were identified in the *Performance Monitoring Framework* for the Evaluation are as follows.

Path to Adoption	Output Indicator	Source	Outcome Indicator	Source
Adoption of new/improved procedures, practices and processes in industry and/or government	Widespread adoption across industries. Incorporation of research results in public programmes in health services, agriculture and natural resource management	CRC Annual reports CRCA Reports.	Extent to which CRC research outcomes have impacted on and/or been reflected in: Business and/or government commitment to development of new and/or improved products; production processes supply chain practice, and public programme performance. Impact in relation to increases in sales, exports, profits, employment and improved Programme performance.	Survey of businesses/industry/government organisations involved in CRCs.
Sale or Licensing of technologies to existing businesses	Patent licensing and or sale.	MDQ Data CRC Annual Reports.	Extent to which patents have been used and applied in the production of new/improved products. Impact in relation to increases in sales, exports, profits, employment.	Survey of businesses/industry/government organisations involved in CRCs
Creation of new businesses in the form of spin-out companies	Start up companies created.	MDQ Data Research.	Extent to which spin-out companies develop into valuable companies that produce products and services for end users. Impact in relation to increases in sales, exports, profits, employment.	Consultant research; economic impact data.
Strategic alliances/partnerships directed towards implementing new processes and/or bringing products to market	Alliances and partnerships formed. Commercialisation agreements entered into.	MDQ Data CRC Annual Reports.	Extent to which commercialisation agreements result in increases in sales, exports, profits, employment.	Consultant research; economic impact data.
Provision of contract research services for businesses	Contracts entered into.	MDQ Data CRC Annual Reports.	Industry/business satisfaction with performance of CRC research in fulfilling contract specifications. Impact in relation to increases in sales, exports, profits, employment.	Survey of businesses/industry/government organisations involved in CRCs.

Information relating to these indicators is provided in this Section of the Report.[51] This is preceded by a brief discussion concerning resource allocation.

7.1 Resources allocated

Commercialisation and technology transfer is a major objective of the CRC Programme. However, from an overall perspective, and according to Department of Education, Science and Training data, only 8.2 percent of resources are allocated to this category. But within the category there are some major individual CRC commitments. For example, five CRCs allocate more than 20 percent of their resources to this category and a further five allocate more than 10 percent.[52]

Expenditure on commercialisation is a good indicator of commercialisation commitment for CRCs where the path to market is new products or business models. Other parties may allocate additional resources where commercialisation is being undertaken by a start-up company (such as technology investor). However, CRCs need to apply resources to get the research to a stage where it is "investment ready". It would be expected that there would be an increased resource commitment to commercialisation at the later stage of the CRC life cycle.

There are also many CRCs where research is adopted through the processes of research itself and it is difficult to disentangle what activity is research related and what is application related. This aspect of industrial research provides an important base for the CRC Programme. It is reflected in those CRCs that have a close collaborative arrangement between researchers and industry partners.

Nonetheless, CRCs with a focus on business development need to commit substantial resources to this specialised field of activity.

7.2 Adoption of new/improved procedures, practices and processes in industry and/or government

7.2.1 Output data

An analysis was undertaken of recent CRC Reports and Reviews, to identify discoveries and inventions that have resulted in an identified application or use and the extent of adoption and estimated economic benefits.

The results of that analysis are set out in Table 26. Information about economic impact, adoption and take-up is included where available.

Table 26: Reported CRC discoveries and inventions and evidence of adoption and utilisation

	Reported Discoveries and Inventions and Evidence of Adoption (Innovation) and Benefits
Agriculture	
CRC for Aquaculture	Biodegradable coating used to protect $10M worth of pearl oyster shells and $5M of salmon
CRC for Australian Sheep Industry	Electronic sheep management to increase flock productivity
CRC for Cattle and Beef Quality	Genetic tenderness test for beef cattle

[51] The Evaluation sought information relating to economic impact (employment, exports, profits particularly) through a special survey of CRC initiated start-up companies. The results and the low response rate indicated that it was too early to reach any conclusions in regard to economic impact of CRCs at this stage.

[52] The data relating to expenditure on commercialisation and technology transfer can tend to overstate variations between individual CRCs due to the state at which they are in their development.

	Reported Discoveries and Inventions and Evidence of Adoption (Innovation) and Benefits
CRC for Molecular Plant Breeding	Halved time of development of new cereal cultivars with increased drought resistance
CRC for Quality Wheat Products and Processes	Adoption of PrimeHard wheat; estimated increased income to growers of $9M from adoption
CRC for Sustainable Aquaculture of Finfish	DNA probes to measure environmental health of fish farms
CRC for Sustainable Production Forestry	Potential payoff of $194M from $2.8M research leading to improvement to the genetic potential of eucalypts for hardwood plantations
CRC for Sustainable Sugar Production	Linkage of sugar runoff and fishkill; Significant gain in sugar content from adoption of new supply management
CRC for Viticulture	Contribution of more than $14M to wine industry through a software package on crop management
Environment	
CRC for Catchment Hydrology	Reductions of up to 50% in costs of proposed works through application of urban stormwater decision-support system
CRC for Coastal Zone, Estuary and Waterway Management	Impact and management of sewage overflows in Brisbane
CRC for Freshwater Ecology	New techniques to assess river health
CRC for Sustainable Cotton Production	CottonLOGIC software for Palm Pilot to optimise pest management First specific weed guide for cotton Irrigation management decision support system to improve crop water management
CRC for Sustainable Tourism	Expected earnings of $3M expected by 2004-5 from system to measure environmental impact of various forms of tourism
CRC for the Great Barrier Reef World Heritage Area	Feasibility of sterilising ballast water
CRC for Tropical Plant Protection	Diagnostics for two banana diseases with potential to save millions of dollars
CRC for Waste Management and Pollution Control Ltd	Sale of subsidiary Waste Technologies of Australia in a 3-stage $20M deal
CRC for Weed Management Systems	Estimates of potential savings of $45M over the next 30 years through biocontrol of bitou bush
Information and Communication Technologies	
Australian Photonics CRC	Direct Rite system allows signals to travel 120 kms without requiring amplification, which will substantially reduce the costs of upgrading telecom networks
CRC for Sensor Signal and Information Processing	Slope Stability radar to detect movement in open cut coalmine walls
Manufacturing	
CRC for Advanced Composite Structures	Time-saving by Boeing-H-de-H in lamination of parts estimated at $100k per part per year. Pullforming reduced labour by30% (in one application) with a potential saving of $0.5M over 5 years
CRC for International Food Manufacture & Packaging Science	Enzyme-based paper production from recycled materials estimated by Visy to increase its earnings by 0.5-1.0M per year
CRC for Welded Structures	Faster construction procedures for natural gas transmission pipelines estimated saving of $10M
Medical	
CRC for Aboriginal and Tropical Health	Targeting kidney disease
CRC for Asthma	Human genome project gives flying start in identifying genes linked to asthma
CRC for Bioproducts	Demonstration of potential of plant cell culture to make pharmaceuticals on a large scale
CRC for Cellular Growth Factors	Identification of EGF receptor, regarded as ideal binding site for a new class of anti-cancer drug
CRC for Chronic Inflammatory Diseases	Identification of a range of promising molecules associated with chronic inflammatory diseases
CRC for Discovery of Genes for Common Human Diseases	Close to identifying key genes behind endometriosis
CRC for Eye Research and Technology	Developing implantable contact lens
CRC for Tissue Growth and Repair	GroPep (commercial arm) listed in 2000 with market capitalisation of $60M
CRC for Vaccine Technology	Progress towards a vaccine for CMV – a cause of crippling birth defects
Mining and Energy	
AJ Parker CRC for Hydrometallurgy	Realised benefit by companies of $34 M (benefit/cost ratio of 10:1)
Australian CRC for Renewable Energy	Solar power to 200 remote indigenous communities; Stand-alone P/V system, Wilpena Pound, SA; High penetration wind turbine, Denham, WA; Wind turbine hardware, Exmouth, WA; P/V trough systems in Solahart installation, Rockingham, WA; AIEW grid installation of a zinc bromide battery, White Cliffs, NSW
Australian Petroleum CRC	Independent economic analysis identified NPV in excess of $300M from $8 M CRC investment
CRC for Clean Power from Lignite	Potential for 15% reduced greenhouse emission, 50% increased efficiency, from burning brown coal
CRC for Mining Technology and Equipment	Tight radius drilling allowing access to gas in currently unmineable coal beds

This material indicates a substantial level of achievement, but it has been difficult to identify and draw out from the array of material that is currently produced. As suggested in Section 4.6 information needs to be prepared and disseminated in a more effective way to target audiences in government, industry and the community.

As indicated earlier, the issue is not about publicity and promotion: it is about communication. Communication is best approached from the perspective of the receiver – not the sender. Production of a glossy brochure or magazine, with "good news" stories does not of itself amount to communication. Such material may merely create "noise" and divert attention from the processes for attracting the attention of potential investors and users.

Recommendation

I - 4. A communication strategy be developed for the CRC programme that is directed towards the provision of consistent, standardised and relevant information to industry, government and the community about CRC results and achievements. The strategy focus on the way in which research has been adopted and applied, and include information on demonstrated economic, social and environment benefits. The strategy be resourced from within the CRC Programme and co-ordinated by the CRC Association.

7.2.2 *Outcome information*

In the *Outcomes Survey* all research users were asked a number of questions in relation to the extent to which their organisations had taken up research results in the development of new products, processes, supply chain practices or methods of service delivery. Information in relation to adoption in a commercial context is provided in Table 27.

Table 27: Performance Indicator: Adoption in Commercial Application

To what extent do you think CRC research outcomes has resulted in your business / company commitment to:	Very High %	High %	Moder-ate %	Low %	Very Low %	Not Sure/ missing %	Total
Develop new and/or improved products	8	24	-	24	16	28	100
Develop new and/or improved production processes	4	16	20	12	16	32	100
Develop new and/or improved supply chain practices	-	8	16	12	20	44	100
Develop new and/or improved methods of service delivery	-	8	12	20	16	44	100

The responses indicate that only 32 percent of research users rated the contribution of CRC research to new or improved products as high or very high. Forty percent rated the contribution as either low or very low. A similar pattern emerges in relation to adoption in production, supply chain practices and service delivery.

A very substantial proportion of respondents indicated that they were "not sure" or did not answer the question. This might suggest that the research results are too early to be refected in a business context and a motivation for CRC participation beyond direct commercial return. This explanation would relate to why 50 percent of research users indicated that they would remain in the CRC Programme. CRC user participants who are focussed primarily on national benefit outcomes would also provide responses in this category.

In relation to the adoption of research from CRCs targeted at non-commercial application, the *Outcomes Survey* indicated that most research users were not sure whether the results had been adopted in one or more programmes. This is indicated in Table 28.[53]

Table 28: Performance Indicator: Adoption in Public Programmes

To what extent do you think CRC research outcomes has resulted in Government's commitment to development of new or improved	Very High %	High %	Moderate %	Low %	Very Low %	Not Sure %	Total
Legislation and/or new regulations	-	12	8	16	12	52	100
Industry support programmes	4	16	8	12	4	56	100
Methods of service delivery	-	8	16	24	4	48	100
Supply chain practices	-	12	16	12	8	52	100

The high level of responses in the "not sure" category also suggests that it might be too early to ascertain impact as well as a perception on the part of commercial CRC user participants that the question was not applicable to their interests or involvement.

From a CRC Manager perspective, the perception of levels of commitment to adoption is much higher. This is reflected in Table 29. That is, 42 percent of CRC Managers rate as high or very high the level of adoption of research in new products and 52 percent in new production processes. The difference in perception between research users and CRC Managers might reflect differences in time horizon and CRC Manager perception of user commitment based on potential.

Table 29: Performance Indicator: Perceptions of commercial adoption by CRC Managers

To what extent do you think your CRC research outcomes has resulted in business and / or Govnt. commitment to:	Very High %	High %	Moderate %	Low %	Very Low %	Not Sure/ missing %	Total
Develop new and/or improved products	18	24	26	10	-	22	100
Develop new and/or improved production processes	24	28	16	6	-	26	100
Develop new and/or improved supply chain practices	6	12	16	14	2	50	100
Develop new and/or improved industry support programmes	8	16	26	10	6	34	100

In relation to adoption through government initiatives and action, the overall level of adoptions is perceived to be moderate. In the area of adoption in broad industry practices, the perceived level of adoption rates at 58 percent in the high to very high categories. This is indicated in Table 30.

Table 30: Performance Indicator: Perceptions of public sector adoption by CRC Managers

To what extent do you think your CRCs research outcomes have resulted in more effective:	Very High %	High %	Moderate %	Low %	Very Low %	N/A /missing %	Total
Legislation or Regulations	8	6	24	10	2	50	100
Government programmes	6	24	26	6	6	32	100
Methods of service delivery	4	26	18	8	2	42	100
Community behaviours	2	20	12	8	2	56	100
Industry practices	16	42	24	4	-	14	100

There is a very high level of uncertainty in the answer to the question in relation to the extent of adoption in regulatory processes and community behaviours.

[53] Not sure whether this table relates to all users or to users with a "public benefit" orientation

7.3 Sale or licensing of technologies to existing businesses

Output indicators relating to technology licensing and/or transfer are provided in Table 31.

Table 31: CRC Programme Outputs - Technology Transfer/Commercialisation 2000-01 - 2001-02 (Total)

	Total
Number of technology commercialisation agreements	474
Number of licenses or options on intellectual property contracted	233
Number of agreements on outright sale of technology to industry and other end users	8
Other commercial agreements	60
IP maintained in Australia (patents)	709
IP maintained Overseas (patents)	59

Up until 2001-02 collection of information relating to technology agreements has been aggregated. More recent collections break this down into income from licenses and options on intellectual property contracted, income from spin-out companies, and income from other commercial agreements. Discussion of spin-out companies is contained in Section 7.4.

Between 1991-92 and 2000-2001 CRCs generated $32m in income from technology agreements. The distribution across industry is identified in Table 32.

Table 32: Income (000s) from Technology Agreements exceeding $100,000 (1991-1992 – 2000-2001)

	Total
Mining and Energy	16,103
Manufacturing Technology	1,500
Information and Communication Technology	1,583
Agriculture and Rural Based Manufacturing	106
Environment	3,440
Medical Science and Technology	8,037
Total all CRCs	32,805

Within the totals of Table 32, there has been substantial income generated by the CMTE, the CRC for Waste Management and Pollution Control and the CRC for Tissue Growth and Repair.

Between 2000 and 2002, 23 CRCs reported income from licenses and options on intellectual property. The total income for the two years combined was $10.2m. Forty two percent of this income was sourced to the Photonics CRC. CRC income from other commercial agreements amounted to $1.2m over the same period. Seven CRCs received income from this source.

7.4 Creation of new businesses in the form of "start-up" companies[54]

Research undertaken for the CRC Association by John Yenken of Karingal Consultants reports a total of $30.4m in sales in 2001-2002 for CRC spin-out companies. Projections, supplied by the CRCs are for sales to reach $944m. The estimated time frame for the sales revenue to be realised is not available. Atmosphere Networks, a

[54] The terms "start-up" and "spin-out" are used interchangeably in this Report.

company created from the CRC for Telecommunications to produce copper loop broadband networking is reported as having been sold for $88.5m.[55]

The income from spin-out companies flowing back to the CRCs as reported to the Department of Education, Science and Training totalled $6.5m over the two year period 2000-01 to 2001-2002. The relatively small scale of this income provides a context when looking at the complexity and cost of preparing Centre Agreements for some CRCs where potential for possible IP revenue streams are envisaged.

These results suggests that if the CRC Programme is to achieve more in the area of research commercialisation, existing CRCs will need to allocate more resources to this area of activity, and the Programme will need to support more CRCs with a specific focus on business development and the commercialisation of research. As indicated earlier, recommendations are made in Part II for the Programme to focus specifically on supporting CRC applications that are based on "investment" proposals.

7.5 Strategic alliances/partnerships directed towards implementing new processes and/or bringing products to market (commercialisation agreements)

The *Outcome Survey* sought information about CRC performance in fulfilling specifications in relation to commercialisation agreements and business partnership agreements. The perceptions of research users, answering from a business perspective, is provided in Table 33.

Table 33: Performance indicator: User perspective on CRC performance in commercialisation agreements and partnerships

How would you rate your satisfaction with the performance of your CRC's research in fulfilling the specifications in its:	Very High %	High %	Moderate %	Low %	Very Low %	N/A /missing %	Total
Commercialisation agreements	16	-	20	16	8	40	100
Business partnership contracts	12	4	20	12	8	44	100

According to Table 33, 16 percent of research users rate the performance of CRCs as very high in relation to commercialisation agreements and 12 percent in relation to business partnership agreements. The very high proportion of responses classified as not applicable would be a reflection of the relatively low number of CRCs that are engaged in this activity. The perspective of CRC Managers on this issue is reported in Table 34.

Table 34: Performance indicator: CRC Manager perspective on CRC performance in commercialisation agreements and partnerships

How would you rate industry/business satisfaction with the performance of your CRCs research in fulfilling the specifications in its:	Very High %	High %	Moderate %	Low %	Very Low %	N/A /missing %	Total
Commercialisation agreements	14	26	14	-	-	46	100
Business partnership contracts	16	38	14	2	-	30	100

Consistent with other responses, CRC Managers rate their performance as much higher that the research users. However, the non-response rate would also reflect the low level of involvement across the CRC system in this form of commercial relationship.

[55] Cooperative Research Centres Association, *CRCs and Spin-Off Companies: Findings from a Survey by the Cooperative Research Centres Association Inc* (Canberra: CRC Association, 2002).

7.6 Provision of contract research services for businesses

Research contracts and consultancy provide a major source of income for many CRCs. Over the time frame of the Programme, a total of $366m has been generated from this source. The most significant contributions have been in the Mining and Energy sector – the AJ Parker Centre, the Petroleum CRC and the CRC for Mining Technology and Equipment (CMTE). The Centre for Eye Research also generates a substantial amount of income from research contracts.

The level of income from contract research for CRCs within the major industry/technology categories is listed in Table 35.

Table 35: Income (000s) from research contracts and consultancies from industry-end users 1991-92 – 2001-2002

	Total
Mining and Energy	125,910
Manufacturing Technology	24,203
Information and Communication Technologies	34,690
Agriculture and Rural based manufacturing	63,298
Environment	66.446
Medical Science and Technology	51,758
	366,305

Information concerning income from contract research on an annual basis is set out in Table 36. The total level of income for 2000-2001 is in line with the Mercer Stocker projection of $35.6m in income from this source. However, the Mercer Stocker prediction was based on 42 CRCs. The level of income increased substantially in 2001-02.

Table 36: Income (000s) from contract research (1998-99 – 2001-2002)

	1998-1999	1999-2000	2000-2001	2001-2002
Mining and Energy	16,564	15,876	11,660	19,774
Manufacturing Technology	1,826	2,385	2,219	3,087
Information and Communication Technology	2,780	2,386	3,673	3,952
Agriculture and Rural Based Manufacturing	8,307	12,290	3,769	5,941
Environment	9,818	6,734	7,673	6,723
Medical Science and Technology	5,901	6,193	6,511	9,142
Total all CRCs	46,672	45,403	36,408	50,262

Contract research undertaken in CRCs raises some difficult issues relating to CRC management. A former General Manager of Rio Tinto observed in a memo to the Evaluation that the situation for companies working with CRCs, and sponsoring research projects, is somewhat confusing because of the cooperative structure. That is:

- The underlying project contracts are usually written with one of the CRC joint venturers, rather than with the CRC itself.
- Depending on the nature of the project, most or even all staff involved may be from just one of the CRC joint venturers.

There is a growing tendency for CRC participants to fund projects, on the basis of direct, single company arrangements. This can be in addition to pre-competitive funding by several companies of a project. However, project funding is not yet seen

to be at a level that provides an 'excess' to support core or underlying basic research, as is undertaken by PhD students.[56]

The emergence of a substantial focus on research contracting and consultancy reflects an evolution of the CRC Programme from the opportunistic collaborative arrangement to the more transactional and integrative (as discussed in Section 3).

7.7 Overall economic and commercial impact

In the *Outcomes Survey*, research users and CRC Managers were asked about the economic, social and environmental impacts of research. Responses from research users are provided in Table 37.

Table 37: Performance indicator: Research user perspective on economic, social and environmental impact

To what extent has your CRC's research outcomes (including patents) had a positive impact in relation to your business's:	Very High %	High %	Moderate %	Low %	Very Low %	N/A/ missing %	Total
Sales	4	8	16	16	32	24	100
Exports	-	12	12	16	32	28	100
Profits	4	4	24	12	32	24	100
Employment	-	12	8	16	28	36	100
The environment	-	8	4	8	12	68	100
Social benefits	-	4	12	-	12	72	100

From the perspective of their own business interest, research users report a predominantly low to very low overall economic impact - as indicated by sales, exports, profits and employment. There is also a very high level of non-responses, suggesting that many CRCs are not oriented in this direction.

This perception is not shared by CRC Managers, who see a moderate to high economic and industry impact. However, CRC Managers were asked the question in relation to overall impact – not limited to the businesses of CRC participants. There is, however, a very high non-response rate, again suggesting that economic impact is not a major driver for many CRCs. This is indicated in Table 38.

Table 38: Performance indicator: CRC Manager perspective on economic impacts

To what extent has your CRCs research outcomes (including patents) has a positive impact in relation to:	Very High %	High %	Moderate %	Low %	Very Low %	N/A/ missing %	Total
Sales	2	30	8	8	-	52	100
Exports	2	20	10	14	-	54	100
Profits	6	16	22	10	-	46	100
Employment	2	10	30	10	-	48	100
Industry support programme performance	8	6	20	12	2	52	100

These responses raise issues in relation to the commercialisation/technology transfer focus of the Programme. This is discussed below.

7.8 Commercialisation in natural resource management

Commercialisation of R&D from the natural resource/environmental CRCs has been minimal, largely because of its primarily "national benefit" nature, and the need to

[56] Submission, Rod Grant, former Chairman of the Metallurgical Society of the Australasian Institute of Mining and former General manager, Rio Tinto

ensure the uptake and adoption of the R&D by resource managers and users, both in government and in community groups.

The broader long-term objective of natural resource/environmental CRCs is to provide information and knowledge to support planning, policy and management processes to address natural resource degradation and prevent the loss of production and economic benefits from the use of natural resources.

While there may be particular areas that could be commercialised – perhaps more at an international than national level – the return would likely not be significant, with high transaction costs, and the funds to develop the commercialised product would generally not be forthcoming.

The 'products' and outcomes of most CRCs in the environmental category are more likely to be in the form of:

- Adaptive management tools and strategies.
- Guidelines for the protection or improved management and use of our natural environment, its resources and services.
- Decision support tools and sound scientific knowledge to inform natural resource management decisions.
- Software programmes developed for a wide range of applications.
- Improved understanding of natural systems, their processes and dynamics, the risks they face, and their responses to human activity.

As the commercialisation of natural resource and environmental R&D is difficult, the CRC Programme will need to look for new ways of extending their R&D into the catchment scene. The application of the R&D should be given a high profile and focus in all CRCs.

7.9 Concerns over the commercialisation focus of the CRC Programme

In submissions, discussions and consultations there was a strong view that the CRC Programme should have a much greater orientation towards commercialisation.

The Australian Venture Capital Association (AVCAL), whose members invest mainly in new companies in the biotechnology and information and communications technologies areas noted in its submission to the evaluation that:

> AVCAL is concerned that the CRC Programme, with some notable exceptions, is on the whole failing to realise commercial benefits to their full potential. Effective technology transfer, including commercialisation, is the best method for capturing long-term economic benefit from the CRC Programme. Successful development of licensing agreements and spin-off companies creates employment, national wealth and harnesses the benefits of CRC research beyond the term of government funding. The significance of the CRC Programme as part of Australia's innovative effort means that it is in the national interest to ensure that it captures the full potential of its research output.
>
> AVCAL attributes much of this failure to cultural and structural barriers that work together to inhibit the will and ability of CRCs to interact with the business community on commercial terms.

The experience of AVCAL and many of the practitioners in the venture capital industry is that CRCs are not always focussed on the importance of capturing com-

mercial returns from their research. The institutional focus of CRCs is seen as being biased too far towards achieving scientific outputs rather than product development, while the geographic dispersion of many CRCs often presents difficulties for early identification and control of IP with commercial potential. Mistrust of venture capitalists and a misunderstanding of the real difficulties of effective commercialisation are seen to compound this situation.

AVCAL argues that "good" people and "good" science are conditions precedent for creating commercial opportunity. This infers that a stronger focus on the commercial outcomes of the CRC Programme will maintain the quality of the scientific results while creating lasting benefit for the community through the creation of employment, innovation and GDP contribution.

The Victorian Government advised the Evaluation Team that, based on key findings of a review undertaken of CRCs in the State, and on separate Industry Innovation and Regional Development consultations, the following recommendations require consideration:

- The CRC Programme needs to focus more closely on the outputs of research as articulated in the objective – "To enhance the transfer of research outputs into commercial or other outcomes of economic, environmental or social benefits to Australia".
- CRC funding should be structured to allow commercialisation and technology transfer activity. CRCs should be encouraged to pursue projects beyond the stage where the research is completed.
- The CRC Programme should place a greater emphasis on industry-led bids. Such bids typically demonstrate an outcome focus.

Similarly, ACCI expressed a concern that not all CRCs place sufficient resources into the commercialisation of research. ACCI considered that CRCs be required to demonstrate a significant increase in commitment to commercialisation of research in the final two to three years of funding. The purpose of this requirement would be to ensure that funding for CRCs does not become institutionalised and that the focus remains on achieving outcomes within seven years, not just on conducting research.

Reflecting these concerns, in some part at least, CRCs selected in the 2002 Selection Round will be required to prepare commercialisation plans within their first two years of operation.

The issue of commercialisation and commercial orientation is addressed in Part II of the Report in the context of shifting the emphasis of the Programme from a "funding" to an "investment" strategy and specific recognition of CRCs oriented towards new business development.

7.10 Conclusion

The differences between research user and CRC Manager views presented in this Section of the Report reflect issues of timeframe and perspective. This is indicated, for example, in the actual sales revenue of CRC spin-outs in 2001-02 being measured at $30.4m, but the prospect being in the order of $1 billion. This estimate does not include prospective sales from promising start-ups where managers have not made

predictions (for example, Carbon ReGen, established to use activated carbon in drinking water).

It is also the case that some of the criticisms of CRC performance are directed at CRCs working in areas of emerging technologies where control over intellectual property, scale up and speed to market are important issues. The prospects for introducing more agility and flexibility into the CRC model is also addressed in Part II of the Report.

Nonetheless, the overall performance of the Programme in the area of commercialisation and technology transfer must be seen as disappointing. The initiatives taken in the 2002 Selection Round, and the actions proposed in Part II are intended to address this shortfall. A large part of the proposed strategy for change involves adjusting the balance of effort within the Programme from a science and technology push to a demand pull, as represented by technology investors and end users. Part of the strategy will involve ensuring a high proportion of applications for CRCs in the more commercially oriented emerging technology areas are supported.

8: Collaboration Outputs and Outcomes

The CRC "Collaboration" objective is:

> To enhance collaboration among researchers, between researchers and industry to other users, and to improve efficiency in the use of intellectual and other research resources.

The Terms of Reference require consideration of whether the Programme has enhanced:

> "collaboration among public and private researchers, and between public researchers and commercial or community interest".

The paths to application identified in the performance indicator framework follow an analysis of the resources allocated to communication.

Path to Adoption	Output Indicator	Source of Information	Outcome Indicator	Source of Information
Connection of purpose and people across collaborating organisations	Numbers of CRCs Numbers of participants	CRC Compendium CRC Annual reports Individual CRC Newsletters-distribution data MDQ data Centre Agreements 2nd and 5th year review reports	Level of CRC management and participant satisfaction with: . Researcher and corporate connection . Level of interaction at other levels of the collaborating organisations . Extent to which ongoing bonds ("social capital") has been created.	Survey of CRC CEOs and researchers Survey of businesses/industry/government organisations involved in CRCs
Clarity of purpose in the collaboration	CRC statements of mission and purpose		Level of CRC management and participant satisfaction with: . The clarity of purpose and mission . The level of detail covered in Centre Agreements . The level of integration between collaborating organisations . The relative importance on corporate collaboration portfolios	
Congruence of mission, strategy and values in the collaboration	Mission statements, project design and involvement in project execution		Level of CRC management and participant satisfaction with: . Participant involvement in planning, development and management of the research programme . The extent to which each participant understands the other's business . The extent to which collaboration is a strategic tool for each participant . Partners have engaged in developing a shared vision for the collaboration	
Creation of value from the collaboration	Commitment of cash and in kind contributions that lead to research outcomes Income from IP licenses, research contracts, teaching and other services.	CRC Compendium CRC Annual reports Individual CRC Newsletters-distribution data MDQ data Centre Agreements 2nd and 5th year review reports	Level of CRC management and participant satisfaction with: . The extrinsic (measurable) benefits that accrue to each participant from the CRC . The relationship of benefit to cost . The economic, social and environmental value created . The balance of benefits between the participants . Increasing value creation and exchange over time . The intrinsic value created through the interaction and ties of researchers	Survey of CRC CEOs and researchers Survey of businesses/industry/government organisations involved in CRCs

Path to Adoption	Output Indicator	Source of Information	Outcome Indicator	Source of Information
Communication between partners and broader research and industry constituencies	Internal and external publications Press and media profile	Newsletters. Websites	Level of user/industry satisfaction with: - . The level of trust and respect that exists between the centre and among participants . The openness and frankness of communication . Collaboration relationship management . Conversion of potential dissenters . Publication of CRC activities, performance and achievements	Survey of CRC CEOs and researchers Survey of busi-nesses/industry/government organisations involved in CRCs
Continual learning from and through the collaboration	Internal and external commitments to learning and dissemination of knowledge about effective collaboration.	Annual Reports Newsletters Conferences Websites Speeches and papers delivered on CRC management and operation	Level of CRC Management and participant satisfaction with: . Ongoing improvements in the in collaborative arrangements . Processes for continually assessing learning from the collaboration Level of alumni interest and involvement in Centre activities The level of contract work flowing to the Centre as a result of referrals by past graduates and staff	
Commitment to the collaboration	Number of organisa-tions/entities involved in collaboration Evidence of ongoing collaborations Evidence of collaborations outside the CRC Programme – eg: . ARC Linkage . Bilateral arrangements	CRC compendium ARC Linkage data University research management and research training reports	Level of CRC management and participant satisfaction with: . The level of industry commitment and engagement . Continued commitment of resources . Mutual expectation among participants . Execution capabilities of the Centre . Participant collaboration portfolio is consistent with capabilities to commit.	Survey of CRC CEOs and researchers Survey of busi-nesses/industry/government organisations involved in CRCs

Information relating to these indicators is presented in the remainder of this Section. In some output categories, information has already been reported in earlier Sections of the Report, whilst in others it has been difficult to aggregate information in a system-atic way. This is due in large part to the way in which information is presented.

8.1 The "collaboration value construct"

All partnerships involve an exchange of value between participants: a key issue is the value of the collaboration to each. The magnitude, form, source and distribution of value among the participants is at the heart of relational dynamics. The perceived worth of an alliance is the ultimate determinant of whether value will be created and whether it will be sustained. The question of value to the participant organisation has been a consistent theme of the Evaluation.

Value is different from the perspective of each participant – for example:

- University – research/teaching, capacity building
- Research organisation – return on investment
- Business (private or public) – application, adoption and or use in new processes, products, programmes that in turn meet a customer need (want)
- Public programmes – new knowledge for application in programme design and implementation (be they expenditure, regulatory, subsidy or communication programmes)

- Government – national, state and regional economic, social and environmental benefits that would not have been delivered otherwise.

There are four dimensions of value to partners:

- Value definition – setting expectations, quantifying benefits and weighing them against costs
- Value creation – how resources can be mobilised to create value, recognising that different types of resources produce different magnitude of benefit. This occurs at three levels –
  - Generic resource transfer – exchange of money in return for good research
  - Core competencies exchange – each partner's distinctive capabilities are used to generate benefits to each partner and the collaboration – allows for greater potential value creation as each partner is leveraging special competencies and providing proprietary/distinctive resources; specific identity of each partner does makes a difference to the type and level of benefits
  - Joint exchange - benefits are joint products derived from the organisations' competencies and resources; a particularly high level source of benefits because it is unique to the alliance and not replicable by others
- Value balance – benefits need to flow in both directions and be deemed acceptably commensurate in value when each partner seeks ways to advance the other's agenda and has learned deeply about the other's business
- Value renewal – relationships are dynamic and subject to alteration due to changes in the external environment, partners needs and changes in priorities; successful collaborations can slide into complacency and cease to search for value opportunities.

A value exchange that gets out of balance can erode a dominant provider's motivation to continue investing in the relationship, or will force a provider to attempt to exercise greater influence on resource exchanges that get out of balance. In collaborations there is a tendency to slip back into traditional contract role of "purchaser and provider". These tendencies arise when trust relationships break down, when the resource circumstances of the partners change, and when there is a change in administration/management regimes in participant organisations.[57]

The way in which CRCs (and the CRC Programme as a whole) delivers value to participant organisations is a major issue for the future of the Programme.

8.2 Connection of purpose and people across collaborating organisations

Performance information from the *Outcomes Survey* in relation to connection of purpose and people across collaborating organisations is presented in Table 39 and Table 40.

[57] James E. Austin, *The Collaboration Challenge: How Nonprofits Succeed Through Strategic Alliances* (San Francisco: Jossey Bass, 2000)

From the research user perspective there is wide agreement about the level of collaboration within the CRC environment, although the perception is by no means unequivocal.

Table 39: Performance Indicators: Research user perception on connection of purpose

How would you rate your agreement to the following statements:	Strongly Agree %	Agree %	Not sure %	Dis-agree %	Strongly dis-agree %	N/A %	Total
CRC researchers collaborate widely with my in house researchers	24	44	-	20	8	4	100
CRC researchers collaborate widely with end users and other organisations	4	72	4	8	4	8	100
My in house researchers collaborate widely with researchers from other participant organisations	28	24	8	28	8	4	100
My managers collaborate widely with CRC Managers	24	32	8	24	8	4	100

From the CRC Manager perspective there is a much higher level of agreement with the proposition that there is a wide level of collaboration within the CRC context.

Table 40: Performance Indicators: CRC Manager perception on connection of purpose

How would you rate your agreement to the following statements:	Strongly Agree %	Agree %	Not sure %	Dis-agree %	Strongly dis-agree %	N/A/ missing %	Total %
My CRC Managers collaborate widely with managers in participant organisations	54	42	-	2	-	2	100
My CRC researchers collaborate widely with other researchers in participant organisations	44	50	-	4	-	2	100
My CRC researchers collaborate widely with end users and other organisations	38	50	6	4	-	2	100
My CRC researchers collaborate widely with researchers in other CRCs	6	44	28	20	-	2	100

The outcome data does serve to indicate that the Programme has been successful in building collaboration between research users and providers.

8.3 Clarity of purpose in the collaboration

Research user views on the clarity of purpose within the CRCs they are involved with are set out in Table 41. Approximately two thirds of research users agree or strongly agree that their CRC strategic documents encourage collaborative relationships.

Table 41: Performance Indicators: Research User Perception on Clarity of Purpose

How would you rate your agreement to the following statements: The strategic documents in the CRC (mission and goals) encourages collaborative relationships:	Strongly Agree %	Agree %	Not sure %	Dis-agree %	Strongly Disagree %	N/A %	Total
Among researchers	36	32	8	20	4	-	100
Between my business and CRC researchers	20	48	8	8	8	8	100
Between the CRCs stakeholders (researchers and participants) and end users of research outcomes	12	52	12	16	8	-	100

The views of CRC Managers in relation to the same issues are reflected in Table 42. In this case approximately 90 percent of CRC Managers either agree or strongly agree that the strategic documents encourage collaborative relationships.

Table 42: Performance Indicators: CRC Manager Perception on Clarity of Purpose

How would you rate your agreement to the following statements: The strategic documents in the CRC (mission and goals) encourages collaborative relationships:	Strongly Agree %	Agree %	Not sure %	Dis-agree %	Strongly Disagree %	N/A %	Total
Among researchers	66	24	2	6	-	2	100
Between my CRC researchers and participants	64	28	2	4	-	2	100
Between my CRCs stakeholders (researchers and participants) and end users of research outcomes	64	28	4	2	-	2	100

8.4 Congruence of mission, strategy and values in the collaboration

The effectiveness of collaboration is impacted by the degree of congruence of mission, strategy and values in the collaboration. Research user perceptions in relation to indicators in this area are set out in Table 43.

Table 43: Performance Indicators: Research user perceptions of congruence of mission, strategy and values

How would you rate your agreement to the following statements:	Strongly Agree %	Agree %	Not sure %	Dis-agree %	Strongly dis-agree %	N/A/ missing %	Total
My business was consulted by the CRC when it was developing its strategic documents (eg collaborative relationships)	36	48	4	8	-	4	100
My business is encouraged to participate in the planning, development and management processes eg research planning	44	36	4	12	4	-	100
The CRC has a high level of understanding of my business	12	60	8	16	4	-	100
My business acknowledges that collaborative arrangements between all stakeholders in CRCs are essential for the efficient use of IP and other resources	52	32	12	4	-	-	100
I am satisfied with the level of detail about collaborative arrangements between my business and the CRC covered in the Centre Agreement	20	36	12	16	8	8	100
Allocation of IP rights have been agreed to by all participants of the CRC	28	52	-	16	-	4	100
My business has appropriate and agreed performance monitoring procedures/mechanisms for the CRC	12	60	8	16	4	-	100

Overall, research users have a high regard for operational aspects of the collaborative arrangements for the CRC they are involved in. There is, however, a significant level of disagreement in relation to perceptions of the way in which a CRC understands the participant's business and indicators of the level of involvement.

CRC Managers also have a very high level of agreement in relation to indicators relating to mission, strategy and values. This is reflected in Table 44.

Table 44: Performance Indicators: CRC Manager perceptions of congruence of mission, strategy and values

How would you rate your agreement to the following statements:	Strongly Agree %	Agree %	Not sure %	Dis-agree %	Strongly dis-agree %	N/A missing %	Total
My CRC worked closely with participant organisations in development of strategic documents (eg mission and goals)	62	30	4	2	-	2	100
My CRC worked closely with participating organisations in the development of management processes eg research planning	48	48	2	-	-	2	100
All participant organisations have a high level of understanding of each others business	16	44	16	22	-	2	100
The expectations of all participants have been integrated into the research programme	16	68	8	6	-	2	100
All participant organisations acknowledge that collaborative relationships are essential for the efficient use of intellectual and other research resources	38	46	4	10	-	2	100
The Centre agreement contains an appropriate level of detail about collaborative arrangements	34	50	8	6	-	2	100
Allocation of IP rights have been agreed by all parties	46	44	2	6	-	2	100
All participants have agreed on appropriate performance monitoring procedures/mechanisms	22	64	6	4	-	4	100

The Survey results indicate a significant level of disagreement with the proposition that "participant organisations have a high level of understanding of each others business".

Overall, the Survey indicates a high level of congruence in mission, strategy and values in the CRC joint venture relationship.

8.5 Creation of value from the collaboration

In terms of the value created from the collaboration, the views of research users are more mixed. This is reflected in Table 45.

Table 45: Performance Indicators: Research user perceptions of value from the collaboration

How would you rate the collaborative research efforts for your business in the flowing areas:	Very High %	High %	Moderate %	Low %	Very Low %	Not sure %	Total
Benefits derived from the CRC	8	44	24	8	8	8	100
The benefits to costs	20	20	12	20	12	16	100
The sharing of benefits between the participants	12	36	24	12	12	4	100
The creation of long term partnerships	20	32	28	8	8	4	100
Relationships between researchers	20	28	32	8	8	4	100

Table 45 indicates that about half of research users consider they obtain either a high or very high level of value from the collaboration.

The CRC Manager perception of value created is somewhat higher. This would reflect the broader focus of collaboration, particularly among other research providers. This is reflected in Table 46. Eighty six percent of CRC Managers consider that CRCs have delivered a high or very high level of benefit to participants, although the relationship of benefits to costs is rated high to very high by only 62 percent of mangers. There is a strong perception about the value created by long term partnerships and relationships between researchers.

Table 46: Performance Indicators: CRC Manager perceptions of value from the collaboration

How would you rate the collaborative research efforts of all your participants in the flowing areas:	Very High %	High %	Moderate %	Low %	Very Low %	Not sure/ missing %	Total
Benefits derived from the CRC	28	58	10	-	-	4	100
The benefits to costs	20	42	24	8	-	6	100
The sharing of benefits between the participants	10	62	20	4	-	4	100
The creation of long term partnerships	38	50	10	-	-	2	100
Relationships between researchers	44	40	14	-	-	2	100

8.6 CRC management performance

The levels of satisfaction of CRC research users with indicators relating to CRC management are indicated in Table 47.

Table 47: Performance Indicators: Research user perceptions of CRC Management

How would you rate your satisfaction with:	Very satisfied %	Satisfied %	Neither Satisfied or Dissatisfied %	Dissatisfied %	Not sure %	Total %
The overall management of the CRC your business participates in	20	44	16	20	-	100
The level of trust and respect that exists the CRC and your business	20	48	12	20	-	100
The level of trust and respect that exists between other participants and your business	12	60	20	4	4	100
The openness and frankness of communication between your business and the CRC	36	48	8	8	-	100
The management of the collaborative relationship	24	44	16	16	-	100
Publication of CRC activities, performance and achievements (between stakeholders)	28	40	20	4	8	100

How would you rate your satisfaction with:	Very satisfied %	Satisfied %	Neither Satisfied or Dissatisfied %	Dissatisfied %	Not sure %	Total %
The CRCs commitment to the commercialisation of the research	28	48	12	4	8	100
Ongoing improvements in collaborative arrangements between your business and the CRC	16	44	28	8	4	100
The processes available for your business to tap into the learning from the collaboration with the CRC	8	48	24	12	8	100
The level of CRC's commitment to ongoing engagement with your business	24	36	24	16	-	100
The ability of the CRC to deliver on agreed research objectives	12	44	20	16	8	100

The highest levels of research users' dissatisfaction relate to the overall management of the CRC and the level of trust and respect that exists in the CRC. These views represent only a fifth of overall user perceptions.

CRC research user perceptions of CRC commitment to collaboration in relation to commercialisation, ongoing engagement and meeting objectives are indicated in Table 48.

Table 48: Performance Indicators: Research user perceptions of commitment to collaboration

How would you rate your satisfaction with:	Very satisfied %	Satisfied %	Neither Satisfied or Dissatisfied %	Dissatisfied %	Not sure %	Total %
The CRCs commitment to the commercialisation of the research	28	48	12	4	8	100
The level of CRC's commitment to ongoing engagement with your business	24	36	24	16	-	100
The ability of the CRC to deliver on agreed research objectives	12	44	20	16	8	100

8.7 Collaboration with international networks

A key objective of the Programme is increased collaboration with international research networks. It is one of the rationales for the increased funding ($227 million over three years) under the Government's *Backing Australia's Ability* initiative. The measurement and reporting on this objective of the CRC Programme is not well defined, and reporting appears to be restricted to CRC *Annual Reports* and the *Management Data Questionnaire*.

The *Management Data Questionnaire* reports the names and countries of CRC collaborations. In 2001-02 a total of 935 collaborations were recorded with overseas institutions. Of these, 29.4 percent were in the United States and 11.7 percent in the UK. Summary data relating to the countries where collaborations are located are provided in Table 49.

Table 49: CRC International Collaborations (Number) 1997-98 to 2001-02

Country	1997/1998	1998/1999	1999/2000	2000/2001	2001/2002
USA	136	143	156	239	275
Asia Pacific	125	137	195	265	233
Europe	132	194	189	247	210
UK	55	71	83	106	114
Africa	26	42	46	45	45
Canada	21	21	24	36	38
Latin America	7	12	17	22	12
Middle East	6	9	6	6	8
	508	629	716	966	935

The data in Table 49 indicate a substantial increase in the number of collaborations over the last five years. Outside the USA, the largest number of collaborations is Australia's region.

To provide an indication of the range of collaborations Figure 4 summarises information prepared by the CRC Association[58] in relation to collaborations in the Asian region from the Directory *Asia Initiatives 2002.*

Figure 4: Examples of CRC Collaborations in the Asian Region

CRC for Advanced Composite Structures (CRC-ACS)	Agreement with the National Aeronautical Laboratory in Tokyo involving joint research and staff and information exchanges. It is also collaborating with the National University of Singapore and exchanging research information on composite structure
CRC for Cast Metals Manufacturing (CAST)	Collaborative links with the Gintic Institute of Manufacturing Technology in Singapore; the Institute of Metal Research of the Chinese Academy of Sciences; the Centre for Advanced Aerospace Materials, Korea; the Korean Automotive Technology Institute; and Yonsei University, Korea.
Australian Photonics CRC	Memorandum of Understanding with the Information and Communications University in Daejon, Korea, for a students/staff exchange program.
Australian Telecommunications CRC	Grant from the Government of Hong Kong for collaborative research on signals in electronic and communications systems. Collaborative research is also underway with the Centre for Wireless Communications and with the DSO National Labs, both in Singapore, and with the Department of Applied Mathematics at the Hong Kong Polytechnic University. Links have also been developed with the Electronics and Telecommunications Research Institute at Daejeon in Korea.
CRC for Satellite Systems	Under agreements with the Korea Advanced Institute of Science and Technology (KAIST) and the Nanyang Technological University (NTU), Singapore, the CRC will develop the FedSat Advanced Data Acquisition and Messaging payload for launch aboard the Korean microsatellite KAISTSAT-4 in 2003, and in conjunction with NTU's small satellite project.
The AJ Parker CRC for Hydrometallurgy	Collaboration with the Bhurupa University in Thailand and Lampung University in Indonesia on a project on the optimisation of crystal growth. Links with scientists at the Regional Research Laboratory in Bhubaneswar, India and is involved in base metals research with the National Iranian Copper Industries Company in Iran.
CRC for Clean Power from Lignite	Three year research project with Hokkaido University, Gunma University and the University of Tokyo (supported by the New Energy and Industrial Technology Development Organisation (NEDO) of Japan) Research collaboration agreement with the Institute of Coal Chemistry of the Chinese Academy of Sciences, which involves a joint study of the chemical changes that occur during the pyrolysis of bio-solids and coal. Collaborating with Taiyuan University of Technology in China on the gasification of Australian and Chinese coals. Other collaborations involve the National Chemical Laboratory in India, and Okayama University and Chiba Institute of Technology in Japan.
Australian Cotton CRC	Collaborating with the Shanghai Institute of Entomology to develop synthetic volatile attractants for Heliocoverpa moths. These are being field trialled in China, the Darling Downs and Ord River areas.
CRC for Australian Weed Management	Collaborative research with the Haryana Agricultural University and the Punjab Agricultural University. The research involves the management of herbicide resistant Phalaris minor in the rice-wheat system of northern India.
CRC for Waste Management and Pollution Control Limited	Signed cooperation and commercialisation agreements and entered into R&D contracts, worth over $2 million, with groups in the East and South East Asian regions. Major collaboration with the Institute of Environmental Technology and Industry (IETI) at Pusan National University in Korea to establish the Korea-Australia Science and Technology Exchange Centre. Memoranda of understanding with the Guangdong Environmental Protection Industry Association and Guangzhou Municipal Environment Protection Bureau to facilitate technical assistance, joint R&D and the exchange of technical information through workshops and training courses, leading to joint business partnerships and commercial projects. Eight technologies from the CRC's R&D programmes are currently under negotiation for sub-license to partners in Asia and North America.
CRC for Cochlear Implant & Hearing Aid Innovation (CRC HEAR)	Cochlear implant workshop program, which have involved participants from Japan, China, Taiwan, Korea, India, Singapore, Hong Kong, Thailand, Indonesia and Malaysia and have led to a rapid expansion of implant clinics in these countries and the adoption of the Australian developed cochlear technology.
CRC for Diagnostics (CDx)	Through its commercial partner, Panbio Ltd, CRC has established collaborations with the Mahidol University in Bangkok on the development and clinical evaluation of tests for nasopharyngeal carcinoma, melioidosis and typhoid. Also collaborating with researchers at the US Armed Forces Research Institute for Medical Sciences in Bangkok to clinically validate flaviviris diagnostic tests.

[58] CRC Association, *CRC Asia Links, Extracts form the Asia Iniatives Directory*(CRC Association, 2002, accessed); available from http://www.crca.asn.au/.

CRC for Eye Research and Technology (CRCERT)	Links with the L V Presad Eye Institute in Hyderabad, India and collaborates in clinical trials to test new vision correction and eye care systems and in investigations of ocular inflammation. These trials have been invaluable in developing CRC products. In 1998 successfully completed the Asia Pacific Contact Lens Education Program, which reached 12,750 practitioners in China, Indonesia, Thailand, the Philippines, Taiwan, Malaysia, Singapore and Hong Kong. Works closely with the International Centre for Eyecare Education and the International Association of Contact Lens Educators in the delivery of eyecare services and education to the region. Development of a contact lens specially for the Asian eye shape. This has involved substantial innovation in rigid gas permeable contact lens design Links with the Centre for Cellular and Molecular Biology in Hyderabad; the Harmano Eye Clinic in Japan; the National Center for Optometry in China; the Tunn Hussein Onn National Eye Hospital in Kuala Lumpar; the Department of Ophthalmology at Ichikawa Hospital in Tokyo; and Toray Industries in Japan.
CRC for Vaccine Technology	Developed strategic linkages with the International Vaccine Institute in Seoul. Works with the Human Institute of Parasite Diseases, the Human Medical University and the Institute of Parasitic Diseases in Shanghai. Work on Epstein Barr virus is facilitated by researchers in Hong Kong. The centre is also collaborating on the development of a malaria vaccine and has formed a number of strategic linkages with the help of the Australia India Council. In India it collaborates with the Indian National Veterinary Institute, the International Centre for Genetic Engineering and Biotechnology and the Postgraduate Institute of Medical Education and Research. It is also working with the Papua New Guinea Institute of Medical Research on malaria.

The Association has also prepared documentation relating to collaborations with the European Union.[59]

Apart from CRC *Annual Reports*, there is no process for reporting the outcomes of the collaborations. The CRC Association should be encouraged to continue reporting the information as part of Communication Strategy recommended elsewhere in the Report.

As most multi-national corporations operate on a devolved basis there is very little international collaboration within the CRC environment in the business domain. What is unclear is how much collaboration is expected (including to satisfy the objectives for increased funding under BAA) and how this is spread across types of CRCs.

8.8 Views of businesses not involved in CRCs

As part of the Evaluation, the *Outcomes Survey* sought information form businesses that had not participated in the CRC Programme. A total of 40 telephone interviews were conducted. Further information about the Survey is located in Attachment 2. Of those surveyed:

- 70 percent had an active collaboration strategy.
- 70 percent had heard of the CRC Programme.
- 36 percent had been invited to participate in a CRC at formation and 32 percent after established.
- 10.7 percent had entered into a contract for the CRC to undertake research with 28.6 percent being very satisfied and 42.9 percent being dissatisfied.

In terms of future involvement in the CRC Programme, respondents provided the following answers:

[59] CRC Association, *CRC Research Links with the European Union*(CRC Association, 2003, accessed); available from http://www.crca.asn.au/.

Table 50: Non-Participating Businesses Attitudes to Future Involvement in a CRC

Would you consider:	Definitely	Probably	Possibly	Probably Not	Definitely Not	Total
Contracting Out Innovation Research to a CRC	10.3	6.9	44.8	27.6	10.3	100.0
Collaborating on Small Scale Research Projects	17.2	24.1	31.0	27.6		100.0
Becoming a participating member of a CRC for the life of a CRC research programme	3.1	13.8	27.6	31.0	24.1	100.0

The responses indicate that businesses are prepared to become involved in CRCs on a short term, project by project basis, but are not willing to make a commitment to long term research. This points to the difficulties, raised elsewhere in the Report, about finding industry participants who are prepared to commit to longer-term research programmes.

The commitments to longer terms research are more likely to be found in the public sector, in areas such as water, agriculture and natural resource management. A recent development has been the involvement of State governments in CRCs as "industry" partners in emerging technology and industry categories.

8.9 Conclusion

The following broad *generalisations* may be drawn from the output data and the *Outcomes Survey* that provides a qualitative perspective of the views of participants in CRCs:

- With some exceptions, a significant proportion of the research user participants feel positive about the way CRCs encourage them to become collaboratively engaged in strategic planning, in getting people networked and working together and making facilities available to each other.
- Most user participants feel that CRCs do make efforts to understand their businesses and that there is significant trust and mutual respect across the membership.
- CRC Managers in large majority agree, or agree strongly, that collaboration is strong between managers and researchers from their CRC with those of participant organisations and also end users. This is held more firmly than the views of user participants.
- CRC Managers believe more strongly, than their research user counterparts, that their strategic documents, eg mission and goals, encourage collaboration with all parties, and consistently rate CRC collaborative benefits significantly higher than their research user counterparts in regards to benefits, cost benefits, shared benefits and long term relationships.

9: CRC Administration, Management and Governance

9.1 Resources allocated

According to Department of Education, Science and Training data, CRCs allocate only eight percent of resources to administration. However, this figure disguises some major variations.

Although it is possible to hide administrative costs in projects, a commitment of resources at around ten percent should be seen as acceptable. It may, however, be a matter of concern that several Round 7 CRCs are allocating in excess of 20 percent to administration – although this may presumably be associated with set up costs.

Resources allocated to administration are not available to contribute to generating the outputs and outcomes of a CRC. Every effort should be made by the CRC "industry" to ensure that these costs are minimised through streamlining and simplification of the set up procedures and commonality of administrative and business systems. It is understood that the CRC Association has commenced such an initiative.

9.2 CRC legal structures

CRCs may be incorporated or non-incorporated entities and both models have chalked up impressive successes[60]. CRCs typically establish related subsidiary entities when there is a perceived commercial need. The CSIRO and most universities have indicated a preference for working through unincorporated entities. Universities report that more problems have emerged with incorporated bodies, as their objectives often diverge over time from those of the university.

There are complex legal and taxation issues associated with both incorporated and unincorporated structures. The issues have given rise to considerable cost in establishing CRCs through the negotiation and formation of Centre Agreements and related governance structures. However, there has been little sharing of information among CRCs with the result that, following a diverse range of advice provided by lawyers and tax and corporate advisory accountants, CRCs have developed a diverse and complex range of operational and commercial structures.[61]

Although some limited generic template agreements are available, new CRCs have typically spent considerable time and money establishing documentation that is drafted specifically to their interests. These documents are reviewed and amended extensively as they pass through many hands, especially in CRCs with multiple participants. A seasoned CEO has described a typical experience in commencing a CRC:

> As the Centre was unincorporated, both the Australian National University and CSIRO partners had to be satisfied with and sign off every contract. Yet neither was made the prime agency and consequently was unable to give the negotiations the immediate and personal contact they required. Consequently, commercial law firms

[60] Of the 63 CRCs in 2002, 51 were unincorporated joint ventures, 8 incorporated and limited by guarantee and tax exempt not for profit, 3 limited by shares and tax exempt not for profit and one limited by shares and tax paying.

[61] See Howard Partners Working Paper. There are a range of other inquiries and advice/guides and published papers on this matter produced by lawyers/tax/accounting/management professionals.

> would be engaged to advise during negotiations and write each contract. The old saying "take two lawyers and expect three opinions" was proven again. It was only in the Centre's last two years that an efficient *modus operandi* was devised. A specialist contracts firm in Canberra was engaged, with a partner who consulted for, and was trusted by, both CSIRO and the Australian National University. This proved a boon for us during contract negotiations. They became faster, the process was clearer and the understandings on the CRC side were far better.[62]

It is still the case that the experience of established CRCs has not been extensively drawn upon, although there are now State-based networks of CRC executives/ business managers committed to sharing information. Nevertheless, CRC stakeholders at CEO and senior executive levels, even after 12 years of CRC operations, hold views such as:

> (At worse) - "there are over 60 different businesses out there"; "its all over the place"; "after all these years I still go to meetings and hear the same issues and nothing has been done"; "new CRCs are still re-inventing the wheel even 12 years on".
>
> (At best) - "better systems have been developed but there remains much duplication - there is need for more consistency and commonality in approach" and "CRCs are SMEs with disproportionate corporate overheads in their set up and efforts to commercialise their IP".

The costs to set up a CRC have been estimated to be as much as $1 million in one instance. ATO rulings on tax status may take 12 months or more.[63] This results in unreasonable waste of time and misallocation of resources, and brings uncertainty, loss of focus and distraction.

The cost, time and effort that is devoted to the negotiation of Centre Agreements and establishing the appropriate corporate vehicle in *anticipation* of a possible stream of income and capital gain from technology licensing and/or creation of a new business may be misplaced when considering the track record in this area. The reality is that there are very few discoveries and inventions that come out of university research that generate substantial financial returns for the institutions[64]. Most of the returns accrue to the investors who take the *market risk* in the commercialisation process[65]. The data presented in Section 8 suggests that the greater part of commercial revenue from CRCs has come from contact research and consultancy.

This situation may change with a greater focus on commercialisation within the CRC Programme, but the current complexity in legal arrangements would work against the creation and operation of CRCs that are directed towards developing a strong commercial focus. The resources required for creating and managing what are essentially temporary organisations, requiring a high degree of flexibility for participants to enter and depart, means that for many businesses the opportunity costs are simply too high.

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[62] Chris Buller and William Taylor, "Partnerships Between Public and Private: The Experience of the Cooperative Research Centre for Plant Science," *AgBioForum* 2, no. 1 (1999)

[63] In one case the tax ruling took four years.

[64] See Australian Centre for Innovation, Howard Partners, and Carisgold, *Best Practice Processes for University Research Commercialisation* (Canberra: Department of Education, Science and Training, 2003), and Australia. Australian Research Council, Commonwealth Scientific and Industrial Research Organisation, and National Health and Medical Research Council, *National Survey of Research Commercialisation* (Canberra: Australian Research Council, 2002).

[65] There is considerable debate when establishing CRCs about the value of background IP. In the commercialisation process the value of inventor equity is continually negotiated down by venture capital investors.

The absence of a direct, simple, templated pathway for the set up and running of CRCs has resulted in a diversion of Commonwealth and other resources into a growing CRC advisory industry. This has, in turn, resulted in some cases in what might be seen as excessive set up and administrative costs with replicated advice in regards to the legal and tax issues confronted by individual CRCs. The complexity involved is out of proportion to the purpose of a CRC as a public-private industrial research partnership with an *intended* limited life. The CRC vehicle should, nonetheless, facilitate the transformation of a CRC into a more permanent arrangement through an appropriate exit mechanism.

The Commonwealth, via the CRC Programme administration area, has not had the mandate to focus attention on these matters. CRCs have had to choose their own set-up and operational structures. The Commonwealth's own preference is for CRCs to be incorporated, or adopt equivalent corporate behaviours if unincorporated. Neither of these arrangements is necessarily appropriate

The reality is, however, CRC success is largely determined by its leadership, not its structure. From all accounts during the Evaluation – in workshops, submissions and interviews – it is the demonstrated CRC leadership provided by a CEO and Chair, the trusting relationship developed over time between the CEO, Chair and Board, and the demonstrated cooperative and collaborative behaviours of CRC participants at all levels that greatly determine the coherence, quality and impact of a CRC's outcomes.

Options and recommendations for an appropriate CRC entity are canvassed in Part II.

9.3 The role of the board and the chair

The CRC Programme has established mechanisms aimed at achieving a high level of industry influence in CRC management. The structuring of boards, governance requirements, ongoing review processes and the incorporation of CRCs have all been refined to facilitate collaborative arrangements. Industry generally supports these efforts and believes that they should remain a component of the CRC Programme. Despite these arrangements, there is a concern that too many governing boards are provider driven.

As CRCs combine disparate interests - from industry with product and outcome motives to academia with research and investigation interests, the goals of the CRC Programme can be compromised in CRCs that fail to actively manage the interests of all parties. A review by the Victorian Department of Innovation, Industry and Regional Development found that successful CRCs outline clear objectives and strategies to achieve those objectives from the outset.[66] Each party's role in achieving those objectives must be articulated and agreed at commencement. This must be agreed at the Board level.

A common observation in submissions and discussions was that the more successful CRCs have strong and well organised Board structures. This in turn, creates strong leadership at both the executive and science levels within the CRC. Where strong leadership at Board level is observed, this has come about primarily by the intent of

[66] Submission, Department of Innovation, Industry and Regional Development, Victoria

the organisations making up the CRC, rather than from strong requirements at the CRC Programme level.

There was a great deal of discussion during the Evaluation about the role of Boards and the importance of having a predominance of industry membership. However, most CRC participants look for board "representation" as a way of exercising control over the Centre's activities. Other participants do not seek Board "representation" but exercise influence in Centre activities through other means and channels.

As CRCs move towards a more commercial basis of operation, and the size of financial responsibilities increases, issues of governance from a corporate perspective become more salient. *A business style of operation requires a business-oriented structure.* The point at which that occurs, however, is a more difficult issue to resolve. As suggested above, such a structure may not be necessary or appropriate at the time a CRC is formed.

The view of most participants is that flexibility should be retained in constitutions and governance arrangements for CRCs. In its submission the University of Melbourne pointed out:

> Flexibility should be maintained in the models appropriate for CRC management. There is no convincing evidence available that the incorporated CRCs have a superior performance to unincorporated CRCs. The key factors should be the strength of the leadership, the quality of the research programmes, the board of management structure and the strategies for knowledge protection and transfer. The CRC Programme should foster diversity not uniformity of approach to the science and technology (S&T) management required.[67]

Both incorporated and unincorporated entities can be successful if well managed. When management problems arise in uncorporated structures they are more difficult for participants to deal with when there is an absence of sound governance practices. For universities, these problems arise when the strategic direction of the CRC diverges from that originally agreed to. Such problems can, however, be mitigated with appropriately structured and accountable boards and competent CEOs.

The CRC Board should clarify each party's expectation of the others. This should be a key objective of a Board and is a pre-condition to resolving any issues of priority, commitment, indemnity, incorporation and management of intellectual property. If particular difficulties are encountered or anticipated, success in a joint venture may be achieved through formal partnering or alignment processes involving expert external facilitation. A CRC Board needs to revisit major issues at regular intervals, especially if the focus of the CRC is changing. The Board should test expectations against known joint venture activities.[68]

9.4 Communication

Managing a CRC requires a major commitment to regular and comprehensive communication amongst participants. This includes communication between:

[67] Submission, The University of Melbourne
[68] Submission, AMIRA

- Researchers within the CRC, especially if they are located at different nodes in different parts of the country.
- The CRC Director, the Board and advisory committees.
- Between the Boards of CRCs in a common industry sector.
- Between industry nominees on the CRC Boards and the industry organisation.
- Between the CRC and industry, government and the community in relation to results and success.

Establishing and maintaining this level of communication is facilitated when there is strong industry leadership, as in the mining, agriculture and water industry sectors. For many CRCs external communication does not appear to be a high priority. Yet communication is an important path to adoption.

According to the Department of Education, Science and Training data, CRCs spend, on average, only 1.9 percent of their total expenditure on communication. Given the purpose of the CRC Programme in promoting adoption, this low level of commitment to communication is of concern. As stated earlier, communication in this context is much more than "publicity" or "publication". It is at the basis of knowledge/technology transfer.

Information collected in the Evaluation *Outcomes Survey* suggests that most CRCs have developed strategies for communication. The approaches are listed in Table 51.

Table 51: Proportion of CRCs reporting communication strategies

Developed strategy for communication of CRC knowledge (what has been learned) to users	Education %	Published reports %	Knowledge broker %	News-letters %	Website %	Other %
Specific strategy for communicating knowledge – form of programme	92	75	37	92	75	7

It would appear that most CRCs address communication through their education programmes, which are a specific target. Other forms of communication rely on paper based or electronic means. However, it is well established that the most effective form of knowledge transfer is through direct face to face contact. The level of commitment to this form of communication, through knowledge brokers, according to Table 51 is quite low.

Research user perspectives on the effectiveness of CRC communication within the CRC environment, rates a combined 56 percent high to very high. This is indicated in Table 52.

Table 52: Performance indicator: Research user view on effectiveness of CRC Communication strategies

How effective is the overall communication strategy	Very High %	High %	Moderate %	Low %	Very Low %	Not sure %	Total
The overall communication strategy	8	48	20	12	4	8	100

Effective communication occurs through targeted communication strategies and campaigns implemented by communication professionals. Results can, and should be measured by changed behaviours, including adoption.

Recommendation

I - 5. As a condition of approval, CRCs be required to identify a clear and credible strategy for the communication of research outcomes to targeted end users.

9.5 Critical success factors for CRC performance

CRC participants identified a number of critical success factors for CRCs performance, which in turn, impact on the overall success of the Programme. They include:

- A clear understanding of purpose, mission and measures of success.
- A commitment from participants who have both something to give and who can get more out of the joint venture than operating alone.
- The CRC Board should clarify each participant's expectation of the others.
- An active industry oriented Chair and a Board dominated by industry.
- First class leadership of the CRC in terms of skills, knowledge and experience of a CEO and other senior positions.
- Key researchers should provide a substantial amount of their time to each CRC.
- Regular and comprehensive communication among stakeholders.

The mining industry is associated with what are perceived to be a number of successful CRCs. Success has not been achieved, however, without some difficulties. A former General Manager of Rio Tinto Limited observed:

- The usual structure of a CRC is as a joint venture between universities (i.e. certain university departments) and one or more divisions of CSIRO. This structure is extraordinarily difficult to manage, and needs the highest level of management and leadership capability in the CRC CEO or Director, to make it work in any reasonable fashion.
- Almost all employees in the CRC are employed by one of the joint venturers, so their primary (and monetary) allegiance is to that employer. Very few staff are employed by the CRC itself.
- As a result, the CRC CEO has little or no direct authority over the individuals, especially the researchers.
- The researchers - many of whom may not be devoted full time to the CRC - tend not to give full recognition/allegiance to the CRC; so for example, their technical publications often give their affiliation as their university department, or CSIRO Division, rather than the CRC.
- This situation makes it very difficult for the CRC to attain the stature, such as in terms of international recognition, that it needs in order to both gain stronger staff allegiance, and industry recognition and support.
- It remains a constant struggle for the CEO in his efforts to weld together the CRC as an entity, rather than just a 'loose association' to which staff give notional support so that they get their share of CRC (ie. government) funds.

The joint venture structure also creates extraordinary problems and tensions in relation to intellectual property, where universities especially tend to jealously defend their 'right' to patents, and the 'cultural' rights that university staff have in this regard. Invariably, there are disagreements in relation to the value of Intellectual Property when it comes to commercialisation negotiations.

9.6 Management and organisational implications of the "maturing" of the CRC Programme

All organisations tend towards formalisation of structure and routine as they mature; but structuring without explicit design can be expensive and can direct resources away from goal achievement. In any organisation there is a need for some degree of structure and routine, but the critical question for the CRC Programme is where that structure should be developed and how it should be applied.

It is apparent that the CRC Programme has been "maturing" in that *organisation* participants (not necessarily the researchers) are moving from an opportunistic, one-off approach to involvement in the Programme to a more careful, considered approach. This maturing reflects an institutionalisation of the Programme *on the part of participating organisations.* There is also increased structuring within CRCs, but the structuring is not uniform or consistent.

It is important to keep in mind that innovation requires organic, or adaptive, arrangements rather than mechanistic, or bureaucratic, structures. This tends to occur best in relatively small organisations – such as CRCs, which are equivalent in scale to small-medium businesses. It follows that individual CRCs should have simple management structures and should be able to draw on experience and learning in relation to centre agreements, governance, management practices, technology transfer, technology marketing, taxation advice, financial and information systems, etc.

Notwithstanding the collaborative objectives of the Programme, collaboration has been mainly at the level of the researcher – suggesting an opportunistic focus. There has been little collaboration between university administrations and other participant organisations including the CSIRO and State government agencies. This is reflected in the diversity of centre agreements, and an inability to get a "participant view" that would enable standing up to the lawyers, getting the reporting requirements reduced, changing the selection process, and benchmarking.

The role of the Department of Education, Science and Training under present arrangements relates to compliance and stewardship: it may be inconsistent with that role to provide advice that could be subsequently challenged through administrative review procedures (FoI, AAT). It follows that the provision of advice could fall to the industry association or to an independent objective third party provider.

10: Programme Management and Administration

The Purpose of this Section is to comment on the current Programme administration arrangements. Suggestions and recommendations for change are addressed in Section 14.

There is a general view from within government, the universities and business that the CRC Programme is "over-administered". The overwhelming message obtained during the consultations process and in submissions was to streamline the administrative processes and arrangements. This applies to all aspects of the application, selection, formation, monitoring and review processes.

10.1 Department of Education, Science and Training management responsibilities

The present staffing commitment in the Department of Education, Science and Training allocated to the CRC Programme is set out in Table 53.

Table 53: CRC Administration - Staffing

Position	Classification	Commitment (FTE)
Branch Manager	SES Band 1	0.5
Managers	Executive Level 2	1.5
Assistant Managers	Executive Level 1	4.5
Liaison Officers	APS 6	4.0
Liaison Officers	APS 5	5.0
Project Officer	APS 6	1.0
Finance and Administration Support	APS 4	1.0
Finance and Administration Support	APS 3	1.0
Total Staffing		18.5

These officers are tasked to advise on the development of Programme guidelines and selection criteria, provide support for the CRC Committee and Expert Panels, and manage the Programme on a day-to-day basis.

The Programme management tasks are reflected in a number of documents. These documents, totalling approximately 250 pages, are listed below:

Figure 5: CRC Programme Documentation

Document	Pages
Guidelines for Applicants 2002 Selection Round and General Principles for Centre Operations	35
Application Form, including Notes on the Completion of the Application Form	35
Agreement between the Commonwealth and a (nominated party) in relation to a Cooperative Research Centre	38
Model Agreement for the Establishment and Operation of a Cooperative Research Centre	26
Management Data Questionnaire	19
Annual Report Guidelines	22
First Year Visit Guidelines	5
Second Year Review Guidelines	18
Fifth Year Review Guidelines	13
Guidelines for Auditors	6
Visitor Guidelines	14
Windup Guidelines	18
	249

The documents reflect the high level of guidance provided and the scope and extent of review activity. The level of review and reporting activity across the CRC portfolio involves an enormous amount of effort and generates masses of documentation. This is quite apart from the work and documentation created by advisers and lawyers retained by CRCs and participants to work through the documentation.

10.2 Eligibility

To be eligible for financial support, a proposed CRC must include at least one higher education institution, as well as at least one research user or industry group, among its core participants.

Applications will be accepted in the fields of natural sciences and engineering. Applicants may submit proposals in areas that complement existing CRCs. For the 2002 round, the *Guidelines for Applicants* advised that preference would be given to proposals that fill major gaps in the research fields currently funded by the CRC Programme.

Participants in CRCs that are within two years of concluding their current contracts were eligible to apply for second and third round funding in the latest round. However, applicants in this category were required to:

- Demonstrate a clear record of research, leading to success in commercialisation, technology transfer or utilisation
- Be based on a research programme involving expansion into new areas of research and the education and training programme related to that research
- Demonstrate strengthened or additional collaborative arrangements between researchers and industry and users particularly in the form of commercialisation, technology transfer or utilisation.

Existing CRCs were also encouraged to submit applications to seek funding for new or complementary programmes combining research and commercialisation, technology transfer or utilisation that they wish to add to their current contract. Such applications cannot extend the length of time of the current contract. Any programmes added must be completed within the current term of the CRC.

10.3 Applying for CRC funding

The first stage of applying for CRC funding is the submission of a Notification of Intent (NOI). This information was published on the AusIndustry website to inform all applicants of any related proposals and to encourage possible collaborations. Applicants that failed to submit a NOI are not precluded from submitting an application.

Applicants are advised in the *Guidelines for Applicants 2002 Selection Round and General Principles for Centre Operations* that:

- All applications will be assessed on merit against the nine CRC Programme selection criteria (see Figure 6 below).
- Applications must be credible against all criteria.
- Applicants should aim to develop an integrated and well-balanced proposal.
- The documents to be submitted as a proposal are a comprehensive strategic business plan and a completed application form.
- The business plan must specifically address the selection criteria, and be no more than twenty-five pages in length.
- The application requires detailed information on participant's cash, in-kind and other contributions as well as details on key staff.

Applicants are invited to attach short curriculum vitae for the proposed CEO and each key researcher to the Business Plan. Applicants are also invited to attach up to ten pages of supporting material, including letters from supporting participants (where not signing the application) identifying financial commitments or letters of support from industry/stakeholders not participating as a core or supporting participant in the application. Applications must be *a joint submission* by all participating organisations. The head of each organisation must endorse the application.

Figure 6: The Selection Criteria for the 2002 Round

Objectives of the CRC
1 The proposed CRC has well defined objectives that address a specific community and/or industry need.
2 The proposed outcomes of the CRC will make a significant contribution to Australia's sustainable economic and social development.
Quality and relevance of the research programme
3 The proposed research programme is of high quality and is well defined, with clear outputs that are achievable over the life of the CRC. The outputs are relevant to the stated objectives under selection criterion 1.
Strategy for utilisation and commercialisation of research outputs
4 The proposed CRC has a well structured, feasible and practicable strategy for the commercialisation, technology transfer or utilisation of the research outputs to achieve the proposed outcomes identified under selection criterion 2.
The strategy should specifically address SME involvement in the CRC through direct or indirect participation and through involvement in the application of research outputs through commercialisation, technology transfer or utilisation, including where appropriate the spin-off of new SME companies. Milestones should be identified as a basis for performance monitoring.
Education and training
5 The proposed CRC has a well developed graduate education and training programme oriented to research user and industry needs. The education and training programme will demonstrably enhance the employment prospects and the value of the graduates of the programme in the industry and user environment.
Collaborative arrangements
6 The collaborative arrangements reflect a strong commitment by participants to build links between the research groups and organisations, and between research groups and user and industry participants. The collaborative arrangements will integrate and enhance the CRCs research and educational programmes. The proposed CRC is required to address the issue of international linkages and indicate how proposed linkages would contribute to the objectives of the CRC.
Resources and budget
7 The budgeted resources, cash and in-kind support, including time allocation of key personnel, from all participants clearly demonstrate their commitment to the CRC and are adequate to support the proposed research and education programmes.
Management structure
8 The proposed CRC has an effective management structure, including financial, operational and research management arrangements, to ensure that the objectives of the CRC are realised.
Performance evaluation
9 The proposed CRC has a performance monitoring and evaluation strategy appropriate for the internal assessment of research and education programmes, and for commercialisation, technology transfer or utilisation. The strategy will also meet the reporting requirements of the Commonwealth.

The CRC *Guidelines for Applicants 2002* provide a detailed commentary on these selection criteria. These run into 11 pages and they are highly prescriptive and, in effect, introduce a number of "sub-objectives" to the Programme in that they direct and also constrain a CRC proposal. The term "should" appears in the *Guidelines* a total of 97 times.

The format and style of the CRC selection criteria and related documents, reflects the emergence of a "rules based" system of administration - commonly associated with the processes of formalisation or bureaucratisation.[69] Applicants have every incentive to an application that satisfies the "rules" – rather than focussing attention on developing "investment proposals" that will deliver sustainable, economic and social development *outcomes* (The essence of the first objective of the Programme as currently formulated).

[69] "Rules based" systems are contrasted with "choice based" systems. Under choice based systems, action is tied to anticipation of consequences (outcome), evaluated in terms of prior preference. Rules based systems are based on a logic of appropriateness and control. See James G March, Martin Schulz, and Xueguang Zhou, *The Dynamics of Rules: Change in Written Organisational Codes* (Stanford: Stanford University Press, 2000)

The periodic Reviews undertaken in the context of the administration of the CRC Programme are also set against the selection criteria. These documents are, in turn, highly prescriptive as to process, procedure and matters to be addressed.

The relationship between objectives and selection criteria is addressed in Part II. At this stage, it is sufficient to emphasise that the selection criteria be simplified with a view to ensuring that CRC proposals are directed towards achieving the *outcomes* of the Programme.

Recommendation

I - 6. The CRC Selection Criteria be revised and simplified with a view to being less prescriptive and more focussed on the way in which a proposal will deliver outcomes in relation to the Programme's mission and objectives.

10.4 Assessment process

The selection process is conducted in three stages with applications being assessed against the CRC Programme objectives and selection criteria. The CRC Committee makes recommendations to the Minister at each stage of the process as to which application will proceed to the next stage.

The CRC Committee bases its advice on the applications submitted and on advice received from the two Expert Panels. The Minister will make the final decision at each stage. The stages of the selection process are detailed in Figure 7.

Figure 7: CRC Application Assessment and Selection Process

Stage 1 - eligibility
The Expert Panels and CRC Committee will evaluate applications received by the closing date against the CRC Programme objectives and selection criteria. The Committee will make a recommendation to the Minister as to which applications should and should not proceed to stage 2 (short listing). Following a decision by the Minister, the Chair of the CRC Committee will formally notify the unsuccessful applicants.
Stage 2 - short listing
For those applications proceeding to the second stage, assessment reports will be obtained from referees nominated by the applicants, and independent assessors nominated by the Expert Panels or Committee. The Expert Panel will make an evaluation of the comments provided by the referees and assessors against each application and advise the CRC Committee. The CRC Committee will make a recommendation to the Minister as to which applications should and should not proceed to stage 3 (interview). Following a decision by the Minister, the Chair of the CRC Committee will formally notify the unsuccessful applicants.
Stage 3 - interview
An interview will be conducted with those applications proceeding to the third stage. The interview will discuss the application in more detail and address specific issues identified by the Expert Panels. Each interview panel will consist of the chair and/or co-chair of the relevant Expert Panel, one or more members of the life sciences or physical sciences and engineering panel and in some cases an independent expert.
The CRC Committee advises the Minister on which applications are suitable for funding, as well as the recommended funding.
The Minister considers the Committee's advice and decides which applications should be funded.
The Minister formally announces successful applications and the funding offered.

Under current arrangements all applications that meet the selection criteria go forward for detailed assessment by the Expert Panels. This is because applicants ensure that they cover off on the identified selection criteria. However, a major effort is required by applicants to make their proposals look "competitive". There is now a high level of risk in committing a substantial level of resources to preparing a bid with no knowledge of the size of the field or indication of likely success.

The DSTO submitted that the CRC model is only practical where there is a strong degree of certainty about whether proposed CRC bids would be successful and where the establishment timeframe is not prohibitive. The Organisation commented:

> Given the long lead time (measured in years) for preparing a CRC bid - of getting support for the CRC concept and encouraging relevant participants - an enormous amount of effort is effectively wasted when these CRC bids are not successful. This timeframe is even longer if the bid participants then wait to submit their proposed CRC to the next round; as well as the lost opportunity of alternate options not being pursued in the meantime.[70]

Should greater certainty in the CRC selection process be provided, DSTO indicated that it would also consider a much more active role as a driver of new CRC proposals with an emphasis on future national research priorities.

These matters can be addressed through the introduction of a two-stage application procedure as is adopted in many other Commonwealth programmes. A two-stage process would involve:

- Submission of a Preliminary Proposal in response to a general and public "Request for Proposals"
- Submission of Full Proposals – following an invitation based on an assessment of the Preliminary Proposal.

A Preliminary Proposal would contain an outline and summary of the research, briefly but clearly stating objectives, methodology and potential national and industry benefits, budget details and the extent of end-user involvement and commitment.

Preliminary Proposals would be assessed against formal (but abbreviated) selection criteria, national and industrial research priorities, the extent of potential national and industry benefits and the resources available within the Programme.

Full Proposals would provide more detail in relation to linkages and contacts with industry, personnel and other resources to be committed, detailed budget estimates and projections, a realistic assessment of outcomes and a strategy for implementation. In this respect the Full Proposal would represent an "investment proposal". Suggestions for a change in emphasis in the Programme towards this end are canvassed in Part II.

Recommendation

I - 7. CRC Applications be submitted and assessed in a two stage process: A Preliminary Proposal outlining the research, objectives and potential benefits; a Full Proposal would be invited following Committee assessment of the Preliminary Proposal

10.5 Funding arrangements

CRCs receive funds from several sources:

- Programme funds.
- Universities.
- CSIRO and other publicly funded research organisations.
- Businesses and industry associations.
- State Government.

[70] Submission, DSTO

Funding is received either directly as cash or as "in kind", represented mainly by the time of research staff from universities, the CSIRO and businesses.

According to the *Guidelines for Applicants, 2002* the amount of CRC Programme funding provided to CRCs amounts, on average, to about one quarter of the total funding. The CRC Committee examines the proposed "leverage" of the Programme funding sought in the application, expressed as the ratio of the total contributed resources budgeted for the proposed CRC to the Programme funding sought from the Commonwealth. The *Guidelines* state:

> The provision of an appropriate and adequate amount of cash is regarded as highly desirable, as it increases the flexibility available to the CRC governing board to optimise its resource allocation decisions. The cash available per full time equivalent researcher is seen as a useful indicator in this regard.

The overall industry commitment to the CRC Programme has grown with successive selection rounds. The Committee indicated in the 2002 round that it expected industry's commitment would continue to increase, particularly for the larger and established industries, and those industries which have a long standing association with the programme.

In an endeavour to build leverage CRC Proposals are tending to include a larger number of industry partners. This, in turn raises questions about the effectiveness of participation – quite apart from the management difficulties involved in a joint venture with multiple partners. However, a wide scope of industry partners allows SMEs to become involved. Many CRCs have encouraged SME involvement through a "collegiate" arrangement.

10.6 Monitoring and oversight

The accountability framework that the CRCs impose on all parties is extremely tight, but open and transparent. This is important when bringing together a range of organisations, particularly for those who are making cash contributions, to ensure appropriate reporting and to ensure high quality science is provided.

That said, an over-riding principle is that as CRCs have been established as a form of "non-government organisation", carrying out responsibilities for industrial research on a devolved basis, they should be entrusted to undertake the tasks that have been agreed in contracts and agreements without detailed oversight. *Accountability should be on the basis of reporting against milestones and achievements.* Essentially, the Boards of the entities should be responsible for ensuring accountability in day-to-day management and operations.

The limiting factor in this area has been the uncertain structure and status of the "CRC entity" in a joint venture environment. This issue is addressed at some length in Part II

10.6.1 Reporting

There is strong support within the CRC system for accountability for the expenditure of public funding. The scope, coverage and intensity of that framework was raised as an issue during the Evaluation.

As the major recipients of Commonwealth funding for teaching and research, universities are highly geared to respond to Government's accountability requirements. However, they view the accountability requirements for the CRC Programme as particularly demanding, especially when compared with other Commonwealth research programmes, such as those administered by the ARC and the NHMRC.[71]

The accountability framework for the CRC Programme involves five separate elements:

- An annual Management Data Questionnaire.
- A second year review.
- A fifth year review.
- An annual report.

There is substantial benefit to the Centres themselves in complying with these accountability requirements, but there is scope for rationalisation. As the system currently operates, there is a very heavy reporting requirement, which research providers particularly see as burdensome and bureaucratic.

It is essential that a reporting and monitoring system:

- Demonstrate an appropriate level of accountability for a large amount of public funds.
- Allow the Department of Education, Science and Training to assess the progress of the CRC in terms of its performance against plan.
- Identify problems and provide guidance if appropriate or termination of funding.
- Perform these functions efficiently with only that level of reporting deemed necessary.

10.6.2 Ongoing monitoring and review processes

Quarterly and annual financial reports

Many CRC Managers claimed in consultations that, for a relatively small organisation the level of financial reporting required is excessively onerous – and more appropriate to larger businesses operating in a corporate environment. At the same time, organisations that are receiving taxpayer funded assistance and support should recognise that there is a basic level of accountability that needs to be met.

CRCs with accounting and financial reporting systems that meet their own management and financial reporting needs should have no difficulty in meeting the reporting requirements for the Department of Education, Science and Training.

Management Data Questionnaire

As would be apparent from previous sections of this Report, the Management Data Questionnaire (MDQ) provides a great deal of useful information about CRC proc-

[71] Submission, Group of Eight

esses and outputs. The MDQ does not, and cannot, provide information in relation to outcomes. However, aggregate and individual reporting of the information can provide useful information about the progress being made towards the achievement of those outcomes

The data generated by the questionnaire provides an important and useful time series of information about CRC activity and performance. However, there needs to be a better system for extracting information from the database and reporting the content of that information back to CRCs. Publication of information will quickly ensure that CRCs who have been remiss in completing returns make certain that accurate information is included.

In general, CRCs should not have a major problem with providing the data for inclusion in the MDQ. The information provided should be part of a standard set of management information reported to Boards. They were, however, particularly interested in seeing the information in aggregate and in comparison to other CRCs. More information about CRC performance among CRC participants, Boards and managers will improve knowledge about the Programme's operations and inspire greater confidence in the way in which CRCs are working towards creating outcomes.

Recommendation

I - 8. The Management Data Questionnaire be continued as an annual report to the Department of Education, Science and Training and be expanded to capture, where appropriate, the outcome indicators identified in the "Performance Monitoring Framework" prepared during this Evaluation; information obtained from the Questionnaire be reported back to CRCs on a regular basis

Second and Fifth Years Reviews

CRCs have commented that it takes most of the first year to really get things working because, although discussions will normally have been held between the main players in developing the application, the investment will not be large until the outcome of the application is known.

It has been suggested that the first review should not take place until at least the end of the third year. As the main purpose of a CRC is to undertake research, not much will usually be achieved until after the first year. There seems little point in putting much effort into simply evaluating systems and procedures.

The Fifth Year Review provides a focus on the commercialisation outcomes of the CRC. In the context of CRC expectations, commercialisation should be considered at the outset if the CRC is to maximize impact from its research.

The Evaluation Team considers that the scope and coverage of much of the present Review Activity should properly be the responsibility of the Boards of CRCs. The Reports of the Second and Fifth Year Reviews follow a relatively standard *pro-forma* and are of little value, or interest, to an external user. The *process* of Review might well provide a benefit to the CRC. To that extent, it should be the responsibility of the CRC to initiate and implement process improvement.

To the extent that CRC Boards are established to be responsible and "accountable for the management of the CRC and setting overall policies, research directions, for utilisation, technology transfer, commercialisation and budgets and for overseeing the executive"[72] it makes little sense to set a condition on this responsibility by requirements for Second and Fifth Year Reviews as they are currently designed. This should be the responsibility of Boards.

Consistent with principles of responsible corporate governance, Boards should, however, be required to undertake regular, independent *Performance Audits*, publish the results of those Audits, and act on the recommendations. Those Audits should be undertaken every three years. Performance Audits should provide an attestation that the decision making processes and procedures that are in place will enable the delivery of the planned outcomes of the CRC. This issue is addressed again in Part II.

Annual Reports

Each CRC produces an Annual Report. There are specific guidelines for their preparation and production.

The Reports cross a spectrum from publicity and promotional documents to serious attempts to meet accountability requirements. There is, therefore, no consistency in reporting for specific measurement purposes in the Annual Report documents.

The findings from a content analysis of 2001-02 *Annual Reports* indicated that[73]:

- Most reports don't specify which authors of publications are CRC researchers and some don't even clearly state which publications are peer reviewed.
- Most don't clearly list number of licenses and patents and sales. The same applies to commercialisation agreements and contracts and there is a wide variety of interpretation as to what constitutes a "commercial agreement".
- A lot of the reports do not state who funds the PhD and Masters students.
- Many of the financials were also difficult to decipher for specific measures and in some cases it was difficult to identify possible double counting.
- It is difficult to determine which collaborations were ongoing and which had been completed.
- A lot of the performance indicators ended up being subjective because most of the required responses were not clearly stated in the reports.

From a communication perspective, many of the reports required a degree of industry knowledge to be able to interpret what was said. In the event that the report was only aimed at the CRC stakeholders, this would be acceptable. However if the report were aimed at a broader target audience, such as financial investors, then the documents would need to better communicate their messages.

CRCs should address the form and content of Annual Reports from a communication perspective.

[72] Australia. AusIndustry, *CRC Guidelines for Applicants 2002 Selection Round and General Principles of Centre Operations*
[73] The content analysis was undertaken for the Evaluation Team by the Australian Institute for Commercialisation.

Commercialisation Plans

For Round 8 the Department of Education, Science and Training introduced a requirement that CRCs prepare commercialisation plans. This will encourage a focus on commercialisation from the CRCs at commencement. These plans should, however, be incorporated into the research project plans and should encourage end user involvement in the research and the associated commercialisation.

Commercialisation plans that are developed separately from the underlying research are considered to be little assistance. Industry-led CRCs focus on commercial outcomes from commencement and build this focus into their research and development programmes.

To the extent that CRC applications are based on an investment proposal basis, as suggested elsewhere in this Report, the integration of commercialisation and research plans will automatically follow. The specific details of commercialisation opportunities will evolve in the context of the research programme.

Recommendation

I - 9. The Annual Report, Second Year Review and Fifth Year Review processes be integrated into a single reporting process that focuses on assessing the achievements of the CRC against credible milestones agreed in the selection process and in CRC operational plans. CRCs continue to be required to report quarterly on income and expenditure against budget; Boards be required to commission regular Performance Audits at least every three years; the results of those Audits be published.

10.7 The role of the Visitor

The role and function of the Visitor has been discussed at length during the Evaluation. From the Commonwealth's perspective, the Visitor can perform a useful role immediately following the establishment of the CRC from a "pastoral" or mentoring perspective, but beyond that there is little value. There is, however, a substantial administrative cost.

During discussions and consultations the Evaluation Team met with Visitors who had quite divergent views about their role and function. In a number of cases, Visitors had no clear idea about what their function was.

The Evaluation Team has concluded that Visitors can and do perform a useful role where the role is defined – either by the CRC or the Visitor. But they are not part of the Commonwealth accountability stream. Without a Commonwealth prescription, that role is best determined by the CRC.

Recommendation

I - 10. The Boards of individual CRCs decide whether a Visitor be appointed and the time frame for the appointment. The cost of the Visitor appointment should be met by the CRC

11: Emerging Issues

The CRC system is now larger, more complex, has more players and a greater richness of interactions between the various players. Moreover, the capabilities of the players have increased. There is now a much more sophisticated understanding of the relationship between research and innovation. This provides both opportunities and challenges.

There are, however, many constraints that need to be overcome to realise the potential of the CRC system as it moves forward. Some of these are canvassed below.

11.1 Managing a long term commitment

Universities and businesses are not well prepared for long-term commitments. During a seven year time frame it is almost certain that there will be significant change. The term is beyond the tenure of most Deans, Heads of Department and Corporate R&D Managers. Small businesses and non-government organisations are also not in a position to commit to long-term programmes.

New Deans of Faculty find themselves carrying the decisions of past Deans. Some expect university staff to commit no more than 50 percent of time to CRCs, and the rest to other university duties and review them accordingly. Research leaders in industry or whole groups are often made redundant.

CEOs in CRCs don't always serve seven years and many work substantially less than this creating challenges in the management of ongoing relationships with participants. CRCs also have industrial relations issues and exposures to deal with. Students in CRCs have reasonable expectations of completing their PhDs in the minimum time of three years.

A number of difficulties also arise in relation to the management of very large research programmes, particularly where financial arrangements are established through a formal Centre Agreement involving multiple parties. These include

- Management of a large team of staff within a university human resources framework can be problematic, including significant industrial exposure
- Financial exposure to severance payments, salary commitments.

The seven year funding commitment, with potential for extension, is seen by universities as a major strength of the system in that it recognises the long-term view that needs to be taken in many research areas. The downside however is being locked into lengthy engagements in circumstances where their own research priorities, personnel and finances may fluctuate.

Though accepting the need for continuity and long-term commitment in areas such as medical/clinical research potential participants in industries that are managed on a global basis do not like long term lock-in even if it includes a one-year notice of exit. Head office priorities change with changes in market situations and strategic directions and corporations want simpler terms of entry and exit in working in collaborations.

11.2 Managing participants

CRCs vary considerably in the number of participants. There has been an increasing tendency for more recent CRC applications to involve a greater number of smaller partners, with the effect that in some cases no single partner is sufficiently large to have real "ownership" of the research programme; the effect is that some CRCs effectively sub-contract out smaller research programmes to the providers rather than developing a strong research collaboration (referred to as the "mini-ARC" effect). This potentially works against a focus on tackling larger, long-term research projects on a collaborative basis.

Where CRCs have multiple partners from a wide and complex range of institutions, there may be no de facto responsibility for the operation of the CRC; some CRCs have so many partners that each partner's equity is below 10 percent. Some CRCs have clearly tried to engage too many research providers and end up by offering very poor returns. There has to be a balance between assembling an appropriate skill base, maintaining cohesion in the CRC, and offering an appropriate level of returns to all partners.

The practicalities of managing a large team of participants and researchers need to be investigated during the selection process. Evidence of prior collaboration between parties should be sought.

11.3 Resource challenges

The central element of the CRC Programme is to bring together industry, research agencies and universities. These players have had to show their commitment to the work of the CRC they support by bringing resources to the table. There are increasing pressures on the capacity to commit those resources. Internal contestability within research and business organisations can also make it difficult to free up funds for strategic external collaborative activities that depend on successful participation in other competitive processes.

Each CRC requires a significant commitment to management and administration, including membership of Boards, committees and involvement in periodic reviews and reporting. They require real, ongoing and long-term commitment of resources (personnel, space, laboratories, infrastructure). In some States, audit and public accountability legislation has made it difficult to devolve responsibilities to CRCs.

From the perspective of many universities, high cash commitments to CRCs consume resources that would otherwise provide support for a diversity of research programmes. As result, some universities are complaining of CRC-fatigue, and claim that they already have reached a limit in terms of the number of CRCs they can support, despite the presence of quality researchers who could join a CRC's research programme.

There is clearly a limit to which organisations can continue to provide funds to become eligible for a CRC. This is especially the case when research agencies respond to other government policies, such as those that require them to develop strategies to focus their research into long term programmes directed towards national priorities.

In consultations, both research providers (the CSIRO and other public research organisations, universities) and research users (major corporations and government agriculture and natural resource management agencies) pointed to far tighter budgets and finances, with the result that there is considerably less "slack" in their systems. All report having to do more with fewer resources than a decade ago.

Moreover, the large research-intensive universities with involvement in up to 20 CRCs have hinted that they are now reaching a limit. Universities are being called upon to act as a "research funder" in CRCs in that most CRC proposals have sought significant amounts of cash. They believe they are now more cash "funders" than "receivers" in CRCs and in future would want and expect research users (industry) to do more by way of cash support. This is despite the benefit of CRC research income boosting the research block grant by 30-40c in the $ that a university gets from its involvement in a CRC.

Research users are also looking at opportunity costs and choosing between using limited resources internally, funding R&D in the public sector on a bi-lateral contract basis (without the CRC "compliance or bureaucracy" burden) or continuing to participate in CRCs at more of a "watching brief" level of investment in a CRC. The complexity of engagement (and disengagement) is becoming too costly. That is, the benefit of being involved in a CRC and in leveraging public sector resources is being assessed against the costs. In this vein, major industry participants in past CRCs have indicated that they will be more selective and strategic in their future involvement. Some have decided if it is possible to collaborate on a bi-lateral level with a research provider they will avoid a CRC.

These considerations suggest that there might be a case for fewer CRCs, with more resources available to each, and a stronger strategic focus among the joint venture partners.

11.4 Researcher commitment and loyalty

In committing staff to a CRC a void is left for other activities in the university. While there may be overlap between CRC and university activities, there will be a substantial amount of time when a CRC researcher is not available for university activities, including Departmental research programmes.

The problem arises on account of the "fractional" involvement of staff in a CRC and determining the balance between effective and token participation; fractional assignment also creates tensions in loyalties and lines of responsibility for staff who are employees of a university with a significant involvement within a CRC.

As many CRCs rely for their research activity on the pooled efforts of individual researchers or groups of researchers working in their parent organisations, the loyalty of these researchers becomes essentially split:

- Is it to the CRC or is it to the parent organisation or a combination of both?
- How are successes publicised and which organisation takes credit?

This aspect has proven to be a major hurdle to good cooperation in many CRCs and steps towards its resolution should be an important consideration in the selection and review processes.

Researchers are strongly influenced by the promotions policies of their home organisations and the issue of appropriate recognition of success needs to be addressed at the national level. For example, some UK universities are quite explicit in considering contributions to the success of cooperative research ventures with the private sector (i.e. analogues of CRCs) in promotions to higher academic ranks.

11.5 Safeguarding the interests of research students

At least part of the research effort for a researcher attached to a CRC is directed or aligned with the priorities of the CRC. These priorities may change over time implying that sometimes "interesting" academic aspects of research programmes may not be fully explored; programmes may be terminated, suspended or interrupted if the priorities of the CRC change; universities have a real potential exposure if resources (including staff) dedicated to CRC programmes are suddenly no longer required.

Moreover, training of higher degree research students is an important part of the charter of the CRC system. Yet many CRCs experience difficulties in changing the direction of CRC research projects when, from a commercial sense, they are judged to lack promise, but there are PhD students working on them. Because the average length of candidature of PhD students is four years, mechanisms are required to allow change in research direction without imperilling students' candidature.

One method that has been successfully used by some CRCs is to guarantee students funding of at least the level of an APA for the whole of their candidature, even though they may receive above-APA funding when they commence and whilst their project remains on the critical research agenda of the CRC.

Associated with any shift to APA-level funding could be a change in the ownership policy for intellectual property, with the CRC giving up its rights to ownership of IP once a project is no longer considered commercially important to the CRC.

There is an attitude amongst the private sector partners in some CRCs that appointing significant numbers of PhD students unduly constrains the flexibility of the CRC to change research direction and believes that the CRC system needs to develop guidelines for new CRCs that overcome this attitude.

Faced with difficulties in recruiting high quality Australian PhD students, some CRCs have extensively hired international research students and have paid universities the international student fee, the students a stipend and have provided infrastructure costs to support the research. This considerably increases the costs of supporting a PhD and limits their numbers.

Whilst recognising that international research students do confer breadth on a research group, there is a concern that too high a proportion of students from overseas, who are obliged to leave Australia at the end of their candidatures, will constrain the pipeline of students into Australian industry. It is important for the CRC system and PhD programmes within CRCs that research training should include some business aspects to make such PhD programmes attractive to local students.

12: Conclusion

There is now greater corporate/industry and institutional volatility than in the early 1990s. All six industry sectors under which CRCs have been classified experience ongoing business cycles and volatility – mergers/acquisitions, global industry fluctuations and currency shifts. Commitment to seven-year business plans is relatively rare, so signing commitments that far in advance is unattractive. Some industries traditionally have not contracted industrial research in this way.

Nonetheless, the availability of a seven-year research *programme* is attractive to many large businesses, but more particularly to public enterprises and government departments and agencies. That said, there are arguments for both long term CRCs in some areas (application of scientific discoveries in a health services/medical environment for example) and shorter more flexible arrangements in others (such as in emerging technologies and industries).

The CRC system has delivered some impressive achievements in many areas. This includes the creation of effective research consortia in mining and energy, the growth of capacity in natural resource management, the training of researchers in natural resource management and the environment who are in a position to contribute to the resolution of Australia's serious natural capital problems and the creation of businesses in medical devices and technologies.

In the area of agriculture, the environment, water, mining and intelligent manufacturing, the CRC Programme has made a major contribution to "matching the technology push provided by [Australia's] strong research base with the demand pull of industry and other research users". In the emerging areas of information and communication technologies, biotechnology and medical devices, the model has been successful when used effectively for development of new business models taken up by existing businesses or involving the creation of new businesses. There is strong industry concern about the commitment to commercialisation in this sector.

Going forward, the CRC Programme would benefit from a stronger emphasis on CRCs managing towards outcomes and a focus on new business development. Individual centres should concentrate much more on the outcomes achieved and on their effective use of research management processes designed to achieve successful outcomes. Such a concentration would no doubt contribute to closing the gap in perceptions of success between research providers and users.

Part II: A Focus on the Future: The CRC Programme within the Broader Science and Innovation System

1: Introduction

The Terms of Reference for the Evaluation required consideration of the following questions:

The appropriateness of the objectives in light of developments in related Australian programmes and policies, developments in related overseas programmes and policies, and current understanding of the nature of industrial innovation:

- Do the objectives, including the balance between them, provide the basis for an effective CRC Programme over the medium and longer term, taking account of developments in:
  - Related programmes including those implemented under *Backing Australia's Ability* (eg, Centres of Excellence, ARC research programmes).
  - Taking account of any preliminary results of the mapping of Australia's science and innovation activities across the public and private sectors to be undertaken by the Commonwealth.
  - Policy on research and innovation, including National Research Priorities.
  - developments in the research 'culture' in universities and public sector research agencies.
  - Structural aspects of Australian industry.
  - Technological and industrial trends?
- Does the mix of economic and social objectives for the Programme remain appropriate?
- Are there overseas programmes and policies that provide a basis for changes to CRC Programme objectives?

These matters are addressed in the first three sections of this Part of the Report in terms of a "strategic assessment" that covers:

- The industrial research environment of the CRC Programme in terms of the changing institutional framework for public-private collaboration and the commercialisation of publicly funded research.
- Related policies and programmes to promote public-private research collaboration.
- The implications and impact of these developments on the CRC System.

This analysis is followed by an assessment of the clarity and appropriateness of the current CRC objectives and recommendations for change and adjustment. A mission (statement of purpose) and revised statement of objectives for the Programme is recommended. This is followed by suggested changes to:

- Selection criteria and procedures.
- Revised Programme management arrangements.
- Funding arrangements.
- The accountability framework.

2: The Changing Institutional Framework for Cooperative and Collaborative Industrial Research

The present operational context of the CRC Programme is significantly different to the circumstances prevailing at the inception of the Programme in 1990 and the announcement of the first CRCs in 1991. In this Section of the Report a number of issues that relate to the positioning of the CRC Programme in the contemporary landscape of cooperative and collaborative industrial research are identified and discussed.

2.1 Introduction

The economic and institutional framework that has evolved over the 12 years since the CRC Programme commenced has placed international competitiveness as a top order priority. This has impacted heavily on all industries, and the businesses that make up those industries, particularly in regards to their plans and strategies for industrial research and innovation. This is reflected in

- Changed business planning horizons, faster product development cycles
- Wider choices in industrial research alliances and in the location of industrial research facilities/infrastructure
- Major structural changes in a number of industry sectors
- Changed national/international business regimes, regulatory controls, capital market downturns, and national security.

In addition, national public policy in the area of science and innovation, and the policies of universities and public research organisations has placed an emphasis on the commercialisation of the results of publicly funded research. There are also high expectations from State governments in this area.

Approaches to industrial research also need to be seen in the context of the adoption of contemporary management practices and a commitment by Boards and CEOs to superior business performance and the maximisation of shareholder value.

High performance companies tend to be organisational activists and more likely to be innovating in the areas of structure, process and boundaries. They do more outsourcing, more downsizing, more operational and strategic decentralisation, and deploy more special project teams[74]. They are also characterised by denser and more inclusive webs of relationships with organisations outside their corporate boundaries. Such factors have altered the way companies pursue industrial research and innovation when working with public sector research providers.

In general, there is now a far higher consciousness of the importance of collaboration, networks, alliances, regional economic clusters, and the trading of complementary assets in intellectual capital as models and frameworks for research-led pursuit of

[74] William G Dauphinais, Grady Means, and Colin Price, *Wisdom of the CEO: 29 Global Leaders Tackle Today's Most Pressing Business Problems* (New York: Wiley, 2000)

innovation. These models are internationally recognised as essential contributors to future economic wealth of regions and countries.

Australia's public policy initiatives and actions in meeting such challenges include greater funding provided under the *Backing Australia's Ability* framework, (eg benefiting for example both the ARC, NHMRC and targeting support for commercialisation and new enterprise formation). This has led, in turn, to new and generally expanded opportunities through which businesses can collaborate with public sector research providers. There remain, however, challenges as to how productive engagement at this public/private sector boundary can be improved further.

In parallel to these initiatives, economic and financial pressures have also engendered challenges to traditional organisational structures, academic research and educational behaviours, cultures and reward systems. These have impacted on individuals, groups/teams, institutions and major public sector industrial research providers, particularly in universities and the CSIRO.

There have been initiatives to focus Australia's public sector resources in defined areas of national research priorities in order to better position Australia against other competitive, knowledge-driven economies and to address security and environmental challenges.

2.2 Innovation pathways: between the "community of science" and the "application of knowledge"

As indicated in Part I, there is also a growing recognition that there are different innovation processes, or pathways to adoption in different industry sectors and components of sectors - from the processes of knowledge creation, as discovery and invention, to the processes of application and use, in a product, process or service that meets a customer need. In some industries aspects of the process are combined or they are skipped or omitted. In others there is a reverse dynamic as science is used to test, explain and enhance the characteristics and performance of products already in the market.

The main differences in commercialisation between industry sectors arise because of differences in the *drivers* of the innovation process along innovation pathways. It is possible to classify pathways into three categories.[75]

- Innovation based on shifts in s*cientific* knowledge - *science* based innovation – such as in drug discovery in the pharmaceuticals industry: discovery is linked directly to a product for an uncertain, untested but potentially highly profitable market. "Discovery" research, using techniques of molecular biology, for example, is important in this process. The innovation process pushes product and market opportunities.
- Innovation based on shifts in *technical* knowledge – *applications or engineering* based innovation – such as in plastics, chemicals, automobiles: product development is the main driver of innovation arising from commercial and market

[75] John H Howard, *ARC Research Investment, Innovation Pathways and Support for Commercialisation: A Discussion* (Canberra: 2002)

considerations. The innovation process pulls through basic research and new knowledge into technologies to create new and/or enhanced products.

This research relies, however, on the continual generation of new knowledge through discovery. But discoveries may take many years to become attached to a commercial application. From this perspective, a high degree of importance is attached to protecting intellectual property in discoveries.

- Innovation based on improvements in *market* knowledge – a *consumer* driven process flowing from greater knowledge of and responsiveness to consumer tastes and preferences arising from the capacity of technologies to track and model market segment behaviours (sometimes referred to as "mass customisation").

There are no doubt other pathways. But the distinctions are important in terms of addressing ways in which information about discoveries and technologies is conveyed to, and taken up by, industry "receptors" along the innovation pathway. The orientation of research, education, commercialisation and collaboration will be impacted by the nature of the innovation pathway relevant to that CRC.

The growing role of universities in the performance of basic research for industry has been associated with recognition by businesses that more fields of research at universities now hold out significant promise of generating findings that may be of commercial significance. The connection between university research and commercial technology appears to be particularly close in biotechnology, a factor that influences the character of many university-industry research relationships - and may distinguish them from university-industry research relationships in other fields.[76]

2.3 Changing strategies for investment in industrial research

At the time of inception the CRC Programme was based on developing a relationship with university researchers and corporate (industrial) researchers. It reflected a traditional, "linear flow" model of corporate research with scientists coming up with interesting ideas and novel concepts and passing them over to production and marketing managers. There was, and still is, a view that there are also a lot of interesting ideas in universities that could be passed over to corporations in this way. However, the difficultly is taking those ideas to the next step through adaptation, scale up, production and, most importantly, addressing an end user need.

The traditional model for funding research has been that corporations "taxed" their business units and used revenues to give to an R&D department or laboratory, as a "subsidy" to pay for research. Some of this funding found its way to universities to tap into specific areas of competency and capability and was managed on a collaborative "laboratory based" model. The new knowledge created would be given away for free. When the R&D department (perhaps in collaboration with a university) came

[76] David C Mowery and Richard R Nelson, "The US Corporation and Technical Progress," in *The American Corporation Today*, ed. Carl Kaysen (New York: Oxford University Press, 1996).

up with something it gave it back to the company – for free.[77] This process was, however, very expensive and resource intensive. Paul Romer points out that:

> The command control – tax, subsidy mechanism is not the perfect solution. While there are a billion haystacks in which there will be some very valuable needles, it is very expensive to look under every one. It is also the case that the research effort gets spread very thinly.

It has become clear to businesses that they cannot just give scientists lots of money and let them follow their curiosity (although this does not imply that there is no value to businesses in basic research). But if they do, the "tax subsidy" system dissipates efforts and does not lead to the highest return to shareholders. As a result, companies are beginning to create market type mechanisms that impose market tests on research.

Research units are increasingly being set up as profit centres, and in some cases outsourced or spun-out entirely as separate entities. As a result of these trends, the model under which businesses enter into open-ended relationships with universities to undertake collaborative research is being superseded. Similarly, university research centres are established with a financial return in mind.

Industrial research is increasingly being approached on the basis of a capital expenditure/investment appraisal decision, and on a project-by-project basis, using a "business" management model. Internal research divisions now charge different divisions for any of the results they produce that other divisions use. These divisions are also being "market tested" against independent research laboratories, including publicly funded research organisations and universities.

In the corporate environment, research and development capability is no longer regarded as a critical strategic asset and a barrier to competitive entry in some industries. Large companies have traditionally done most of the research, including basic research, in their respective industries – DuPont, Merk, IBM, GE, AT&T. Now, these companies are finding strong competition from newer companies – Intel, Microsoft, Sun, Oracle, Cisco, Genentech, Amgen – who do little or no basic research on their own. They have innovated with the research discoveries of others. Research capability is acquired through acquisition of technologies developed in start-up companies.[78]

An important aspect of industrial innovation is now based on creating start up companies to develop and market new discoveries and "disruptive" technologies to end-users. These users may be a final consumer but, more likely, will be an established corporation further along the industry value chain. These features are apparent in the life sciences, information or communications industries. The creation of these start-ups, based on knowledge assets, and little in the way of "complementary assets" such as buildings, plant and equipment, has been facilitated by the availability of a new form of risk finance – venture capital. This aspect of industrial innovation explains the interest in "spin-outs" from CRCs.

The larger corporations that use these technologies in taking new products and services to market (for example, computer hardware, telecommunications and phar-

[77] Joel Kurtzman, "An Interview With Paul Romer," in *Thought Leaders: Insights on the Future of Business*, ed. Joel Kurtzman (San Francisco: Jossey Bass, 1998).
[78] Henry Chesbrough, *Open Innovation: The New Imperative for Creating and Profiting from Technology*. (Boston: Harvard Business School Press, 2003)

maceutical companies) invest less in internal R&D and more in "scouting" and acquiring technology and start-ups. Alternatively, they can enter into meaningful strategic alliances with small and medium sized companies whose business model is to increase the value of the technology/discovery and sell it on fast. More generally, outside perspectives and competencies flow into and out of organisations through many routes:

- Partnerships with universities.
- Alliances and acquisitions.
- External venture investments.
- Recruiting and hiring.
- Customers and suppliers.
- Relationships and curiosity of individual employees.

These sources of external influence have played pivotal roles in all aspects of corporate innovation.[79]

Many established companies have also found that much of their basic research wasn't useful to them. They exited or abandoned projects – only to have them taken up by start-ups and turned into valuable companies. This form of "open" innovation is contrasted to "closed" innovation models in the following terms.

Figure 8: Closed vs. Open Innovation

Closed innovation	Open innovation
Industries: Agriculture, mining	Industries: Information, Communications, Pharmaceuticals
Largely internal ideas	Mainly external ideas
Low labour mobility	High labour mobility
Little venture capital	Active venture capital
Few, weak start-ups	Numerous start-ups
Universities unimportant	Universities important

Source: Chesbrough, Henry. *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Boston: Harvard Business School Press, 2003.

Within this overall context there appears a broader trend of companies in many sectors cutting back on their long-term in-house research. This trend increases the importance of the role played by research organisations with close industry involvement as they build up the 'R&D corporate knowledge' of a sector. However, the trend does not apply to all sectors.

The nature of industrial research in health-related fields is long, expensive, risky and heavily regulated. The role of IP, and patents in particular, is vital. Because of the length and cost of the developmental phase, companies need an exclusive right (through a patent) to recoup these development costs. This makes the idea of having more than one commercial partner involved in particular projects quite fraught.[80] In contrast the CRC for Photonics has a large number of partners, including SMEs, as

[79] John D Wolpert, "Breaking Out of the Innovation Box," *Harvard Business Review* 80, no. 2 (2002)
[80] Consequently, the CRCs for Cellular Growth Factors, Inflammatory Disease, Cochlea Implants, Diagnostics, Discovery of Genes for Common Human Diseases, and Vaccines, all only have one commercial partner

does the CRC for Cast Metal Manufacturing. The Programme should retain the flexibility to cover the various needs of all industry sectors.

Emerging industries often have less research and industry infrastructure (and less of a track record) to draw on than more established areas. Companies are often small and face difficulties fully engaging with other research organisations and other firms. This can work against proposals from such sectors in the CRC selection process. A CRC can have a significant catalytic effect on the growth of such industries and this potential ought to be given weight in the selection process.

2.4 Changes in the higher education system and orientation of public research agencies

The unified national system introduced in 1988, together with a continuous flow of policy changes and constrained public funding, has created a series of management challenges as well as major opportunities for universities to participate in a broader and growing market for teaching and research services. The higher education sector has gone through, and is continuing to adjust to a process of "industrialisation". The changes that have occurred are often referred to as an academic "revolution" in the higher education sector.[81] This revolution, which has also occurred in Europe and North America, shares many of the characteristics of prior processes of industrialisation.

To many, the "academic revolution" involves the translation of research into new products and new enterprises together with an increasing reliance by businesses on knowledge originating in academic institutions.[82] Whilst a great deal of the discussion and discourse in the literature on knowledge commodification and knowledge capitalism is concerned with scientific and technical knowledge, the "academic revolution" relates as much to the teaching and advisory activities provided by higher education personnel.

These changes are occurring in a broader context of evolution of the "mode" of knowledge production. Knowledge creation is becoming increasingly distributed in the context of the global knowledge economy, with the role of universities changing from the familiar mode (mode 1) involving generation in disciplinary contexts – to a system of production that occurs in broader trans-disciplinary contexts and arises in the process of application and adoption in business, industry and government (mode 2).[83] That is, mode 2 knowledge production occurs in many different sites and in many heterogenous contexts of application.

Universities are unique in this process in that they produce both knowledge and train future knowledge producers; they contain strategic sites, or home bases, of both research and science. This feature of the new production of knowledge is a central feature of the CRC system: CRCs create industry relevant knowledge as well as training future knowledge producers for industry.

[81] An industry is characterised by the existence of producers and consumers, the production of commodities (goods and services) that have an exchange value.
[82] Henry Etzkowitz, Andrew Webster, and Peter Healy, eds., *Capitalizing Knowledge: New Intersections Between Industry and Academia* (New York: State University of New York Press, 1998)
[83] Gibbons and others, *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*

The realisation that university based knowledge is of use to industry has also led to changes in the rules governing how universities and companies interact with each other – shifting the relationship from a 'eleemosynary' (electing to choose) to a business basis. The emergence of a business orientation involves not only the production of a commodity but also its marketing, as a product, to a customer (that is, an end user). It has meant that the function of technology transfer within a university environment involves much more than registering intellectual property rights; it involves its "packaging" and active marketing.[84]

Accordingly, technology transfer has become more complex with a large range of specialisations involved – IP law, technology marketing, corporate finance and management. In an industrial context, the concept of technology "transfer" becomes redundant; technology is produced, packaged and marketed in an exchange transaction. The process might also be "vertically integrated" and managed in an organisational framework – such as in a CRC. The interaction of market based and managed relationships is the subject of ongoing research.[85]

2.5 The emergence of university research centres

The emergence of new forms of knowledge creation has seen the emergence of the "university research centre" as the organisational and management vehicle.

University Research Centres are generally regarded as flexible, comprehensive research and education organisations, offering a research climate that focuses on product development, design testing, as well as the traditional basic research discovery activities. They are also seen as focussing on interdisciplinary research, technology transfer, and technical assistance to industry. They are expected to bridge the gap between academic applied research and the more narrowly focussed technology activities that hopefully lead to economic development in their own states and the global economy.[86]

There are many forms of research centre of which Cooperative Research Centres are a special category. In Australia, their distinguishing characteristic and feature is the involvement of government through the provision of funding, on a competitive basis, as a way of leveraging industry and university research effort and commitment. Apart from that, they do not reflect any specific research priority or direction. They also provide, through a seven-year funding arrangement and a legally binding joint venture agreement an element of stability in an increasingly dynamic and turbulent industry and academic environment.

The benefits of research centres in industrial research are seen to lie in the following attributes:

- Faculties involved in centres are often more involved in technology transfer.
- Centre research staff are advantaged in relationships with industry scientists.

[84] See Ron Johnston and John H Howard, "Engagement in An Era of Industrialisation," in *TBA* (2003).
[85] John H Howard, *The Industrialization of Higher Education: From Knowledge Creation to Knowledge Production* (Forthcoming)
[86] William R Tash, "University Research Centers Rising!," *Scipolicy* 2, no. 1 (2002)

- Centres are an important resource for employment for non-tenured scientists and post doctoral scientists until they find more permanent employment.
- They encourage scientists to become more involved in cutting edge technologies and interdisciplinary research.
- There is advantage for students in participating in hands on research and for later careers in industry.

Cooperative arrangements have, however, been criticised on the grounds that they still tend to focus on single disciplines[87] and that universities and researchers see industry funding as a way of underwriting their own research programmes and agendas. Some other problems often raised include:

- Weak and/or cumbersome governance arrangements.
- Lack of financial support from the host university and other research providers.
- Red tape in negotiating agreements and hiring personnel.
- Inadequate management support and infrastructure.
- Absence of faculty rewards for participation.
- Poorly trained centre managers who cannot bridge the gap between the "community of science" and the commercial drivers in the world of business.
- Inappropriate director appointments that lead to obsolescence in research creativity
- Competing demands for research and teaching.

The presence of research centres however is considered to be one of the factors stimulating the growth of the university sector - but their continued expansion is now requiring more rather than less university financial support. In this regard it is of interest that CRCs are heavily concentrated in Australia's largest research universities.[88] Smaller and regional universities, whilst involved in fewer CRCs tend to make heavy commitments to agricultural and natural resource management CRCs. During this Evaluation, all universities raised concerns about the commitment to providing cash in CRC applications.

Cooperative and collaborative research is projected to become an increasingly significant element in the higher education industry and government research activity. The form and extent of business involvement is evolving as companies move towards a system of "open innovation" where companies seek to distribute and acquire IP through licensing arrangements, joint ventures and other arrangements.[89]

Notwithstanding these beneficial outcomes, there are some concerns as well. These include the constraints that collaborations with commercial firms bring to freedom to publish their work, pressures on university research to shorten the time horizon for their technical vision, and the pressure that commercial financial interest may place

[87] Richard Florida, "The Role of the University: Leverage Talent, Not Technology," *Issues in Science and Technology* (1999)
[88] Monash University and the Universities of Adelaide, Melbourne, New South Wales, Queensland and Sydney each participate in 10 or more CRCs. The University of Queensland participates in 24.
[89] For a discussion of this development see in particular: Chesbrough, *Open Innovation: The New Imperative for Creating and Profiting from Technology*. and Henry Chesbrough and David J Teece, "Organizing for Innovation: When is Virtual Virtuous?," *Harvard Business Review* 80, no. 2 (2002), Henry Chesbrough, "The Era of Open Innovation," *Sloan Management Review* 44, no. 3 (2003)

on faculty duty to colleagues and students. The key to success in university-industry partnerships is seen to depend on the primary motive of each partner. That is:

> If the universities value the partnership as a means of exposing faculty and students to leading edge technical issues that are driving innovations of benefit to society, and are not basing their expectations primarily on revenues from patents, a stable, productive relationship may endure. If the firms see universities as sources of new ideas and as windows on the world of science, informing their own technical strategies, rather than viewing students as a low cost, productive source of near term problem solving for the firm, they too will be rewarded. Each partner must understand and accepts the other's priorities. The money and services exchanged should be seen as the means to broader ends.[90]

A recent trend has been for large business enterprises to enter into *long-term developmental research agreements* with universities that involve "umbrella agreements" with mechanisms for the selection of specific projects. Proprietary considerations, principally involving patent rights and rights to publication, tend to be rather detailed and complex and require formal mechanisms for management and review. The industry based CRC model, involving multiple participants, is not well suited to this sort of arrangement.

The most significant barrier that inhibits effective research partnerships relates to intellectual property concerns and specifically patenting rights. Matters concerned with intellectual property management are canvassed briefly below.

2.6 Ownership and control of Intellectual Property (IP)

The ownership, control of, access to, and returns from the sale and/or licensing of IP is a major issue in public-private research partnerships and in the commercialisation of publicly funded research. It occupies a great deal of the time of corporate lawyers and taxation accountants in the negotiation of agreements. Much of this negotiation is premised on the prospect of substantial income and/or capital gains flowing from the commercial application of IP and how those returns should be distributed.

In the United States the *Bayh-Dole University and Small Business Act* encouraged universities to protect the intellectual property created from Federal funds and license it to the private sector. This initiative has largely been seen as a success. A number of problems have emerged in the biotech-health sciences area where researchers are getting too dependent on the provisions of the Act and are "torquing their research", keeping their results to themselves and not discussing it with other researchers because they do not want to do the patent work up front.[91] Policy makers are now seeing a need to get the best out of the Bayh Dole provisions but not impede the science by keeping it bottled up and not getting an outcome.[92].

[90] Lewis Branscomb, "Research Partnerships in Public Policy," (United States Congress, House Committee on Science, Task Force on Science Policy, 2003)

[91] United States. Department of Commerce Technology Administration, *Innovation in America: University R&D* (Washington, 2002).

[92] For example, because of the many ways of gene expression, a company may have to license many intellectual properties making the royalty requirements to universities wipe out any profits. Some patents –eg a gene sequence – create a bottleneck and anything done beyond that requires a license. Some universities cannot do their work or they have to license a patent to do so. Thus, the problem with the Bayh Dole provisions is that it is possible to patent essentially the tools of research – gene line, cell line, a gene, or a way to manipulate the gene. This has worked to hinder biomedical research

The reality is that most patents are worth very little and it is hard to know in advance which patents have any value. There is an assumption often made by people tasked with valuing IP that technology assets have some inherent value independent of any business model used to employ them. *Technologies embedded in IP only have value when commercialised through a business model.*[93]

Much of the work in managing IP undertaken in a university and public research organisation context assumes that there is some objective value for a technology separate from how it is commercialised. The result is that proactive IP management misses some key issues. Specifically:

> Technologies acquire economic value when they are taken to market with an effective business model. When research discoveries are driven by scientific inquiry and not connected to any business purpose, the commercial value of the resulting discoveries will be serendipitous and unforeseeable. Unsurprisingly, most of these discoveries will be worth very little, although a few may be worth a great deal – once they are connected to the market through some viable business model.[94]

Within a CRC context, research providers need to be educated about the way in which research relates to the business models of the research users so that researchers can understand the potential connections early on in the process. At the same time, research users become concerned when researchers endeavour to develop business models that do not fit the models of the participants, or in which participants seen no economic or commercial merit.

This suggests that in some cases CRCs could be justifiably created without a research user having an established business model. This may mean that there are no established research users willing to participate in the CRC. This will most likely occur when a CRC is involved in the development of "disruptive" technologies. In such cases governments acting as "state entrepreneurs" may represent "potential users". Venture capital investors may also be involved. This trend is occurring in CRCs established to develop new businesses in new technology areas.

2.7 The "collaboration continuum"

Collaboration is often seen in terms of a continuum moving from a situation of "opportunistic" access to funds, through more formal transactional arrangements, to an integrated and seamless strategic alliance. The features of this continuum are summarised in Figure 9.

Figure 9: Features of Collaboration Relationships

	Opportunistic	Transactional	Integrative
Nature of the relationship	"Gifts" are made to support the "good work" of a research organisation – based on the reputation, past achievements, perceived importance of the research and promotional capabilities of the researchers and sponsorship managers.	Resource exchanges through specific activities and formal agreements in relation to support provided and research services that are to be provided.	Missions, people, and activities are more collective and organisationally integrated – a joint venture that is central to both; strong personal interactions – at director level; processes and procedures to manage growing complexity.

[93] Chesbrough, *Open Innovation: The New Imperative for Creating and Profiting from Technology.* p.156.
[94] Ibid. p. 161

	Opportunistic	Transactional	Integrative
Collaboration mindset	Gratefulness and appreciation Minimal collaboration in defining activities. Separateness.	Partnering Increased understanding and trust.	"We" mentality in place of "us" vs. "them".
Strategic alignment	Minimal fit required beyond a shared interest in a particular issue area.	Overlap in mission and values Shared positioning at top of organisation.	Broad scope of activities and strategic significance. Relationship as a strategic tool Shared values.
Collaboration value	Generic resource transfer Unequal exchange of resources.	Core competency exchange More equal exchange of resources. Projects of limited scope and risk that demonstrate success.	Projects identified and developed at all levels in the organisation, with leadership support. Joint benefit creation; need for value renewal. Shared-equity investments for mutual "return".
Relationship management	Corporate contact person usually in R&D department; university contact person usually directly involved in research; corporate personnel have minimal personal connection to cause. Project progress typically communicated via written status report. Minimal performance expectations.	Expanded personal relationships throughout the organisations Strong personal connection at leadership level. Emerging infrastructure, including relationship manager and communication channels. Explicit performance expecta-tions. Informal learning.	Expanded opportunities for direct employee involvement in relationship. Deep personal relationships across organisations. Culture of each organisation influenced by the other. Organisational integration and execution, including shared resources. Incentive systems to encourage partnerships. Active learning process.
Funding,/financing	*Grants*	*Conditional, specific purpose*	*Investment*

Based on and adapted from James E Austin, The Collaboration Challenge: How Nonprofits Succeed Through Strategic Alliances. San Francisco: Jossey Bass, 2000, pp.36-37

Relationships move along a "continuum" from the opportunistic to integrative. The progression is not automatic: it results from conscious acts and efforts. It is also multifaceted and strategic. Over the last 12 years participants in the CRC Programme have moved their focus from the "opportunistic" to the "integrative" form of collaboration. This has implications for Programme design, participant involvement and CRC management.

A critically important issue for the CRC Programme, CRC participant organisations and CRC management is where *they want to be* on the continuum on the path to application and use of research outcomes.

2.8 Conclusion

The institutional framework for public private industrial research collaboration has undergone a substantial evolution over the last decade – the period in which the CRC Programme has been operation.

A feature of the evolution is not only the emergence of a greater level of cooperation and collaboration between research providers and research users but also a focus on the *value* of interactions and a growing *marketisation* of those relationships. With corporations giving greater attention to market relationships in the management of their research programmes, and the increasing attention of universities and public research organisations on the marketing of knowledge assets, university-industry interactions are increasingly being conducted in a trading relationship.

At the same time, partners in industrial research relationships have been giving greater attention to the management of their collaborative relationships. Loose, opportunistic alliances are giving way to more strategic, integrative relationships.

This has, in turn, raised the need for management skills and capabilities that are specifically focussed on effective alliance management.

These developments have substantial implications for the future design of the CRC Programme.

3: Related Policies and Initiatives to Promote Public-Private Industrial Research Collaboration

The purpose of this Section is to identify and comment on policies and programmes that relate to linkages between research and application. The Terms of Reference specifically sought comments in relation to:

- The National Research Priorities.
- Australian Research Council (ARC) Centres of Excellence, Linkage and (proposed) Networks.
- CSIRO Flagships.
- National Health and Medical Research Council (NHMRC) programmes.
- Major National Research Facilities (MNRF).
- National Industry Action Agendas.

In addition to publicly supported collaborations, there is also a substantial amount of collaboration between research providers and users that occurs on a bi-lateral basis.

3.1 National Research Priorities

In December 2002 the Prime Minister announced four national research priorities and their associated priority goals:

- An Environmentally Sustainable Australia.
- Promoting and Maintaining Good Health.
- Frontier Technologies for Building and Transforming Australian Industries.
- Safeguarding Australia.

These four areas are intended to provide a vision for research by focusing research effort on key challenges for Australia currently and into the future.

As indicated in Part I, the currently operating CRCs fit well within the Research priorities. In particular, the emphasis of the Programme in agriculture and the environment has a very strong orientation towards sustainability. Similarly, the health and medical CRCs are directed towards the "good health" purpose.

Frontier technologies lie behind many of the mining, manufacturing and information and communication technology CRCs. The involvement of DSTO in several CRCs also addresses the final goal.

3.2 Centres of Excellence

ARC Centres of Excellence Programme covers research in predominantly emerging, enabling or platform technologies, where there is wide potential application across various fields or industries. For Centres with funding commencing in 2003 the following priority areas were identified as a basis for selection: Nano-Materials and Bio-Materials; Genome/Phenome Research; Complex/Intelligent Systems (CSI), and Photon Science and Technology (PST). In addition to centres funded in these categories, the ARC funds a further 27 centres around Australia

The objectives of the ARC Centres of Excellence program are to:

> a) undertake highly innovative research at the forefront of developments within the designated Priority Areas, with a scale and a focus leading to outstanding international and national recognition;
>
> b) promote research that will enhance Australia's future economic, social and cultural wellbeing;
>
> c) link existing Australian research strengths and build new capacity for interdisciplinary, collaborative approaches to address the most challenging and significant research problems;
>
> d) build Australia's human capacity in the Priority Areas by attracting, from within Australia and abroad, researchers of high international standing as well as the most promising research students;
>
> e) provide high-quality postgraduate and postdoctoral training environments for the next generation of researchers in the Priority Areas;
>
> f) offer Australian researchers access to world-class infrastructure and equipment, and to key research technologies;
>
> g) develop relationships and build new networks with major international centres and research programs that help achieve global competitiveness and recognition for Australian research;
>
> h) establish Centres of such repute in the wider community that they will serve as points of interaction among higher education institutions, Governments, industry and the private sector generally; and
>
> i) raise awareness of the designated Priority Areas in Australia, particularly their importance in innovation and international competitiveness.

Cross referencing CRC objectives, selection criteria and general attributes with those of the Centres of Excellence Programme indicates that whilst the programmes have significant operational similarity, they also have important points of strategic difference. These are summarised in Figure 10.

Figure 10: Comparing the CRC Programme with the ARC Centres of Excellence

	CRC Programme	Centres of Excellence Programme
Scope	Researchers and proposals from all the physical and biological sciences and hence there are CRCs that cover different industry sectors. All CRCs must pursue some form of industry uptake of their research.	The ARC Centres of Excellence are presently confined to four priority areas of research
Engagement with industry	Researchers jointly commit over seven years to support the CRC, providing resources (both cash and in-kind) that match or exceed the Commonwealth's cash funding	Engagement with industry collaborators in ARC Centres of Excellence is not mandatory.
Research outcomes	CRCs have an expectation and a performance requirement to transfer research outputs into commercial or other outcomes of economic, environmental or social benefit.	Although "likely to make discoveries that have the potential for development to the point of commercial application", there is no expectation in the short or mid-term. They would not necessarily seek input from industry nor have industry partners involved in the Centre Management unless of their own choosing.
Research focus	CRCs are required to pursue research excellence in a wider portfolio based manner, with both short-term and longer-term projects, with part of their R&D portfolio industry led or aligned.	Focus is on more long-term curiosity or discovery based research areas.
Scope	CRCs support and fund medical science and technology related research.	ARC does not fund this area and cooperatively manages a divide with the NHMRC in pursuit of such research.

Other than these major and important distinctions, as well as those of scale and scope and resources, the two Programmes support similar areas of research.

Under funding from *Backing Australia's Ability* National Centres of Excellence have been established in information and communications technologies and biotechnology–

- The ICT Centre of Excellence: National ICT Australia (NICTA)
- Biotechnology Centre of Excellence: National Stem Cell Centre)
- The Australian Centre for Plant Functional Genomics.

The National Food Industry Council, funded under the *Food Industry Action Agenda*, agreed in 2002 to the establishment of two food centres of excellence in:

- Food Safety and Integrity
- Human Health Functionality of Foods.

There are potentially strong and close relationships between Centres of Excellence and CRCs insofar as the CRC Programme has a focus on the commercialisation of research and building links with industry and technology investors.

3.3 ARC Linkage programmes

ARC linkage[95] includes programmes designed to foster industry collaboration. The programmes support collaborative projects between higher education researchers and industry and must contain an industry contribution. The interaction with users of research outcomes is a critical element.

The key objectives from an industry collaboration perspective are to:

- Encourage and develop long-term strategic research alliances between higher education institutions and industry in order to apply advanced knowledge to problems and/or to provide opportunities to obtain national economic, social or cultural benefits.
- Foster opportunities for postdoctoral researchers to pursue internationally competitive research in collaboration with industry, targeting those who have demonstrated a clear commitment to high-quality research.
- Provide industry-oriented research training to prepare high-calibre postgraduate research students.

The research may span from pure basic, to strategic basic to applied research. Funding support is on a project basis and supports people development at various stages of their career plus project maintenance, equipment and travel. There are controls of overlaps in funding of CRC activities.

The distinguishing features between the CRC Programme and the Linkage Programme are primarily:

- Purpose – Linkage is project based, typically on a bilateral not a multiparty basis, and has considerable focus on people development.
- Scale and duration of funding – Linkage funding is for a one to five year project with an industry partner who must contribute cash and in-kind to match ARC funding $ for $; the minimum grant size is $20,000 per annum and the maximum is $500,000 per annum.

[95] See http://www.arc.gov.au/grant_programs/linkage_projects.htm

In the view of some, the more simple bilateral nature of the linkage programme eliminates the complexity of working in a multiparty agreement in a CRC context.

In 2002, a total of 736 industry partners from around Australia contributed investment to research under Linkage projects. The ARC 2002 investment of $78.2 million in Linkage project grants and awards attracted $120.2 million in matching contributions, in cash and in-kind, from industry project partners. In the same year, the ARC awarded 397 postgraduate scholarships and 32 postdoctoral fellowships to researchers seeking to work in partnership with industry[96].

Linkage projects also cover other aspects of research support such as infrastructure and people development. Research infrastructure consists of the institutional resources essential for mounting high-quality research projects in a particular field, including associated indirect costs. The ARC provides funding to support the collaborative development and shared use of large-scale research facilities and equipment.

In 2002, support is being provided for 70 research infrastructure development projects around the country. An investment of $27.2 million is attracting contributions from partner institutions to enable the purchase of equipment and facilities to a total value of $48.6 million[97].

3.4 Proposed ARC Network programme

The ARC is proposing a new Networks Programme,[98] the purpose and conditions of which are:

- To provide an environment supporting highly creative, inter-disciplinary research that is not averse to risk-taking, and which aims to move a field forward or create exciting, novel research themes.
- To assist groups of researchers to coordinate and communicate their research activities across disciplinary, organisational, institutional and geographical boundaries.
- To encourage and fund an open exchange of information and sharing of resources, development and implementation of coherent and integrated research plans among researchers working independently on topics of common interest, and efforts to nurture the careers of young investigators and research students by promoting a sense of community and strong, effective mentoring.
- To bridge between university-based researchers and teams who are eligible to receive ARC funding assistance, and researchers working in, or supported by, other research bodies and research funding bodies, with a focus on relationships between *people* rather than *organisations*.
- To provide for extremely flexible relationships between organisations involved in Networks.

[96] Australia. Prime Minister, *Backing Australia's Ability: Real Results, Real Jobs: The Government's Innovation Report 2002-03* (Canberra: Department of Education, Science and Training, 2002)
[97] Ibid.
[98] See http://www.arc.gov.au/grant_programs/centres_networks/research_networks.htm

ARC Research Networks will be funded at up to $500,000 per annum for up to five years, with approximately 15 networks funded at this level. The ARC does not intend to restrict participation in Networks to research professionals but will encourage participation by end-users, policy makers, and members of the community with particular knowledge and skills. Funds cannot be used for activities funded under other ARC programmes.

The proposed Programme makes no specific comment on relationships to CRCs, and the proposal appears complementary to and not overlapping with CRCs objectives.

3.5 CSIRO Flagship programme

The CSIRO National Research Flagships initiative aims to deliver scientific solutions to advance six national objectives:

- Strong, sustained economic growth, new industries, competitive enterprises and quality jobs.
- Healthier, more productive lives for Australians.
- Clean, cost-efficient energy.
- More productive and sustainable use of water.
- Sustainable wealth from oceans.
- Growth and prosperity for regional Australia.

Each Flagship addresses two or more of these overarching national objectives, and the initiative as a whole is closely aligned to the Commonwealth Government's National Research Priorities.

Every Flagship is a partnership of leading Australian scientists, research institutions, commercial companies, CSIRO and selected international partners. Together they are expected to make a sustained contribution to our economic and social growth and sustainability over a 25-year period.

Flagships will focus, integrate and re-direct existing scientific resources to issues of pressing national importance. They are targeted initially at six fields of national endeavour - health, energy, water, agrifood, light metals and oceans. In these fields they seek to achieve technological revolution, in the sense of discovering, developing, commercialising and applying frontier technologies to dramatically improve performance and, wherever possible, set world-best standards.

Each Flagship is intended to stand at the heart of an industry export cluster - many of these being new industries. Potential interactions with CRCs occur in a number of areas. The CRCs, with a focus on adoption and application provide a basis for the development of strong linkages between research providers and research users.

3.6 NHMRC programmes

The NHMRC has an interest in the work of nine CRCs in the Medical Science and Technology area, and strong working relationships with many of the scientists and personnel in these CRCs.

The NHMRC have established industry - linked programmes[99] as a result of the Wills Inquiry and Report. The two major programmes now established by the NHMRC are:

- Development Grants – designed to support the development of health and medical research that has a commercial potential and which has a potential to benefit the Australian community.

  These are targeted to provide support for research commercialisation at the early proof-of-concept stage and while commercial partners, if they exist, are encouraged, it is not a requirement that applicants have a commercial partner in place. The grants are for one year, not more than $200,000 and cover activities in development of diagnostics, medical devices, pharmaceutical product development, biotechnology, bioinformatics, biomaterials, new medical device prototypes etc.

  CRCs have been successful applicants for these grants (about 6 of 22 applications in the last round).

- NHMRC Industry Fellowships – designed to provide support for Australian researchers to gain experience in industrial research including business planning, project planning, and knowledge of business and industry dynamics and to increase knowledge of commercial aspects of R&D within research institutions. These fellowships target outstanding researchers who spend up to two years in industry and two years in a research institution. The fellowships have been established to foster interaction between Australian researchers and high technology industries.
- Health Research Partnership Grants aim to solve or prevent complex health problems through multi disciplinary research. The cost of the research is shared amongst partners with a contribution (if application successful) from the NHMRC. Partners can be drawn from the domains of basic, population health, health services and social policy research and from outside the health area as appropriate. It has included partnerships with industry in injuries, diabetes and metal health.
- The NHMRC are considering new programmes in health networks.

These NHMRC programmes are not of the same scope or size of the CRC Programme. They operate in the limited medical science and health services and have complemented and supported the CRC Programme in these areas.

3.7 Major National Research Facilities (MNRF)

The MNRF Programme funds R&D facilities[100] to provide Australian researchers with access to *large-scale*, world-class *research infrastructure*. As such they are centres devoted to assembly and use of expensive research infrastructure eg laboratories and major equipment. The MNRF Programme funds facilities on the basis of potential national benefit and scientific merit. The objectives of the programme are to:

- Improve Australia's capability in science, engineering and technology

[99] See http://www.health.gov.au/nhmrc/research/develop.htm
[100] See http://www.dest.gov.au/MNRF/

- Maintain support for the rapid commercialisation of research results.

MNRF proposals have been approved with the Commonwealth providing up to 50 percent of the MNRF total eligible project costs with the balance provided by participant organisations, supporting agencies and users of the facility. Some of these facilities are progressing to commercial status in that they have formed operating companies and/or are associated with commercial ventures. The expectation in their formation was that they would attract use and industry support, but that it was not mandatory.

The CRC Programme has no direct overlaps with the MNRF, other than the latter provides in some cases the facilities and capabilities that CRCs may wish to use, rather than duplicate. A CRC may provide the operating environment for a MNRF – as is the case with the Australian Photonics CRC.

A CRC proposal is being developed for the Australian Synchrotron facility based in Melbourne.

3.8 Industry Action Agendas

Action Agendas are a major part of the Commonwealth Government's strategy to assist the long term development of Australian industry. Action Agendas have been established in a number of sectors including the Environment Industry.[101]

Action Agendas are intended to provide a flexible model for industry to consider and develop sectoral priorities, and to plan for the future in partnership with government. They provide a process to enable industry direction for a whole-of-government approach on key issues such as innovation, investment, market access, regional development, education and training, environmentally sustainable development, workplace relations and regulatory reforms.

There are currently 29 Action Agendas at various stages including four under development and 16 that are being implemented through the adoption of recommendations. Nine have been fully implemented.

Outcomes under Action Agendas have included new industry-led CRCs in construction, wood manufacturing and spatial information.

3.9 Other forms of public-private industrial research partnership in Australia

A review of 2002 University Research and Research Training Reports has identified a number of significant industrial research partnerships between universities and businesses that are not built around public programme support. These are identified in Figure 11. The listing does not include university initiatives for business incubators and technology precincts.

[101] Australia. Department of Industry Science and Resources, *Action Agendas* (Canberra: AGPS, 1999)

Figure 11: University-industry Relationships without Public Programme Support

University	Relationship
ANU	BlueLab (Taiwan) has set up R&D laboratories on campus
Deakin	The Ford Australia Program - A long standing partnership between Ford Australia and the University. It began as a specialised training program and has evolved into a major research and development enterprise with a particular focus on research training of direct relevance to industry.
Griffith University	A University contract with AstraZeneca (London and Sweden), which is the largest pharmaceutical research and development project in Australia. Unexpended support exceeds $70million.
Monash	Location of Biota laboratories for chemistry and microbiology within the faculties of Science and Medicine respectively BHP research teams for railway maintenance and engineering in the Engineering Faculty
University of Adelaide	Santos – provided $25m to sponsor the University's education, research and education programs in petroleum engineering Hickinbitham Roseworthy Wine Science laboratory on the Waite campus Colgate has provided $3m to support a Clinical Dental Research Centre
University of Western Australia	A strategic partnership with Motorola through the development of a $50 million software engineering centre. An investment of $7.5 million by Samsung Corning, which joined with the UWA spin-off company Advanced Powder Technology Pty Ltd to form a new company – Advanced Nano Technologies (ANT).
UTS	UTS and Alcatel have entered into a special Education and Research Partnership which includes the establishment of an innovative Centre for Telecommunications Systems for collaborative research and development.
Victoria University	Victoria University and the Austin Research Institute (ARI) are the major partners in the establishment of the Victoria Institute of Biotechnology (VIB), a $35m project at Werribee.
Western Sydney	The Centre for Construction Technology Research, a collaborative arrangement involving the transfer of over $2 million of assets and annual research funding of almost $700K from BHP to UWS
Wollongong	The BHP Centre for Steel Products and Processes, which during 2000 received a renewed commitment for funding of $500K per year for 5 years A collaboration between the Digital Media Centre and Sun Microsystems, aimed at UoW becoming a Sun Partner University.

The trend towards industrial partnering directly with universities reflects the pattern that has emerged in North America and Europe. It raises the issue about where public policy and programmes to support public-private research partnerships should be directed and with what outcomes in mind. This issue is taken up in the following Section.

3.10 Overseas programmes and policies that support public-private industrial research collaboration

As part of the Evaluation reference an analysis was undertaken of similar policies and programmes in the United States, Canada, United Kingdom and New Zealand relating to public-private partnerships for industrial research collaboration. The programmes included

- Cooperative Research and Development Agreements (United States)
- National Centres of Excellence (Canada)
- Faraday Partnerships (UK)
- Research Consortia (New Zealand)

These programmes contain many of the design features of the CRC Programme. Of interest is the adoption of a staged, negotiated application processes in some programmes, commencing with expressions of interest and followed by submission of additional material and dialogue - and an opportunity for the Selection Panels to provide additional strategic input and brokering with other participants.

3.11 Conclusion

It is apparent that the current national context in which CRCs presently operate, and the operating environment of the major participants is undergoing substantial change. There has been over the last ten years a substantial increase in the range of public programmes that support university-industry collaboration and cooperation.

From this perspective it is important that the CRC Programme be clearly identified in terms of its purpose and "distinctiveness". These relate, in essence, to the expectation that the Programme reflects a "demand pull" from industry (industry driven) and the focus is on the application, adoption and use of research results.

Both the ARC and NHMRC have made changes to their programme portfolios since the early 1990s, since the start of the CRC Programme. ARC Linkage programmes require 50:50 cash and in-kind contributions from an industry partner. Other programmes urge recipients of awards to try to leverage their grants against industry funds. The CRC Programme by comparison has been able to successfully leverage research user funding in a ratio of 3:1.

Since the Wills Review[102] and *Backing Australia's Ability* the ARC and NHMRC have used their greater funding to extend their activities well beyond basic research grants and have now minor but significant fractions of their funds to build their industry research collaboration portfolios. This is focussed particularly in people development programmes, designed to better engage researchers within the commercial/industrial environments. There is also a range of industry support and incentive programmes – although none provide assistance and support at the CRC level.

The Major National Research Facilities (MNRFs) have also developed alongside the establishment of CRCs. MNRFs also now require matching funding, meaning more resources from universities and supporting research institutions have been required to attract Commonwealth funds. The major research universities have typically enjoyed greater success at winning such grants and funds (represented in terms of size, but not necessarily in proportion to overall research funding), and consequently have had to make greater commitments.

The future direction of the CRC Programme is this environment, together with the changing industrial research environment, is considered in the next Section.

[102] Australia. Health and Medical Strategic Review, *The Virtuous Cycle: Working Together for Health and Medical Research* (Canberra: Australian Government Publishing Service, 1999)

4: Future Directions for the CRC Programme

The purpose of this Section is to draw together material in the previous Sections relating to the changing industrial research and policy and programme environments and provide a perspective on the evolution of the CRC Programme during the course of its operation.

4.1 Categories and "trajectories"

The CSIRO noted in its submission that it is important to recognise that CRCs fall into different categories. In particular, there is a major distinction between:

- CRCs operating in a clearly commercial context and whose outputs will require investment by industry or business to produce rewards.
- CRCs working in the "public good" arena , which will often require government or community participation to capture the benefits of the research.

CSIRO points out that the pathway to the effective utilisation of research outputs is different between these two cases. For example, some of the detailed agreements necessary to manage and identify ownership of IP that are necessary in the former case may be unnecessary or even counterproductive in the latter.

Many other submissions pointed to a difference between commercial and public good CRCs. While the distinction has strong currency, the two categories share a common purpose in that they are both required to deliver economic, environmental and social benefits. The national benefits that may accrue from a "public good" CRC in the area of salinity abatement, for example, may deliver economic outcomes running into $billions in terms of improved agricultural practices.

The issue for the CRC Programme is that there must be a clear path to adoption – even if that path takes many years.

It is also the case that many CRCs share commercial and public good outcomes. CRCs in agriculture, mining and the medical areas deliver commercial benefits to participating companies and also general industry as well as community benefits through widespread adoption and use. This reflects the well argued "spill over", or "externality effect" of industrial research and development. The issue of the public benefit-commercial benefit split is less relevant when the CRC Programme is viewed from a broader perspective of national industrial research and development and capacity building.

Within this context it is nonetheless possible to identify three quite distinct trajectories in the evolution of the CRC Programme, and which have relevance for its ongoing development in the national science, industrial research and innovation system.

- CRCs that operate as *national benefit* research centres – with a strong focus on resource sustainability
- CRCs as *industrial research collaborations* – which have a strong focus on cross industry performance improvement
- CRCs as *business development centres* – which have a strong focus on research commercialisation in individual companies.

The basis of the differentiation is that not only are the paths to adoption, application and use different, the processes for selection, approval, funding, monitoring and reporting should be adapted to differing needs and requirements. The differences are outlined below in terms of models or types:

Figure 12: Trajectories in the Evolution of the CRC System

	Category 1	Category 2	Category 3
Mission Orientation	National Economic, Environmental and Social Benefit	Industrial Research Collaboration.	Business Development.
Nature of the Collaboration	Strategic and structured to resolve issues of national economic, environmental and social significance	Transactional. Reflects trend towards distributed systems of knowledge creation	To "commercialise" research through the creation of new business models – in existing or in new enterprises.
Research focus	New discoveries, new knowledge that may have, or the potential to have application over the longer term. Strong science focus.	Application of existing knowledge to develop technologies that have an industrial application. Strong technology focus.	Applications technologies in products that meet an identified or potential customer need. Strong market focus.
Leadership and Direction	Chief Researcher with strong academic research background.	R&D Manager with industrial research background.	Entrepreneurial Manager with experience in starting businesses.
Nature of Benefits	Increased scientific knowledge and intellectual capital and knowledge available for application for national benefit.	Platform technologies available to industry.	Experimental science and/or technology development leading to the development of intellectual property and the transformation into products and processes.
Distribution of Benefits	Broad and general distribution to the economy and society	Technology transfer across industry	New business formation based on ownership of IP assets.
Industry Partners	State natural resource management agencies.	Companies in global markets. Agriculture Departments and Rural RDCs acting for primary producers. Water services authorities.	CRCs. State governments acting as innovation agents. Venture capital investors (including corporate VCs).
Nature of Innovation	Exploratory.	Continuous/incremental.	Disruptive.
Examples	Natural Resource Management CRCs Biodiversity CRCs Public health CRCs	Mining CRCs. Composites, Alloys and Welding CRS Agriculture CRCs. Water Quality & waste management CRCs.	ITC CRCs, Biotechnology CRCs Medical Devices CRCs – Vision and Cochlear.
IP Management	IP important as a basis for marketing and/or adoption and supplementary income	IP less important than complementary assets.	IP a core strategic asset.
Funding and financing requirements	Long-term commitment, but with a strategy for transition.	Medium term - to provide incentive for industry partners to ameliorate developmental risk.	Short term – with opportunities for flow on and scale up
Exit strategy	Permanent Government Programme	Industrial R&D Institute.	New Technology Company.
Organisational characteristics	Stability and continuity.	Complexity in working with multiple stakeholders and interest.	Flexibility and agility.
Constraints on development	Orientation of academic researchers to discovery/ curiosity research; lack of commitment to implementation and adoption.	Shortage of managers credible in science, knowledgeable of IP and with business and commercial skills necessary to attract and meet needs of partners.	Shortage of managers with business and commercial skills necessary to develop technologies into products and sustainable business models.
Rational for government support	Long term economic, environmental and social benefits	Arguments relating to support for industrial research and development.	Arguments related to new business and associated research commercialisation.

	Category 1	Category 2	Category 3
Issues to address in current CRC programme	Encourage collaborations that involve long term commitment and potentially high level of resource commitment. Securing community involvement	Ability to resource fewer centres at significantly higher levels than at the moment. Securing long-term industry engagement.	More flexibility in application, assessment and monitoring processes; lower initial levels of funding. Securing venture investment
Major weaknesses	"Mini ARC" granting arrangement.	Research outsourcing; cost shifting. Industry finds difficult to commit for long term.	Difficulty in meeting current selection criteria relating to commercialisation hurdles
Major strengths	Continuity, commitment, stability.	Effective collaboration; economies from collective approach; focus on global competitiveness.	Innovative, agile, flexible.
Distinctiveness	Focus on application of scientific discoveries and user involvement.	Industry/user driven.	Opportunity driven; innovation focus.
Risks	Application driven funding models.	Anti competitive behaviours.	Business failures. Trust failures.

Further discussion on each category follows.

4.2 National Benefit CRCs

The primary purpose of national benefit CRCs is to deliver outcomes related to the preservation, restoration and repair of Australia's natural capital and the maintenance of biodiversity. They also have roles in public and environmental health and more recently in national disaster research.

During the 1990s, and particularly from 1996, there has been growing national policy interest and concern with natural resource management, environmental protection and sustainable agriculture. These issues have been approached from an intergovernmental policy and program framework where responsibilities are shared between the Commonwealth, the States and local government.

The significance of the policy interest was reflected in the report to the Prime Minister's Science, Engineering and Innovation Council, *Dryland Salinity and Its Impacts on Rural Industries and the Landscape*. The Report noted, for example, that while salinity is widely recognised as causing problems for agriculture it is less appreciated that dryland salinity causes serious damage to downstream water users, aquatic eco systems and biodiversity and to regional and urban infrastructure due to damage to foundations from shallow, saline groundwater[103]. The report also noted:

> There are clear market failures in that the costs of degradation to downstream users and to the environment are not borne by those benefiting from upstream exploitation of the landscape. In many cases the costs will be borne by future generations. Leaving it to the markets to resolve will cause serious and irreversible offsite impacts to biodiversity, rural infrastructure and downstream water users, as well as causing unnecessary hardship to landholders.[104]

It was also during this period that the contribution of science to the resolution of natural resource management problems received wider acceptance. This was re-

[103] Australia. PMSEIC, *Dryland Salinity and Its Impacts on Rural Industries and the Landscape* (Canberra: Department of Industry, Science and Resources, 1998) P.5
[104] Ibid. , p. 9

flected in another report to PMSEIC in 1999[105]. However, the critical issue is translating scientific knowledge into practical application. Thus, contemporary approaches to natural resource management require comprehensive strategies at the national, regional and community and level to develop new, sustainable land, water and soil management systems to repair and replenish natural capital and prevent further biodiversity loss.

It is now well recognised that the work of regional and community organisations is much more effective and sustainable when based on the application of scientific knowledge in strategies that address and reverse the pattern of natural capital degradation and biodiversity loss. Moreover, there is a very high level of awareness, understanding and acceptance among natural resource managers, rural industries and the community that sound environmental management is important to achieving the economic, environmental and social goals[106].

The CRC Framework is an important vehicle in natural resource management through facilitating cooperation and collaboration between universities, the CSIRO, the Rural Research and Development Corporations, State Government Departments and rural based industries. The scientific knowledge created and transferred through effective communication strategies provides the basis for implementation in the form of "on-ground" works and action by organisations operating at the regional and community level. There is, however, more that can be done to involve nongovernmental organisations (NGOs) in this process[107].

The outcomes of research adoption in the natural resource management area take many years to realise – but the economic benefits can be immense, in terms of the contribution to sustainable agriculture and minerals production and national water quality. This is apart from the benefits reflected in the maintenance of biodiversity and natural heritage assets. The critical issue in assessment of outcomes, however, is the integrity, validity and continuity of the planning and decision making processes that have been put in place for implementation.

In addition to universities and publicly funded research agencies, the participants in these CRCs are predominantly public sector organisations and agencies. In this respect the CRC Programme has complemented State Government effort in environmental research and facilitated the application of science to public policy and public programmes. The Programme is important in contributing a science input into Natural Heritage Trust Programmes and Regional delivery frameworks.

Natural Resource Management CRCs play an important role in building community capacity and involvement in natural resource management. That role should continue; the prospects for greater involvement of non-government organisations in environment CRCs should be approached in the same way as involvements of SMEs in more commercially oriented CRCs.

[105] Australia. PMSEIC, *Moving Forward In Natural Resource Management - The Contribution That Science, Engineering And Innovation Can Make* (Canberra: Department of Industry, Science and Resources, 1999)
[106] Howard Partners, *Review of the Administration of the Natural Heritage Trust* (Canberra: Department of Environment and Heritage, 1999)
[107] The barriers to NGO involvement in CRCs are similar to the involvement of SMEs in industry improvement and business development CRCs.

4.3 Industrial Research CRCs

The core focus of the CRC Programme has been on the development and operation of long-term industrial research partnerships. These arrangements have thrived in mature, commodity-based industries where there is a common concern with factors such as productivity, product quality and international competitiveness. Speed to market rather that intellectual property is the primary driver of business development.

The approach to invention and innovation is to develop industrial processes and practices that can be implemented across an industry. An objective is to let intellectual property out into the field as quickly as possible and promote its rapid adoption. There is an understanding that wealth creation will occur through broad industry adoption rather than returns to businesses acting alone.

The CRC Programme is highly regarded among research users for innovation in industrial processes and practices across the agriculture, minerals, energy, and water industries. These industries have a strong track record for collaboration in research and they exhibit strong leadership. Agriculture and mining operate in highly integrated, global supply chains while the water services industry is the responsibility of regionally based monopoly suppliers. Successful industrial research collaborations have also developed around materials sciences (composites), alloys and welding. Australia is a world leader in the manufacture of mining equipment as well as medical devices.

Industrial research collaborations also utilise the most powerful tool for effective diffusion of knowledge: the movement of young scientists, engineers and doctors from their university setting to the commercial world, taking their tacit and codified knowledge with them[108]. Graduate education and research training is regarded as a critically important dimension of the Programme.

Many of the outputs of supported research in industrial research collaborations do not necessarily take a tangible form, such as inventions, patents or prototypes. They are often intermediate outcomes – that is, pieces of intangible knowledge that help firms conduct their own R&D more efficiently, suggest ideas for new products or open up new domains for research. These intermediate outcomes can be transferred in numerous ways, including research papers, hiring of students and informal interactions.[109]

Some very large Industrial Research CRCs have emerged over the last 10 years and have made substantial contributions to development in their industries. They have established international reputations for innovation. They undertake research for businesses on an "outsourced" or contract basis and earn substantial amounts of revenue from this source. In some instances CRCs are competing with private research providers.

There are several CRCs operating as industrial research collaborations that have entered their third round of funding – implying continued Commonwealth support for

[108] Branscomb, "Research Partnerships in Public Policy,"
[109] Wesley M. Cohen, Richard Florida, and Lucien P Randazzese, "Industry and Academy: Uneasy Partners in the Cause of Technological Advance," in *Challenges to Research Universities*, ed. Roger G Noll (Washington: The Brookings Institution, 1998).

21 years. There is a risk that these partnerships will become "institutionalised" as research organisations in a manner beyond the intent of the Programme.

CRCs operating as very long term industrial research collaborations should be encouraged to exit the CRC Programme after second round funding and develop into self-sustaining industrial research institutes, which can be supported independently by industry.

While the Industrial Research Collaboration CRCs flourished in commodity industries and industries with strong leadership and a track record of collaboration, they have not had a major impact in the development and application of research in industries where there is a high degree of product based competition such as in the food industry. Success is often limited to "pre-competitive" R&D and more often associated with development of processes, practices and prototypes rather than specific products.

In industry sectors characterised by strong competitive pressures, industrial research is being approached increasingly on a market and contested basis. The open-ended industrial research partnership with multiple participants has evolved into more specific contract research relationships with nominated research organisations and researchers[110]. Within the CRC Programme a number of large businesses now seek to negotiate specific research contracts with universities and researchers outside the main Centre Agreement.

In the current commercial environment there are few businesses that have the "free" resources to provide to CRCs to undertake research that does not address a specific business problem or opportunity. There is little interest among the established business community in involvement in CRCs where the path to market is likely to be through the creation of a start up company or supporting the growth of a "new technology based firm" (NTBF – a special sort of SME). It is well known, however, that new companies based on disruptive technologies pose major threats to the competitive position of established companies[111].

The CRC Programme does not address, and nor was it intended to address, short term small-scale project research. This area is now well covered with ARC Linkage Programmes and there is no case for the CRC Programme to extend back into this domain. The focus of the CRC Programme has been on longer-term applicable research with end user involvement in adoption, application and use as the underlying criterion. It has tended to concentrate in those industries where Australia has a competitive strength, and has been instrumental in maintaining and building that strength.

From the material presented in Section 3 of Part II of the Report it is apparent that the industrial research collaboration "space" now involves a great deal more activity than it did ten years ago. There is now a wider range of alternative support programmes to facilitate the production of industrially applicable knowledge, particularly in Centres

[110] This is occurring in industries where businesses are going through a process of corporate "disaggregation" and moving away from an organising principle based on markets to one based on contracts. See for example John Hagell and Marc Singer, "Unbundling the Corporation," *McKinsey Quarterly* 3, no. 3 (1999)

[111] See Clayton M Christensen, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail* (Boston: Harvard Business School Press, 1997), Clayton M Christensen, Mark W Johnson, and Darrell K Rigby, "Foundations for Growth: How to Identify and Build Disruptive Businesses," *Sloan Management Review* 43, no. 3 (2002)

of Excellence and Major Research Facilities. However, these Centres are predominantly located in areas of what is sometimes referred to as "new science". The capacity of existing Australian businesses to pick up opportunities in this area is limited. There are, however, opportunities for the creation of *new* businesses.

In Part I of the Report it was noted that research providers and public sector research users intended to take a more strategic approach to their involvement in CRCs. It follows that the Programme design should reflect the intention of the universities, the CSIRO, State Departments, and others who indicated that they would be taking a more considered approach to their involvement in CRCs. These factors tend to suggest that there will be a fall off in high quality applications for CRCs based on the existing format of industrial research collaborations. Nonetheless, the CRC Programme should continue to strongly support industrial research collaborations in those industries where Australia has a global competitive strength. (This not only includes the commodity industries, it also includes high technology manufacturing equipment and devices)

There is also an opportunity for the CRCs to develop close ties with the ARC and other Centres of Excellence and MNRFs in relation to the adoption and application of research. This applies particularly in the ICT and biotechnology sector but can be extended to other areas where Centres are creating commercially applicable knowledge. In this regard, the CRC Programme would continue with its focus on research commercialisation through new business development for the outputs of these Centres. The development of the CRC Programme as an *investment* Programme would support this direction.

The trends inherent in the development of the CRC Programme point to a movement in emphasis from the established industrial research collaboration CRCs to CRCs based on new business development.

4.4 Business Development CRCs

The interest in business development flows directly from public policy. Universities, and public research organisations also have a strong interest in generating returns from the creation of businesses out of technologies they have developed. This is the essence of research commercialisation. With the realisation of the potential for economic growth built on knowledge-based businesses and industries through the commercialisation of public research, there have been growing expectations of the CRC Programme in relation to new business development.

While the CRC Programme Guidelines place a priority on research commercialisation, only 20 percent of CRC expenditure was taken up in what can be classified as business development CRCs. This reflects in large measure the application and assessment process where all CRCs are judged against each other in the same pool. The application of commercial assessment criteria can actually work against CRCs based on new business development, as it is easier to assess (and question) commercial viability. In national benefit CRCs commercial outcomes are rarely relevant.

New business development is most likely to be found in fields where science is advancing very rapidly, where people capable of advancing in a field are in relatively short supply, and where intellectual property protection is available and very impor-

tant. These characteristics occur most predominantly in information and communication technologies, biotechnology, medical devices, and to some extent in electronics. As indicated above, it is in these areas that Centres of Excellence have been established.

The potential for commercialisation within the CRC Programme is strongest where path to market is through licensing to an industry partner that takes on product development, manufacture, and marketing, or the creation of new business models (i.e.. start-up companies) supported by venture capital investment.

In the business development category the CRC Programme is, in effect, endeavouring to respond to the "demand-pull" of technology investment opportunities. The task of the CRC is to develop technologies and prepare business models to a stage where they are "investment ready". This requires a range of intellectual property management and commercial skills – in addition to the research skills of scientists. However, venture capital and other technology investors have raised concerns about the current level of capabilities of CRCs in this area and their understanding of what constitutes "investment ready".

Many CRCs involved in business development are associated with only one industry partner. An important issue has been whether the Programme should be supporting "single user" CRCs in this area – that is, where one company will reap the primary benefit of commercialisation outcomes. For example, where CRCs have been successful in developing medical devices, a question has arisen about whether it is appropriate to have a CRC with only one business partner. In most cases, however, the business partner dominates the industry and provides substantial benefits back to the research provider in the form of education and new scientific knowledge.

In some other cases a CRC proposal will not be able to attract *any* industry partners due to the "disruptive" nature of the technology being developed. That is, there is little industry "demand pull" for research in this area. Existing businesses may be interested in acquiring or licensing the technology once developed and demonstrated, but unwilling to invest in that development – particularly if their R&D strategy is based on technology acquisition. In these situations State Governments with an interest in encouraging research commercialisation are involved with the CRC in a role of "state entrepreneurs". Venture capital investors may also be involved.

To date the overall performance of the Programme in research commercialisation has not been strong. This reflects the traditional orientation of the Programme to national benefit and industrial research collaborations where the results of research are used and adopted by the industry participants. Commercialisation through technology licensing or spinouts to parties outside the CRC is not generally considered to be a major issue in these CRCs. Some revenue is made by sales of product and services to users outside the CRC but the amounts reported are quite small and do not form the major focus of the work of the CRC. Commercialisation may actually create problems for CRCs and participants in the form of unexpected (and unwanted) tax liabilities.

To increase the rate of commercialisation, it will be necessary to shift resources within the Programme to funding more CRC proposals that are based on new business investment strategies and in particular, strategies based around the exploitation of

disruptive technologies. That is, in order to have an increase in commercialisation outcomes, it will be necessary to have more CRCs based on commercialising research.

A greater focus on commercialisation will, in turn require more attention being given to the investment nature of a CRC proposal. The Report makes a number of recommendations to shift the focus of the CRC Programme from a "research grants" mechanism to an "investment appraisal" vehicle in Section 6 where it is proposed that CRC selections be based on "robust and compelling investment propositions". Recommendations are also made to streamline the application, approval and monitoring processes.

Commercially oriented CRCs need to allocate a sufficient level of resources to business development, including IP protection, management framework, product quality and integrity, and technology marketing: that is, to become investment ready.

To the extent that Commonwealth CRC Programme funds are not intended to finance the actual starting of a business, as distinct from getting a technology to the stage of business "investment ready" and given that those resources are unlikely to be available from industry partners (for reasons outlined above), it would also be expected that the CRCs would have greater access to publicly supported pre-seed and seed funds once the basics of the business model had been developed.

CRCs should not be precluded from access to AusIndustry Pre-Seed funds..

At the same time, it is important that CRC proponents be realistic about the expected returns from the science and the technology that has been developed in a research environment and the importance of actually creating a business model for commercialisation – that will attract the interest of a technology investor – either as a licensee, development partner, or equity provider in a start-up company. *A technology without a business model has no commercial value whatsoever.*

4.5 Conclusion

The CRC system has clearly evolved down the three trajectories described in this Section. The system was initially based on "Category 2" arrangements with the emphasis on industrial research collaborations. However, with an increasing emphasis being placed on the commercialisation of publicly funded research, greater attention is being given to expectations of CRCs performance in relation to Category 3. At the same time, a focus on commercialisation causes a high level of unease for people associated with national benefits CRCs.

It is therefore proposed that the CRC framework clearly acknowledge the three CRC categories and relate selection criteria, oversight and monitoring arrangement to suit the needs of each. It is also suggested that a common thread through all categories is to see Commonwealth support for CRCs as an "investment" with clear intentions and expectation relating to adoption, application and use.

To address these issues, the CRC Programme needs to be seen as more an investment Programme. Recommendations to this effect are made in subsequent sections of the Report.

5: The Clarity and Appropriateness of the Current CRC Objectives

The Terms of Reference for the Evaluation required consideration of:

The clarity of the objectives:

- Do the individual objectives provide a coherent overall framework for the Programme?
- Is there a clear relationship between the Programme objectives and the selection criteria?
- Is there any conflict between any of the objectives, for example commercialisation/collaboration or selection criteria?112

These issues, together with considerations of Programme appropriateness are addressed in the light of the discussion in the earlier Sections of this Part of the Report and from feedback through consultations and discussion during the Evaluation.

5.1 Overarching vision and purpose

In a management sense, a vision for a public programme identifies the overarching purpose and defines the direction of actions and activities. The vision is the concept, or the idea, that captures the imagination, attention and interest of participants and stakeholders.

The original vision for the CRC Programme was presented by the then Minister for Science and Technology in the following terms:

> The Cooperative Research Centres will help Australia to achieve closer linkages between science and the market.
>
> Australia must match the technology push provided by its strong research base with the demand-pull of industry and other research users, and these centres will make an important contribution to that goal.[113]

In discussions and consultations no reason was given to depart from this "visionary statement". It applies to research that is oriented towards direct industrial application in businesses as well as research oriented towards the conservation and repair of Australia's natural capital assets (land, soil, water) to enable their more productive and sustainable use.

Since their introduction CRCs have been a major element in Australia's scientific and research infrastructure. They were established to draw together outstanding research groups in universities, the CSIRO and other government research institutions and link them to research users in industry and other sectors of the community.

CRCs were intended to "reflect a balance between longer-term strategic research and short term, market oriented projects that is essential to forging the links we need between science and industry". The centres would also "play an important role in training in science and engineering research, providing the skilled people we need to be internationally competitive into the next century".[114]

[112] The selection criteria for the 2002 Round are attached
[113] Minister for Science and Technology in announcing the first Cooperative Research Centres, 14 March 1991.
[114] Ibid

In the light of the developments in approaches to industrial research and the central place of public-private research partnerships in the science and innovation system, the overarching purpose of the Programme remains relevant and applicable. It is important that its sense of purpose be kept constantly at the forefront of attention.

Recommendation

II-1. The CRC Programme be promoted on the basis of an overarching purpose "to create and sustain active public-private research partnerships oriented towards the adoption and utilisation of research in a national, industry and business context"

The purpose of the Programme is not so much to match public research with corporate research, although this is part of the process. It is to take an integrated approach to industrial research with the intention of generating wealth through higher industry and business performance and ensuring the long-term sustainability of Australia's natural capital assets. By implication, the purpose of the Programme is also to encourage businesses and public organisations *to use and apply* the results of research in the development of marketable products, industrial processes and in public programmes.

The original Programme objectives were:

- to contribute to national objectives, including economic and social development, and the establishment of internationally competitive industry sectors through supporting long-term, high quality scientific and technological research;
- to capture the benefits of research, and to strengthen the links between research and its commercial and other applications, by the active involvement of the users of research in the work and management of the centres;
- to promote cooperation in research, and through it a more efficient use of resources in the national research effort by building centres of research concentration and strengthening research networks; and
- to promote the active involvement of researchers from outside the higher education system in educational activities, thus stimulating a broader experience in education and training, particularly in graduate programs and to offer graduate students opportunities to be involved in major cooperative, user oriented research programs.

In announcing the first 15 successful applications in 1991, the Minister articulated some specific expectations of the Programme:

- Improve Australia's industrial base, especially advanced manufacturing and information industries, by drawing our experience in the emerging fields of material science and information technologies.
- Capture the benefits of our world class capability in medical research, both through the development of pharmaceuticals and other commercial products contributing to public health.
- Strengthen the established resource based industries both by providing the knowledge that will underpin their continued competitiveness and addressing the challenge of the sustainable use of our natural resource wealth.
- Contribute to more responsible and effective environmental waste management and the exploitation of commercial opportunities in this area.
- Take a leading scientific position in the Antarctic, enabling us to continue to strengthen Australia's lead in the international consideration of this unique region.

The available evidence suggests that the CRC Programme has delivered well in relation to these expectations.

These original objectives have a strong outcome orientation and provide a focus for action. Over time, the objectives of the Programme have been revised and reworded and have become more process oriented. The current objectives are:

- To enhance the contribution of long-term scientific and technological research and innovation to Australia's sustainable economic and social development (the research objective).
- To enhance the transfer of research outputs into commercial or other outcomes of economic, environmental or social benefit to Australia (the commercialisation objective).
- To enhance the value to Australia of graduate researchers (the education objective).
- To enhance collaboration among researchers, between researchers and industry or other users, and to improve efficiency in the use of intellectual and other research resources (the collaboration objective).

These objectives are supplemented by selection criteria, which provide the basis for assessment of applications and ongoing evaluation and review. These selection criteria are:

- Objectives of the CRC.
- Quality and relevance of the research programme.
- Strategy for utilisation and commercialisation of research outputs.
- Education and training.
- Collaborative arrangements.
- Resources and budget.
- Management structure.
- Performance evaluation.

The relationship between the objectives and the selection criteria is discussed further below.

5.2 The relative priority and emphasis of the current objectives

In consultations and submissions there was a wide range of comments concerning the relative emphasis, interpretation and application of objectives.

5.2.1 Contribution of long term scientific and technological research to sustainable economic and social outcomes

The CRC Programme is premised on the basis of commitment to long-term research. The quality of the research programme is one of the nine selection criteria. However, the meaning of long term must also be understood in the context of achieving tangible and measurable outcomes. If the research does not have tangible and measurable outcomes and impacts within the funding life of the CRC then there is little possibility of being able to track the extent to which the benefits have been captured and achieved.

The difficulty is to a large extent overcome in the *Guidelines*, which imply a relationship between basic and long-term research. That is:

> It is important that CRCs maintain an appropriate level of basic research to underpin the overall research programme, provide a sound basis for the education programme, and build on the existing intellectual capital of the participants.
>
> It is expected that CRCs will maintain a strategic focus on long term, high quality research. Contract research and short term problem solving should only be used as a

> subsidiary means of fostering effective collaboration, particularly with users. Such research should complement the main objectives of the CRC.
>
> The strategic commitment of users, both in the public and the private sector, is critical to the success of the Programme. It is not intended that CRCs function simply as short-term contract research providers.

In other words, basic and/or long-term research is required in the CRC portfolio to balance short-term research and long-term programme research. Shorter term and problem oriented research projects are attractive to end users, particularly where resources available for research are highly constrained. The outcomes of shorter-term project research are also easier to measure and report on.

Notwithstanding the intent of the *Guidelines*, there are many businesses that effectively outsource their research to CRCs. This outsourcing reflects the trend in industrial research referred to in the preceding Sections of this Part of the Report. From an industry policy perspective it is a legitimate activity, providing that externalities and national benefit can be demonstrated in the same way as assistance provided under programmes such as R&D START.

5.2.2 Commercialisation and technology transfer

There is a strong view within industry that the CRC Programme, whilst scientifically robust, is failing to effectively capture commercial benefit for the broader good of Australia. This was recognised in the latest selection round and commercialisation and technology transfer now receives a substantial level of attention in the Programme Selection Criteria. For example, the 2002 *Guidelines* provide:

> A key objective of the Programme is the transfer of technology to the research users. Each CRC must have in place a well-defined strategy for the commercialisation, technology transfer or utilisation of the research results, in which the benefits of the research will accrue substantially to Australia. Evidence of benefit to Australia will need to be based on realistic projections. These projections must reflect the capacity for commercialisation or for the uptake by users in areas of national interest.

The capacity to deliver on this requirement has been an important issue in the assessment process. Commercialisation and technology transfer involves much more than a strategy: it involves a commitment to implementation, which in turn requires a realistic allocation of resources and appointment of people with the skills and competencies necessary to take discoveries and inventions through to market and other forms of use and application. This has been demonstrated in a number of CRCs, including Eye Research, Cochlear, Vaccine Technologies, Beef Quality, and Photonics.

The objective to enhance the transfer of research outputs into outcomes should be approached within the reality of the innovation process. Technological outcomes of research are simply either inventions or know-how. Innovation is a *management* process requiring skills in areas such as product development, design, marketing and business development. Management is also a practice-based discipline, learned through experience and exposure to the rigours of the market.

The issue is not whether research is public or commercial; the issue is whether it results in addition to wealth by either producing new products or services or improving the natural resource productive base. In this regard the Programme should require

that CRCs demonstrate a clear plan articulating how research results are to be applied to the benefit of Australia, and how this will be implemented. Performance against this plan should be regularly and rigorously assessed as a requirement of funding.

5.2.3 Enhancing the value of graduate researchers

The meaning of the objective *to enhance the value to Australia of graduate researchers"* is not especially clear. However, the *Programme Guidelines* envisage that education and training activities are likely to produce some of a CRC's most enduring achievements.

The Programme Guidelines require that education and training programmes be designed to meet the needs of the user sector. The Guidelines prescribe:

> In designing education activities, applicants should ensure that students in the CRC receive a broad range of experiences and skills development. These programmes should be aimed at enhancing their acceptance by the user sector, and consequently their employment prospects.
>
> The programme for students should include appropriate induction courses in such areas as occupational health and safety, research utilisation and commercialisation, intellectual property rights (including their own), and project management.
>
> Where appropriate, CRCs may provide professional training for people already in the work force to update technical skills and to facilitate technology transfer.

Several CRCs are engaging with vocational education and training institutions in their education and training programmes. This has the important outcome of training people to use technology as well as thinking up ways to apply it. It is important that this practice continue and be developed.

5.2.4 Collaboration

The Programme Guidelines advise that the development of effective collaborative arrangements is a key element in the success of a CRC proposal:

> CRCs should establish strong interactive linkages among individual researchers, between the participating organisations and between the researchers and the users of the research. This can be best achieved if researchers from all the participating organisations in the CRC, including the user groups, are actively involved in a majority of the CRC's programmes, and this is strongly encouraged.

It is important however, that collaboration be genuine and that the selection process tests the veracity of the proposed interactions. By the time researchers come to being considered seriously for the substantial level of funding available under a CRC grant, they should be able to demonstrate a track record in collaboration. This goes beyond joint authorship of papers into demonstration of effective collaboration in projects that have produced outcomes.

With experience in collaboration in other contexts, the CRC Programme provides an important avenue for researchers to access larger amounts of assistance and support to take on larger and possibly higher risk investment opportunities than would otherwise have been possible.

In view of the trend towards increased devolvement of natural resource management (and other) decision-making to regional or catchment bodies a suggestion has been made to include specific reference to community groups in the objective about

"collaboration among researchers, between researchers and industry or other users".

5.3 Conflicts between objectives

During discussions and consultations and in submissions the potential for conflict among objectives was raised. The main area of concern was apparent conflict between research *excellence* and research *relevance*.

5.3.1 Between research and commercialisation

Businesses and research funding agencies consulted during the Evaluation suggested that collaboration and commercialisation/technology transfer objectives are fundamentally at odds with the education and research objectives. They argue that the Universities are highly (and correctly) focussed on research and education objectives. CRCs, on the other hand, should be focussed on the technology transfer/commercialisation and collaboration objectives that address a user need. Businesses tend to be less interested in foundation research because it typically does not address their needs and concerns in a direct and useable way.[115]

At the centre of the issue is an absence of a clearly understood definition of "research excellence". The term can be used, for example, as a measure of research output (publications, patents, etc), and related to values of curiosity driven "disinterested" research and academic freedom. In a contemporary vein, however, excellence can also be interpreted to reflect research outcomes - research "products" transferred to "the public" as commodities[116] - that is research utilisation.

The reality is that in some areas of industrial innovation, such as in drug discovery, scientific excellence is required, for example, to identify molecules or proteins that have a therapeutic impact. Increasingly, new industrial applications are based directly on the results of scientific discoveries rather than technological inventions. Nonetheless, involvement of industry partners with an interest in path to market should still remain an essential component of the CRC Programme.

The history of industrial research is characterised by both research excellence and relevance. It is not one or the other. *Relevant research must also be excellent – but in an industrial research context, it must also be applicable.* Excellence in this regard is taken to mean world class, as indicated by a reputation for creation, successful application and guiding the adoption of industry relevant processes and products. There are many researchers in the CRC system who would fit this criterion.

The CRC Programme should not, however, be seen to support excellent research for its own sake. This should be the task of other programmes.

5.3.2 Between publication and profit

It is often argued that the academic quest for "eminence", involving open disclosure of foundation research, conflicts with the profit motive of firms. Again, this gives rise

[115] Cohen, Florida, and Randazzese, "Industry and Academy: Uneasy Partners in the Cause of Technological Advance.", p. 186
[116] Corynne McSherry, *Who Owns Academic Work? Battling for Control of Intellectual Property* (Cambridge, MA.: Harvard University Press, 2001)

to a conflict between the research and the commercialisation objectives of the Programme. Firms prefer less disclosure of research findings to increase the appropriability of the profits of any product or process innovations that may emerge out of the research. There is evidence from the United States that growing ties between universities and industry are inducing academics to accept restrictions on the disclosure of their research.[117]

Similar conflicts arise in relation to disclosures and the prospects of commercialising research through a spinout company – although the pressures are internally rather than externally induced.

5.4 Relation of Current Programme Objectives to the Selection Criteria

The tendency for the Programme management and delivery to focus on the Selection Criteria rather than objectives have been noted above and in Part I. This arises largely because of the generality of the objectives and the reliance on the selection criteria to guide the application and selection process in particular directions. In other words, the selection criteria provide constraints and direction in relation to the interpretation of objectives. This is indicated in Figure 13 below.

Figure 13: Directions and Constraints Contained in Programme Selection Criteria

Selection Criterion	Directions/Constraints
Objectives of the CRC	Applicants should be able to explain the national significance of the proposed outcomes in economic, environmental or social terms. Quantitative estimates of potential benefits should be presented where practicable. This should include revenue and expenditure forecasts for the period for which CRC Programme funds are sought and should also provide an analysis of competitive activity in the research field selected.
Quality and relevance of the research programme	The emphasis of the programme is on high quality research that will contribute to national economic, environmental and social objectives. Some examples of national objectives are: the development of internationally competitive industry sectors; the development of emerging industries; the health and well-being of Australian society; the understanding and management of the environment; and the development of ecologically sustainable practices and industries. There would be strong preference for proposals that fill major gaps in the research currently funded under the CRC Programme The challenge is to ensure that the establishment of a CRC and the resulting cooperative interaction will result in new research, that would not otherwise have been undertaken. The CRC research programme should constitute a real addition to, and enhancement of, existing research. The research must be considered to be of a high quality and world class when assessed by peers. There should be an emphasis on leading edge technologies that can assist Australian industry to become more innovative, competitive and productive The research conducted in the CRC should result in outcomes of benefits in the hands of research users, the participating industry sector and Australia's sustainable economic and social development. For users in the public sector, outputs may include an enhanced understanding of environmental issues to support environmental or renewable resource management and decision support systems for improved delivery of health services. For industry-focussed CRCs, the outputs are generally in the form of innovative products or production technologies, and also importantly whole new industries..
Strategy for utilisation and commercialisation of research outputs	The utilisation and commercialisation strategy should also include methods to: · Improve researchers' and students' understanding of the utilisation and commercialisation process; · Monitor the needs and capabilities of the user sector(s); · Monitor relevant alternative and competitive developments world-wide; · Facilitate the continual diffusion of technology and knowledge to the wider user community; and · Enhance SME involvement, including technology transfer to, and spin-off, of SMEs.
Education and training	Applicants should give detailed consideration to developing innovative approaches to graduate education and training. Education and training programmes should be designed to meet the needs of the user sector. In designing education activities, applicants should ensure that students in the CRC receive a broad range of experiences and skills development. These programmes should be aimed at enhancing their

[117] Cohen, Florida, and Randazzese, "Industry and Academy: Uneasy Partners in the Cause of Technological Advance.", p. 187

Selection Criterion	Directions/Constraints
	acceptance by the user sector, and consequently their employment prospects.
Collaborative arrangements	CRCs shall ensure that they interact effectively with SMEs in their sector. CRCs should develop a strategy to ensure that these businesses have access to their research and training activities. The strategy should specifically address SME involvement in the CRC through direct or indirect participation and through involvement in commercialisation, technology transfer or utilisation of research outputs, including where appropriate the spin-off of new SME companies. Milestones should be identified as a basis for performance monitoring. The proposed CRC is required to address the issue of international linkages and indicate how proposed linkages would contribute to the objectives of the CRC.
Resources and budget	It is anticipated that the average amount of Centre funding may be around $3 million per annum, while the existing flexibility in size and duration will be maintained.. The Government, through the programme, will provide a maximum of fifty per cent of the total cost of establishing and operating each CRC. The amount of CRC Programme funding provided to existing CRCs amounts, on average, to about one quarter of the total costs, ie for every dollar provided by the programme, more than three dollars of resources are contributed by the participants. The CRC Committee will examine the proposed leverage on the programme funding sought in the application, expressed as the ratio of the total contributed resources budgeted for the proposed CRC to the programme funding sought from the Commonwealth. Contributions may be provided as cash and/or 'in-kind' resources. The provision of an appropriate and adequate amount of cash is regarded as highly desirable. The cash available per full time equivalent researcher is seen as a useful indicator in this regard. It is expected that industry's commitment will continue to increase, particularly for the larger and established industries, and those industries which have a long standing association with the programme. Funding will be available for up to seven years, but shorter periods will be considered where appropriate.
Management structure	There needs to be clear lines of responsibility and accountability linking the various participants. All core participants will be individually required to enter into the Commonwealth Agreement.
Performance evaluation	The business plan should include an evaluation strategy that identifies its particular programme objectives and milestones (identified targets), and the performance measures that will be used to measure performance against them. The application should also outline the ways evaluation will be built in to the management and decision-making processes of the CRC.

There is a tendency in submitting proposals in this environment to ensure that the bid addresses all selection criteria, and the document is worded in such a way that each criterion is covered off. Proponents will have an incentive to identify "Collaborators" to cover particular criteria – whether they have worked with them previously (and whether they really have an intention of working with them if a tender has been successful). Some collaborators are included for minimal time simply to include the capability.

While there is considerable detail in eligibility and selection criteria, there is, on the other hand, a great deal of scope for interpretation of the intent of Programme objectives by industry and by applicants – especially as they are all prefaced with the term "to enhance".

There is a concern that a system of "pattern bargaining" has emerged directed by advisers and consultants where applications, following a relatively standard template, are written in such a way that they will always meet the Programme objectives and selection criteria. Truly novel and innovative approaches may not be submitted or be dropped from the assessment process because they fail to meet specific criteria.

The greater the scope for interpretation of objectives, and the more extensive the specificity of the guidelines, the greater will be the opportunity to game the system.

It is a credit to the Expert Panels that they can work through the vast amount of material they are presented with and exercise their professional judgement to identify the meritorious proposals. However, it would be a benefit to all concerned if the

rules were simplified and only the information necessary to make a decision were prepared and submitted.

Notwithstanding the detail in the Selection Criteria, the decisive factors for assessment and proposal selection should, in all reality, be what an application will achieve in relation to the CRC Programme mission and objectives. This means establishing a credible linkage between research, education, technology transfer and collaboration activities and *results* from an end user perspective – defined in terms of adoption, application and use. This requirement should set the CRC Programme apart from general research funding programmes.

It is therefore suggested that the balance be restored between objectives and selection criteria, with a greater emphasis on meeting the mission and objectives of the Programme. Selection criteria should cover off the more administrative matters such as eligibility and the capacity to deliver what is proposed. These issues are canvassed below.

5.5 Redefining Objectives

The Evaluation has been undertaken by addressing a number of specific matters identified in the Terms of Reference. These formed the basis for reporting in Part I of the Report and were:

- Contributing to Australia's economic growth, social well-being and environmental outcomes.
- Contributing to Australia's public and private industrial research capacity in the areas of national need or global opportunity.
- Producing research that is of an excellent standard and that would not have been undertaken otherwise.
- Adding to the nation's intellectual property and its commercialisation or utilisation.
- Enhancing collaboration among public and private researchers, and between public researchers and commercial or community interest.
- Increasing the proportion of public researchers who are commercially oriented.
- Upgrading the innovative capacities of Australian business enterprises.

These items are, in effect, statements of intent. They reflect in large measure the tenor of the changes and evolution in the form of interactions between the public and private sectors in industrial research. They require some adjustment in the light of observations, conclusions and recommendations made earlier in the Report. In particular,

- Collaboration is not of itself an objective – it will be the result of achievement of other objectives
- There is a need to include a specific education objective to reflect the intent of the Programme from the point of view of both research providers and users
- The statement about research that "would not have been undertaken otherwise" is not an objective – it is a constraint
- The term "applicable" is added to convey a message about research application.

The proposed objectives, with comments relating to purpose, are provided below.

Figure 14: Proposed CRC Objectives

Proposed objective	Interpretation
Contributing to Australia's economic growth, social well being and environmental outcomes	This provision is already included in the Programme Guidelines. Raising it to the level of an objective would recognise its importance and focus attention of applicants
Developing Australia's public and private industrial research capacity in the areas of national need or global opportunity	This relates specifically to both public-private partnership in industrial research and consistency with National Research Priorities, Action Agendas, and various industry and environmental policy objectives
Producing applicable research that is of an excellent standard	High quality research is the basis for sustained innovation in public programmes, industrial processes and practices, and in the creation of new businesses based on the commercialisation of research
Adding to the nation's intellectual property and promoting its adoption, application and use in businesses and public programmes	This focuses directly on technology transfer, communication and commercialisation through business development in existing and new businesses
Producing graduates with skills, knowledge and experience in the application of research in a national, industry and/or business context.	This objective is intended to stimulate a broader experience in education and training, involving external supervisors and teachers, and in major cooperative, user oriented research programs. Reference to skills development encompasses involvement of the vocational education and training (VET) sector.
Upgrading the innovative capacities of Australian business enterprises	This is taken to mean rasing the capacity of an enterprise to effectively manage the innovation process. This has as much to do with applying existing technologies in new combinations as it does the acquisition of radical or breakthrough technologies. It has a specific application to SMEs and NTBFs

The work carried out for Part I of the Report provides a substantial background of material to assist in creating expectations in relation to performance against the objectives.

Recommendation

II-2. The Objectives of the CRC Programme be redefined as follows:

- ***Contributing to Australia's economic growth, social well being and environmental outcomes***
- ***Developing Australia's public and private industrial research capacity in the areas of national need or global opportunity***
- ***Producing applicable research that is of an excellent standard***
- ***Adding to the nation's intellectual property and promoting its adoption, application and use in businesses and public programmes***

- ***Producing graduates with skills, knowledge and experience in the application of research in a national, industry and/or business context.***
- ***Upgrading the innovative capacities of Australian business enterprises***

The objectives stated in these terms provide a focus on achievement, results and outcomes and provides a sounder basis to position and market the Programme. This is discussed below.

5.6 Positioning of the CRC Programme

Drawing on the discussion earlier in this Part of the Report, the CRC Programme should move away from being seen as a grants and research funding programme to a strategic investment programme directed towards investments in collaborative (incorporated, unincorporated, or otherwise) ***partnerships*** between research providers and research users to deliver outcomes that are capable of adoption and use in a commercial or public application.

Those partnerships may be established as public private industrial research partnerships between research providers and users or as business development partnerships involving research providers, users and/or technology investors.

Emphasis on investment carries with it a connotation that the funds provided will achieve outcomes and will deliver benefits and returns over time – be they economic, environmental, social, industry or business. It is critical that the Programme move away from the traditional "funding" model under which financial assistance is provided for projects that meet selection criteria.

As the CRC Programme is operated on a devolved basis, that strategic interest is reflected in the way in which the Board of the CRC manages the investment. The Commonwealth steps back and allows the Board to get on with the job, relying on periodic performance reporting relating to probity, results and achievement – as well as meeting needs for public accountability.

The repositioning would address industry concerns over Programme performance and build on the commitment that has been made by universities, research organisations and the CRC industry in delivering successful outcomes. It would also clarify issues in relation to the entry of "public good" CRCs into the Programme and encourage researchers to seek more appropriate arrangements for purely research driven proposals. These arrangements might include the creation of research centres and institutes with specific research missions and funding arrangements outside the CRC framework.

The positioning should build on the tri-modal framework that has evolved over the 12 years of the Programme's operation and discussed in Section 4: . The dominant view expressed by stakeholders in the Programme is that the relevance of the Programme to industry and to other end-users, including technology investors, would be improved if greater scope were provided for these three distinctive missions to be pursued. This implies that *relaxing* the various constraints imposed by the current arrangements

should allow the tri-modal structure to become more efficient and effective than it is at present.

A relaxation of some requirements is a necessary but not a sufficient condition for improving the effectiveness of the CRC Programme. Two major complementary changes are also required.

- First, the shift to a programme that aims to generate well-planned paths to market and end-use rather than to simply assume that promising discoveries and technologies will be adopted/commercialised by CRC partners or other entities.
- Second, the establishment of a specifically designed CRC *investment vehicle*[118] for carrying out these end-use focused missions as investment projects. In many cases, the path to market and the investment-based approach will be provided by industry-led initiatives that bid for CRC grants in partnership with public sector researchers.

When there are no existing industry partners the onus will be upon the CRC's proponents to provide a convincing case for investment that lays out *why* forming new businesses is important for Australia and *how* this will be achieved. *In this investment-based approach the planned R&D is the means to an end not an end in itself.*

This approach allows for managing the uncertainty over the R&D and the eventual end-user uptake. It differs from current CRC funding awards by placing a greater emphasis upon the planned process for achieving stated end-use objectives and upon accountability in meeting these objectives.

Recommendation

II-3. The CRC Programme be clearly positioned as an "investment" programme that is expected to deliver outcomes in the form of national economic, social and environmental benefits, the improved competitiveness of Australian industry, and/or the creation and sustaining of viable new technology based businesses.

The positioning of the CRC Programme in this way is entirely consistent with the advice and information reported in Part I in relation to the approaches of the CSIRO and other public research agencies to take a more strategic involvement with CRCs. It is also consistent with the approaches of State governments who are working towards a "whole of government" approach to CRCs.

[118] The investment vehicle would be a specifically designed corporate entity that overcomes the complexities and unintended effects of the corporations and taxation laws – as discussed in Section 7.3 below. ,

6: CRC Selection Criteria and Procedures

In this Section of the Report the Following item in the Terms of Reference is addressed:

Selection criteria and procedures

- How should the selection criteria and procedures (including the collaboration model implied in these) be modified to give effect to any proposed change to the objectives for the Programme?

In the previous Section it was argued that selection should be more closely related to achieving the objectives of the Programme and that the Selection Criteria should be scaled back.

6.1 Basis of Selection

As indicated, selection of a CRC "investment" should be based on an appraisal of the extent to which a "proposal" will achieve the objectives of the Programme. *The collaboration should be genuine and add value*

Inevitably, and despite extensive checking and exhaustive examination, the Commonwealth has to place a very high degree of trust in the capacity of applicants to achieve what they proposing. This in turn, relies heavily on an assessment of the capacity of the proposed CRC partnership to deliver.

Capacity to deliver will involve an assessment of:

- The *Credibility* of the proposal - in terms of its identified results (ends) and the way in which it intends to go about achieving them (means).
- The *Reputation* of the Researchers - in terms of their knowledge, skills, and experience *and* their track record in collaboration.
- The *Integrity* of the nominated governing Board - in terms of its capacity to provide strategic direction *and* fulfil the obligations of good corporate governance.
- The *Leadership* and management capacities of the nominated Chief Executive Officer and executive team.
- The *Commitment* of all involved in the proposed CRC to achieving the intended outcomes.

These criteria are reflected in the present selection criteria, but they do not receive prominence. What is proposed is to turn the process from checking against selection criteria to one that centres on the "business case". That is, proponents need to convince the Commonwealth of the extrinsic and intrinsic merit of the proposal in terms of its ability to deliver results that reflect the mission and objectives of the Programme – within the limits of the resources that are and will be available.

Inevitably, the selection will involve a high degree of judgement by the expert panels and the CRC Committee. In this regard, the membership of expert panels may need to be refocussed to align more closely with the industry as well as the science and technologies in which the CRC "investment" is being proposed.

Recommendation

II-4. The basis of selection should be, first and foremost, an appraisal of the strength and value of of the collaboration and the extent to which the Proposal will achieve the objectives of the Programme.

Aspects of the selection criteria are canvassed below.

6.2 Investment appraisal

Under the present arrangements there is no requirement or strong recommendation to provide a formal *investment appraisal* as part of the proposal. The suggested content of the business plan submitted as part of the proposal does highlight the relevance of quantitative justifications but it does not place a major priority on this aspect of the investment proposition.

An investment appraisal identifies the benefits that the CRC proponents plan to generate, the costs of generating these benefits and (most importantly) the uncertainties and risks involved. In a commercially oriented CRC there is a reasonable expectation that these benefits can be quantified.

Given the focus of the CRC Programme on investing in "well defined objectives that address a specific community and/or industry need" and that "the proposed outcomes of the CRC will make a significant contribution to Australia's sustainable economic and social development" formal investment appraisals, provided that they incorporate risk assessments would be advantageous.

It is pertinent that the recently published report from the House of Representatives' *Inquiry into Business Commitment to R&D in Australia* has recommended that risk-assessment based investment appraisals be incorporated into the 'R&D Plans' that a company is currently required to prepare in order to be eligible for claiming the R&D Tax Concession (Recommendation 26).[119]

The requirement or recommendation to submit a formal investment appraisal should be defined with care in order not to decrease the potential agility of the CRC Programme in being able to respond quickly and flexibly to emerging opportunities and challenges. The sophistication, and therefore the effort required, to quantify the intended benefits relative to costs should be proportional to the size and duration of the funding being sought.

The greater the funding sought the greater the investment risk faced by the CRC Programme in deciding to fund this investment. Consequently, the greater the weight put by the CRC Programme's expert advisors and Programme management staff on a strong, formal, investment proposition.

Recommendation

II-5. The selection and renewal of CRCs should give preferential treatment to robust and compelling 'investment propositions'. These proposals should detail the path to market or other end-uses by quantify-

[119] House of Representative Standing Committe on Science and Innovation Australia. Parliament, *Riding the Investment Wave: The Case for Increasing Business Investment in R&D* (Canberra: Parliament House, 2003)

ing, to the greatest extent possible the costs involved in attaining these objectives, the scope, extent and estimated value of benefits to be obtained, the anticipated risks faced. The proposal should clearly identify the feasibility, desirability and practicality in relation to implementation – from an end user perspective

The emphasis in the application process should shift to giving the proposal's proponents an opportunity to 'sell' their investment proposition via imaginative free-form proposals rather than try to fit their vision into a highly structured form with a 25 page business plan attached.

In Part I of the Report it was recommended that the selection process be designed as a two stage process: a Preliminary Proposal and a Full Proposal.

Consistent with the intent of the two-stage process, the Preliminary Proposal should consist of the investment proposition in a short Executive Summary together with supporting information relating to matters such as:

- Partnership/joint venture description
- Indicative demand/need and how the proposal is to address that demand/need
- Research undertaken to date and planned research
- Indicative risk-return analysis
- Indicative financial data
- Proposed joint venture management and operational framework
- Basis of the legal and contractual arrangements.

Recommendation

II-6. In line with the priority placed upon robust and compelling investment propositions the Preliminary Proposal should consist of the investment proposition with a short Summary and indicative material relating to demand/need, research, risk return, finances, operations and legal/contractual matters

This emphasis on 'selling' the investment proposition is in line with the CRC Programme's mission to invest in generating *end-uses* from R&D.

It is envisaged that at this stage the CRC Committee would contact proponents with similar proposals with a view to encouraging parties to collaborate and develop a stronger application.

Having identified potential investments, the appraisal process would examine a full proposal against the following criteria. These criteria would be communicated to proponents:

- *Management and research team* – proponents need to be committed, outstanding, creative and resourceful and driven to deliver a sustained outcome; evidence of capacity to work together in defined areas of responsibility
- *Wealth creation* (for industry collaborations and business development proposals) – assessing the impact on international competitiveness, especially in relation to new and high valued exports; commercial return; potential national benefits and spill-over/externality impacts

- *Environmental and social return* (for national benefit proposals) – nature and scale of potential benefits, or of reduced risks or avoided costs; end user beneficiaries; applicability to current or emerging public policy
- *Capacity building* – education and training outcomes; impact on participant capacity to innovate
- *End user involvement* – extent of commitment by identified end users to adoption and application
- *Risk analysis* - identifying sources of risk and how they are to be managed and mitigated
- *Access to and ownership of Intellectual Property* – treatment of background IP; ownership of IP created
- *Implementation and milestones* – a clear and robust plan for research, development and implementation, including milestones and key decision points; this plan would be the basis for monitoring and attestation

These screening criteria, which are heavily oriented towards management, market, and financial factors, provide the basis for realistic investment appraisal.

6.3 Communication of change

The innovative nature of these suggested changes to the CRC Programme's objectives would need to be communicated to Australian businesses, industry and government departments and agencies. This is in line with the shift from an emphasis on tailoring funding requests to detailed and highly prescriptive selection criteria to actively 'selling' an investment proposition to a potential investor in a more permissive funding regime.

Recommendation

II-7. The Department of Education, Science and Training should send out a clear message that the selection and renewal of CRCs will in future place a priority upon robust and compelling "investment propositions" in which industrial research is a means to an end - not an end in itself

6.4 Assessment Panels

Consistent with the investment appraisal approach outlined in this Part of the Report, it is appropriate that Expert Panels have a focus on assessing the *application* of the research. In advocating this approach, it should be taken as given that the science and technology underlying the application would need to be of a world class standard.

The key role of the Expert panel is in assessing the scope for application in a national benefit, industrial and business development context. To that end, Panels should have deep and extensive knowledge and contacts in those areas – from a global perspective. Knowledge is highly specialised and different across sectors, as argued in Section 4.5 in relation to innovation pathways.

In areas where application is likely to be in the form of public policy and programmes, capacity to assess the scope for adoption by Commonwealth and State Governments should be available. In terms of industry expertise, knowledge and

experience of the application of new science and technology in industrial process and practices would be appropriate. Expertise and knowledge of research commercialisation from an international perspective and practice would also be essential.

It is suggested that four Investment Assessment panels be established, based around the characteristics of the science and technology and characteristics of paths to adoption:

- Information and communication technology.
- Health/medical/bioscience.
- Environment, agriculture, water.
- Mining, manufacturing, infrastructure.

Recommendation

II-8. Four Investment Appraisal Panels be established with a focus on the fields of investment rather than the science input. The panels should cover the following specific areas: information technology and communication; health/medical/bioscience; environment/ agriculture/water industries; mining, manufacturing, infrastructure. The panels be constituted by people with strong backgrounds in research relating to resource sustainability, industrial application of new science and technology, and research commercialisation.

7: Implementation

In this Section of the Report matters related to implementation are canvassed and recommendations for change and improvement presented.

7.1 Key Programme design criteria

Much has changed since the CRC Programme started, and indeed CRCs themselves have been a major flagship in driving such change.

In reflecting on this, it is important to examine the CRC Programme from a general design and strategic perspective. This means optimising and balancing key Programme design features that take into account the characteristics of both the Programme itself, and those programmes and organisations with which it is related.

These issues can be addressed from a number of dimensions and perspectives:

- *Governance* – appropriate structures in relation to incorporated and unincorporated joint ventures. This covers the legal rights, risks, obligations, and accountabilities of participants, boards, committees, controlled entities, chairs, CEOs and Visitors. It is reflected in Centre agreements and agreements with the Commonwealth. Governance is affected by State policies, universities legislation, corporations law, intellectual property law and taxation law.
- *Management and leadership* – the capacities and capabilities of CEOs, business managers, research managers and others to build productive and creative cooperative partnerships and personal networks in order to achieve the results of the CRC.
- *Business and administrative processes and systems* – the selection, approval, resource allocation, governance and monitoring/accountability arrangements best suited to the needs of the Programme, its objectives and design features.
- *Critical mass* - the scale, scope and focus of CRCs (coverage, overlaps, and most importantly depth, quality and relevance of the research from an international perspective) and the strengths of the CRC model as compared to complementary, and possibly alternative, cooperative and collaborative arrangements, such as Special Research Centres and Centres of Excellence.
- *Agility* - the flexibility given to the players in the Programme. The capacity to respond to opportunities and issues as they emerge and the speed with which this response can be achieved (the time required to select, set-up and make significant progress both for new CRCs and for projects within CRCs).
- *Longevity and predictability* - expectations of continuity, stability of funding and long-term financial sustainability.
- *Up-front planning for technology transfer* - the deliberate placement of planned R&D effort and resources in an industry or policy-related "value chain" that has the best chance of leading to a measurable economic, social, environmental benefit (such a path may span pure discovery to knowledge uptake/adoption).
- *Systemic context* - the articulation across, and alignment with, other parts of the national R&D and innovation support framework (where and how does the Programme fit in relation to other public support and assistance initiatives).

- *Human capital* – the development of people capabilities both via targeted training and by on the job experience.

CRCs have been selected and have operated for over a decade under a relatively unchanged set of objectives and framework of rules and procedures/processes. The above criteria have been used as a basis for recommending reorientation and changes in Programme design.

7.2 Governance structure

There was a strong view reflected in consultations that CRCs structured as unincorporated joint ventures generally suffer from a reduced commercial effectiveness. Unforeseen circumstances inevitably lead to complications that require referral to the partners for approval. For example, seven partners mean seven legal departments and seven opinions on the best way to structure a deal.

Incorporation of CRCs, where proportional ownership is reflected in the equity held in the company, prevents these issues and leaves the Board free to enter commercial agreements on a realistic basis, over realistic time frames. The absence of an appropriate vehicle to run the "business" of a CRC is seen as a barrier in the evolution of the Programme.

Many of the highly commercial CRCs have indicated that they are hamstrung by their current governance and ownership arrangements. Some have argued that they could grow bigger, pulling in more industry contracts and constantly finding new partners, with different funding and governance structures. Others have argued that the current model, which tends to result in large numbers of shareholders with competing interests, pushes them too much towards medium-risk, lower-return work. A research organisation that tries to manage the needs of 18 or 20 shareholders, many of whom are also the organisation's clients, is simply not effective.

There is, on the other hand, a view that the unincorporated joint venture model has proven relatively robust and viable for most CRCs. It has both significant advantages and disadvantages. It has allowed in some instances scope for some (larger) participant stakeholders to significantly influence operating behaviours, and so exercise their strategic imprint and resource interests over CRC decisions, especially where there are significant competitive interests, or commercial aspirations and potential rewards.

The incorporated model (typically a tax exempt Company limited by guarantee) has also proven to be a robust model, but this too has some disadvantages. The interplay of all factors above has meant that, taken as a whole, too many CRCs have encountered far too many unnecessary "barbed wire fences" that have hampered efficiency and 'commercial' effectiveness.

In these circumstances there is an urgent requirement for an entity that is appropriate to the CRC Programme – one that is sufficiently flexible to allow for an effective *partnership*, but solid enough to provide the basis for a long-term commitment and transformation into a more permanent entity. The entity, in its creation, must be unconstrained by the unintended effects, constraints and disincentives that arise form the application of the taxation and corporations law.

Any changes or enhancements to the CRC entity structure would need to recognise that CRCs obtain substantial resources from universities, the CSIRO and other publicly funded research organisations which will wish to ensure that their interests are appropriately managed and accounted for. Moreover, given the "in kind" nature of those resources, arrangements need to ensure that potential conflicts of loyalty and commitment are effectively managed.

7.3 An appropriate CRC "entity"

CRCs when working with the professional advisory industry have appropriately asked: "what's possible, and what is the optimal way of structuring our affairs within the current national legislative framework?" With the benefit of hindsight, it may be better to now ask: "what is needed to make things easier and simpler for all".

Under the present arrangements achievement of mission and objectives, and the opportunities to engage industry participants, is frustrated by complexities in designing the organisation and administrative framework. These relate to provisions in the taxation and corporations law. They are canvassed in detail in a Working paper prepared during the course of the Evaluation.

Desirably, a CRC should be established and managed in a framework that exhibits the following characteristics:

- It provides for the effective involvement and engagement of participants.
- It is tax exempt in its simplest form – and Boards and managers know what it can/can't do by way of commercial activities, such as start-ups or consulting in order to retain that status, using income to sustain its primary research purpose, whilst also being "easier to do business with".
- Be set up so as to sweep aside current disincentives to incorporation, and build in greater incentives for companies to invest in CRCs eg by removing present tax inefficiencies.[120]
- Serve as a simple 'apprenticeship entity' ie an enterprise that has migrated to incorporation; has retained its public/private sector mix of interests as 'members' with appropriate representational rights; yet is protected from undue complexities (eg income tax, defined areas CGT) until it reaches a performance level in revenue or other tests.
- Provide uniformity such that if CRCs seek to merge, they do so from the same standard.
- Overall, reinforce and strengthen the ability of ideas/people to bridge the gap between excellent research and its successful uptake via a "path to use" by industry or other end-users.

From a management (rather than a legal) perspective, Programme mission and objectives should drive structure – not the other way around. In the following paragraphs a range of options is presented designed to facilitate the creation of appropriate implementation arrangements. They range form the minimalist to the more far reaching.

[120] They could exit a CRC with a share of funds, and could retain/dispose of interests in start-up companies.

A minimal option - a generic agreements "tool-box"

One partial solution is to create and maintain a comprehensive "tool-box"[121] of generic documents suited to further customisation to cover all aspects of typical CRC activities. Creation of such a "tool-box" of examples could be initiated and maintained by the CRC Association to the benefit of its members. It is understood that CEOs of CRCs have taken actions in establishing such a "tool-box".

This is a minimalist option, and it would go some way to assisting CRC Boards and CEOs manage in the complex environment. It is not, by any means, a "solution" to the problem – the problem still exists.

Developing greater awareness and coordinated help from the ATO

Greater specialist knowledge of CRCs by the ATO is highly desirable. A single point of contact or small unit expert on CRCs would be able to assist in consistency and clarity of advice. Greater communication between the ATO and the CRC Association would also help.

Again this option may provide greater clarity, but it would not resolve the problems inherent in the law, particularly the taxation law, in relation to CRCs.

Expand the provisions relating to "scientific institutions"

A further option is to expand and clarify the law covering the tax-exempt status of "scientific institutions"[122] via legislation and regulations and/or general tax rulings[123]. This is the model under which a majority of presently incorporated CRCs operate as companies limited by guarantee and tax exempt (per private tax rulings), and from which significant experience has been gained.

Achieving the preferred model would require addressing some of the present tax inefficiencies and uncertainties for tax paying CRC participants, systematically addressing the reasonable objections to incorporation by some stakeholders, and finally including incentives for tax-paying companies to invest in CRCs.[124]

New CRC Specific Legislation

An additional option is for the Commonwealth to consider legislating a clearer highway for CRCs, and at the same time consider how to entice greater industry interest and stronger engagement with CRCs. Legislation specific for CRCs is not

[121] To include for example updated templates for Agreements between the Commonwealth and JV Participants, Agreements between JV participants themselves, model Company Constitutions that have been adopted by CRCs Cos and received ATO approval as not for profit "scientific institutes", indicative structures and licensing/transfer documents; non-disclosure agreements, MoUs, .materials transfer, service agreements etc.

[122] Refer to *Section 50-5 (item 1.3)* of the *Income Tax Assessment Act 1997* (Tax Exempt Scientific Institute). The primary activity of the Company must be non-profit as written into its constitution. Company must behave as a scientific institution with expectations that earned revenue is for the purposes of self-funding and without any intent or actual distribution of benefit to equity holders. Disposal of assets on wind-up of the Co must be to like non-profit entities. Typically Co tax exempt non-profit Co is limited by guarantee rather than limited by shares and has members rather than shareholders.

[123] Limited examination of the ATO and Attorney Generals data bases indicates only one public tax ruling regarding CRCs, which is a class ruling covering tax status of short-term summer scholarships (CR 2003/4). There are public rulings covering tax exempt, not for profit entities eg TR2000/11 that relate to charities under Subdivision 50-B of the Income Tax Assessment Act 1997 and these give scant coverage of "scientific institutions".

[124] There is precedent in the exclusion from "claw-back provisions in respect of the R&D Tax Concession.

over kill - given the Commonwealth relatively large and increasing investment in CRCs.[125]

As a precedent example, Pooled Development Funds (PDF) are established under the *Pooled Development Fund Act 1992* to encourage early stage investment in advanced technology companies. PDFs have specific tax provisions.

In the renewed vision of CRCs being an investment programme rather than a grants programme, CRCs could be legislated as special-purpose entities. This would require CRC-specific and related legislative changes.[126] It would not necessarily preclude current options, but would make one model far more attractive than the current choice between two broadly unsatisfactory models operating under current legislation.

A number of alternatives exist to create such entities, either specific to the CRC Programme, or more broadly to the "not for profit scientific institutions" category eg MNRF related or other activities with significant Commonwealth funding.

Recommendation

II-9. The Department of Education, Science and Training explore the feasibility of legislation for CRCs to be established with a specific status. The objective would be to resolve uncertainties and complexities in corporate and taxation status and provide a sound basis for a public-private research partnership. The legal status could also be relevant to other public-private research partnerships such as MNRFs and Centres of Excellence

The entity must facilitate the involvement of universities and publicly funded research organisations by allowing for the effective contribution of in-kind resources. Insisting that CRCs be incorporated will not solve or resolve many of the complex problems that have emerged. However, failure to take action will allow a situation to persist that makes the operation and implementation of the CRC Programme complex and expensive, creating a great deal of work for the taxation and legal profession but with not much value added to the outcomes.

With a greater focus on investment and new business development in the CRC framework it will be all the more necessary to have an entity framework that facilitates the commercialisation of research from a tax-exempt institution and its transition into a corporate environment.

7.4 Board structure and membership

The 2002 Guidelines suggest that CRCs adopt a structure headed by a governing board. The Guidelines state:

> Boards must have independent chairs. Board members should include nominees of the main participating research organisations in the CRC, but the majority of board members should be drawn from the industry or user participants, or be independent members ie external to the contributing parties. While it is recognised that it may not

[125] On a annual basis, CRCs cost about 1/3rd of the revenue forgone under the R&D Tax Concession.
[126] Other than S73B clawback and partnership provisions, CRCs appear to have no other mention in tax legislation, and none in the *IR&D Board Act (1986)*

> be practicable for the application to identify the full complement of board members it is required that a general board structure be identified.

The 2002 *Guidelines* provide that the board is accountable for the management of the CRC and setting overall policies, research directions, for utilisation, technology transfer, commercialisation and budgets and for overseeing the executive. Selection of board members should take into account the board's responsibility for guiding the CRC in such a way as to maximise outcomes in terms of the CRC Programme's objectives.

It is of interest to note that although membership of a Board might exercise control over the activities of the entity, it does not necessarily provide a capacity to influence the activities of the entity on a day to day basis. Many participants in CRCs do not sit on boards but seek to *influence* the activities of the entity through other means.

Much of the debate over the effectiveness of Boards in the CRC context is concerned with its role and function. In this regard the strengths and weaknesses of participant and independent directors were canvassed during the consultations and discussions in the Evaluation, following the patterns of thinking in the corporate environment.

The size and membership of a CRC Board was a matter raised continuously throughout the Evaluation. The principles and requirements of good corporate governance in relation to board memberships and responsibilities are well understood within the system. However, these observations need to be put in the context of the "not for profit" nature of CRCs and the relatively small scale of CRC operations.

In the "not-for profit" sector generally, organisations are characterised by strong and active boards; in some the board actually runs the organisation. With the growth of an organisation and the professionalisation of senior management roles, particularly the CEO, boards need to remain active if not for the only reason that participants have a strong personal commitment to the organisation's cause. Thus:

> Precisely because the non-profit board is so committed and active, its relationship with the CEO tends to be highly contentious and full of potential for friction. Non profit CEOs complain that their board "meddles". The directors, in turn, complain that management "usurps" the board's function. This has caused an increasing number of non-profits to realise that neither board nor CEO is "the boss". They are colleagues, working for the same goal but each having a different task. And they have learned that it is the CEO's responsibility to define the task's of each, the board's and his or her own.[127]

The key to making a Board effective is not to talk about its function, but to organise its work. In this respect, successful Boards have a number of working committees dedicated to addressing specific functions. This involves a complex cultural change that will only occur through a targeted process, with the leadership of the CEO and Chair of the Board being absolutely critical. Building trust and mutual respect through whatever processes necessary have to be primary goals.

Boards must also be manageable. It is common practice for Boards to be small with membership of around seven. It would be appropriate, however, for Boards but with

[127] Peter F Drucker, *The Essential Drucker: Selections from the Management Works of Peter F. Drucker* (New York: Harper Business, 2001), p. 45

Committees dedicated to functions relating to finance, research, education, communication and commercialisation.

Recommendation

II-10. Contracts specify that CRCs be governed by a relatively small Board, consisting of around seven members, committed to the objectives of the CRC; membership include a majority of research users; the governance structure include appropriate functional committees.

Following examples set by Rural Research and Development Corporations, Animal Health Australia and Plant Health Australia, arrangements should be put in place for regular meetings of all stakeholders as a means for holding Boards accountable.

7.5 Agreements and contracts

Responsibilities and accountabilities of a CRC are covered in an Agreement with the Commonwealth and in an agreement among the participants in the CRC. The Commonwealth Agreement is negotiated following notification of approval.

This process is unnecessarily cumbersome. Moreover, proponents should not be able to significantly alter the basis of their investment proposal in negotiation of an agreement with the Commonwealth. The investment proposal would be at the centre of the Agreement

Recommendation

II-11. The Commonwealth Agreement with a CRC entity should be based on the CRC Investment Proposal as approved by the CRC Committee.

7.6 Management and leadership

In the current operational environment CRC managers have to work through the values, expectations and motivations of science, business and executive cultures. This, in addition to a requirement to manage significant intellectual property and commercial issues. It has required CEOs to have a much stronger "general management" focus. It is a management challenge of the highest order.

While CRC applications are generally couched in terms of collaborative programmes and strategic outcomes, there is usually little attention paid at the outset to the partners' underlying culture and performance drivers, many of which are not inherently collaborative in nature. There is a need to manage a shift in culture from one of tight funding and support for individual research programmes to a more coordinated team approach to the achievement of some major targets and more flexibility in the resource allocation model that would make such outcomes possible.

Such change won't simply occur as a result of project agreements and is probably one of the most complex challenges facing a new CRC CEO. CRCs need to be vision-led and this needs to be brought about through a specific process with corresponding target outcomes, timelines and measures. Planning and implementation of changes from allocated project support to a more strategic use of resources has to involve, and

have the support of, participants and be phased in over a manageable timescale that takes account of original expectations, student programmes and staff employment.

Management and organisation theory indicates that project based and matrix organisations work best when there are "free resources" in the system. When resources are tightly controlled, the task of management is overwhelmingly directed towards managing a budget – sometimes to the detriment of ensuring that outcomes that involve interpersonal cooperation and collaboration are achieved. This is reflected in the CRC system with the attention given to, and the complexity inherent in, costing and managing "in-kind" contributions.

Precisely because of the centrality of the management and leadership to the success of a CRC, it is vital that the profile of the person who is going to be CEO of a proposed CRC be clearly defined in the preparation of the investment proposal that forms the basis of the CRC application. Preferably, the identity of the proposed CEO should be known, and party to the Proposal.

Recommendation

II-12. The position profile of the CEO of the CRC be clearly identified in the CRC proposal. Where possible, the CEO should be nominated in the proposal.

7.7 Critical mass

Critical mass is a term that creates a great deal of confusion. Often it presupposes a requirement for formalisation in structural and administrative arrangements to gain access to, and facilitate the utilisation of, key resources of facilities, equipment, people and other resources.

A CRC that had a global orientation, in an industry that involves substantial commitment of costly complementary assets, that draws together a range of scientific and science/engineering specialisations and competencies, and includes specialised skills in relation to adoption, application, and use of research outputs would be expected to require a greater commitment of resources than a group of related CRCs with a national orientation focussing on specific and relatively well compartmentalised problems and issues. In the former case a structured "formal" organisation would be appropriate, whilst in the latter a loose coalition among participants would work.

During discussions and consultations in the Evaluation, suggestions were made for a category of "Super CRCs" that would combine the resources of existing CRCs and other entities into an overarching management and organisational framework. A specific proposal for an Australian Metals Manufacturing Centre of Excellence, involving the CRC for Cast Metals Manufacturing, the CRC for Intelligent Manufacturing Systems and Technologies and the CRC for Welded Structures is currently being canvassed.

The proposal is reflective of the evolution of the CRC Programme, as discussed in Section 3. It reflects the influence of a growing global orientation in manufacturing and the significance of international value chains to build economies of scale and scope into operations. It is not the task of the Evaluation Team to assess the benefits, costs and projected returns from what is essentially an investment proposal. The

threshold question is the "value add" of the additional investment in management over and above what can be achieved through a partnership approach.

Recommendation

II-13. In relation to the proposed "super CRCs" the level of programme funding to be made available should be based on the investment proposal and the "business case" rather than representing a "special case"

7.8 Agility and flexibility

Relatively high-risk investment proposals are best presented as a CRC bid involving successive stages of investment with movement to the next stage dependent upon performing well in the current stage.

In such 'high risk' cases a CRC proposal should consist of a set of options that the CRC Programme may or may not wish to exercise depending upon the progress made. This provides flexibility for both the proponents and the Commonwealth to undertake exploratory high-risk investments aimed at innovative end-uses of R&D whilst limiting the exposure of the CRC Programme to the risks generated by a long-term funding commitments in such circumstances.

Recommendation

II-14. The CRC Programme should be open to investment proposals based upon presenting a sequence of options for investment with progress determined on the basis of success. This type of investment proposal will encourage exploratory propositions with high-risks but high potential returns by providing flexibility over how far the venture should proceed

7.9 Longevity and predictability

Given that the intention behind creating a CRC is to achieve an outcome over a defined time period, it is important that participants understand and appreciate that there will be an inevitable wind-down This applies to CRC "renewals" which are understood to be embarking on a new research programme. It follows that each CRC Proposal should have a clearly defined strategy for sustainability and a process for "exit" after Programme funding terminates

An understanding of "exit" sets the CRC system apart from research funding programmes that create an expectation among researchers of ongoing grant assistance and support. Exit from a CRC can include the formation of an organisation that has established commercial sustainability, transformation into a new entity, or establishment as an independent research centre that attracts ongoing support from participants including businesses and Commonwealth and State governments on the basis of its expertise, credibility and reputation.

The purpose and objectives of the CRC Programme are inconsistent with ongoing support for research into "public good" activities. CRCs that require ongoing or indefinite Programme support, and are not involved in adoption and application of research, should not be admitted to, or continue within, the Programme: to the extent

that the research merely has potential to deliver public benefits but cannot demonstrate a path to adoption, application and use by the participants in the CRC, or other clearly identified end users, funding should be sought from other programmes.

8: Funding and Accountability Arrangements

This Section of the Report addresses the following matter in the Terms of Reference:

Funding arrangements

- How should funding arrangements (eg, size and duration of grants, funding for 'new from existing' CRCs in successive rounds) be modified?

Accountability framework

- How should the accountability framework (including reporting and review processes) be modified to ensure the achievement of any proposed change to the objectives for the Programme?

8.1 Size of investment

The Guidelines for the 2002 CRC Round advised potential applicants that:

> As in previous rounds, it is expected that CRCs emerging from the selection process will vary considerably in size. Selection will be based on merit and equal consideration will be given to proposals for large and small CRCs, provided the objectives of the programme can be achieved. The amount of funding provided to CRCs in the last round ranges between $1.6 million and $3.14 million per annum, averaging $2.45 million per annum. Additional funding provided for the expansion of the CRC Programme will enable an increase in grant size. It is anticipated that the average amount of Centre funding may be around $3 million per annum, while the existing flexibility in size and duration will be maintained. To the extent that it is consistent with the objectives of supporting quality research, there may also be an increase in the number of CRCs supported.

In the 2002 selection round, CRCs were approved across a range of $12m to over $32m in Commonwealth funding for the duration of the CRC.

This spread is consistent with a "portfolio" perspective, under which the CRC Committee would support a range of large and small investments and investments spread between the three CRC categories identified in Section 4.

8.2 Leverage

In public announcements and Programme publicity much is made of the way in which the Programme has "leveraged" private research and development funds. This leverage includes both cash and so-called "in-kind" contributions. In all reality, however, leverage is simply a means to an end – not an end in itself. There are also substantial difficulties in establishing a realistic value for "in kind" contributions.

Under present Guidelines the Government, through the Programme, will provide a maximum of fifty per cent of the total cost of establishing and operating each CRC. Currently, the amount of CRC Programme funding provided to existing CRCs amounts, on average, to about one quarter of the total costs. That is, for every dollar provided by the Programme, more than three dollars of resources are estimated as being contributed by the participants.

The CRC Committee examines the proposed leverage on the Programme funding sought in the application, expressed as the ratio of the total contributed resources

budgeted for the proposed CRC to the Programme funding sought from the Commonwealth. Contributions may be provided as cash and/or 'in-kind' resources.

The provision of an appropriate and adequate amount of cash is regarded as highly desirable, as it increases the flexibility available to the CRC governing board to optimise its resource allocation decisions. The cash available per full time equivalent researcher is seen as a useful indicator in this regard.

The extent of leverage that is necessary to be successful in winning CRC funding is being seen as a serious issue for all participants, compounded by the growing market for research services that has arisen over the last 15 or so years. While the contribution from participants can be in-kind as well as in funds, the extent of leverage necessary to be successful is placing increasing strains on participation.

As discussed in Part I, the Evaluation Team is of the view that linking in-kind contributions to "leverage" unnecessarily complicates and distorts the thrust of the CRC Programme. It is the Team's view that CRC proposals should be assessed on the basis of the "investment proposition" not on the leverage of participant funding. There should not be a restriction placed on the source of that funding, except to the extent that it be sourced from active participants.

8.3 Supporting investors

It is likely that State and Territory governments will continue to have a strong interest in making substantial funding contributions to CRC investment proposals. As mentioned earlier in the Report some State/Territory governments are establishing funding programmes with the explicit aim of leveraging Commonwealth CRC funding. This leverage should be encouraged, particularly with respect to the category of business development CRCs that aim to create new business entities in areas where none currently exists.

In these situations State/Territory government involvement provides a means of building critical mass in the prospective CRC partnership to compensate for the lack of industry partners. No recommendation on this issue is necessary because the onus is upon the CRC investment proposal's proponents to persuade State/Territory governments to actively participate in the CRC.

Similarly, where a CRC proposal involves a substantial benefit to a Commonwealth agency in terms of policy and/or Programme impact, there could be a reasonable expectation that the agency would be involved as a participant. This is evident in relation to the Greenhouse Accounting CRC, and the Biosecurity CRC, but the precedent could be extended.

Involvement of Australian venture capital investors as joint venture partners in business development CRCs should also be encouraged where there is a commitment on the part of the investor to undertake subsequent commercialisation activity. This would be appropriate where there is no clearly identified established industry end user and path to adoption is through new business creation.

8.4 The role of CRC Boards

It has been argued in previous Sections that the CRC Boards have a central role in the accountability framework.

A Board of directors performs two important functions for organisations:

- Monitoring management on behalf of shareholders – and that effective monitoring can improve firm performance by reducing "agency costs"; interest is in relationship between proxies for board incentives to monitor (eg, board dependence on equity compensation) and firm performance
- Boards as a provider of resources (including legitimacy, advice and counsel, and links to other organisations); interest is in "Board capital" – consisting of human capital (experience, expertise, reputation) and relational capital; (network of ties to other firms and external constituencies) – and how board capital leads to the provision of resources to the firm[128].

In practice boards both monitor and provide resources. It follows that Board membership should reflect both considerations. The relative weighting and importance of each consideration varies through an organisation's development life cycle.[129]

With responsibility of delivery of Programme outcomes the responsibility of Boards and CEOs, the Department of Education, Science and Training should not be involved in detailed oversight. The focus should be on holding Boards accountable for performance. Within this framework, Boards should oversight the preparation of Annual Reports and the three-year Performance Audit Reports recommended in Part I.

Recommendation

II-15. The focus of accountability under the CRC Programme should be on holding CRC Boards accountable for performance. Boards be required to sign off on Annual Reports and commit to implementation of the three yearly Independent Performance Audit Reports

8.5 Reporting

As final impacts of industrial research will not always be known for many years it is often necessary to adopt a "proxy" approach and to look at the logic and integrity of the *planning and decision-making* processes that are in place, and in particular, the approach to managing risk and dealing with uncertainty. Uncertainty arises when the consequences of a plan/decision will not be known until well after commitment. From a management perspective, for example -

- There can be no guarantee that a good plan/decision will lead to good consequences
- A good plan/decision can lead to a bad outcome due to circumstances that are unpredictable and beyond the control of the decision maker

[128] See Amy J Hillman and Thomas Dalzeil, "Boards of Directors and Firm Performance: Integrating Agency and Resource Dependence Perspectives," *Academy of Management Review* 28, no. 3 (2003)
[129] Matthew D Lynall, Brian R Golden, and Amy J Hillman, "Board Composition from Adolescence to Maturity: A Multi theoretic View," *Academy of Management Review* 28, no. 3 (2003)

- A bad plan/decision can lead to a good consequence – in circumstances that cannot be replicated (i.e. luck).

There is the additional benefit in the "learning by doing effect". Similar considerations apply to long-term research projects.

In these circumstances the emphasis in reporting has to be on the quality of the plan/decision making – as well as the quality of the consequences. Thus, there is a need to look at the *planning and decision-making processes* – including capacity to identify problems/opportunities, assessment of options and alternatives, implementation, and approaches to managing uncertainty.

This capacity also includes the way in which information and knowledge is acquired, including access to informed and expert opinion – nationally and internationally. Moreover, decisions will involve "calculated risks" and an important issue is how well these are addressed, managed and documented.

The ability to make good decisions and to manage uncertainty is highly contingent on individual, organisation and management capability, reflected in the criteria of *credibility, reputation and integrity* and the absence of self-interest (or conflicts of interest). In other words, suppliers of resources have to place a very high level of trust in the capacity of an organisation to be able to deliver the outcomes sought, particularly when the outcomes may not materialise for many years. This trust has to be verified on a regular basis[130].

An important part of regular reporting, and periodic evaluation, involves attestation of the trust related values of credibility, reputation and integrity in governance, planning, resource allocation and management decisions. The greater the extent to which these values predominate, the greater is the likelihood that expected outcomes would be achieved.

Part of this attestation process involves providing evidence about how the work that has been undertaken (that is, activities) will deliver the results intended. It is not enough to simply provide evidence that work has been done and there is *potential* for achievement.

Recommendation

II-16. The Three Yearly Performance Audit Reports attest to the credibility, reputation and integrity in governance, planning, resource allocation and management decision-making processes in the CRC.

[130] Failure to engender trust leads to loss of confidence. For example, the recent corporate failures have pointed to the lack of credibility and integrity in financial reporting and have substantially weakened the confidence of shareholders and other stakeholders in auditors to attest to the financial performance of companies.

9: Other matters

9.1 Approach to Commercialisation

Individual CRCs, acting on their own, do not have the resources to develop strong capabilities in research commercialisation. University technology transfer offices that do have the capability are heavily committed to work coming directly from the university.

Suggestions were made during the course of the Evaluation that CRCs should collaborate to develop the depth of expertise and capability required for the successful commercialisation of research results through these means. A number of groups, including the Australian Institute for Commercialisation, have expressed interest in supporting a brokerage role in this area. There are also a number of people with relevant skills and experience planning to establish a business focused on public sector research commercialisation.

To be successful, however, the CRCs must have ownership and commitment to such a vehicle. This would require the commitment, support and involvement of individual CRCs and the CRC Association.

Recommendation

II-17. CRCs work collectively towards the creation and/or engagement of an entity that will provide skills and capabilities to assist with effective research commercialisation. The CRC Association should take the lead role in facilitating this initiative.

9.2 Support for Small to Medium Businesses and Non Government Organisations

There is a significant barrier to the engagement of SMEs and NGOs in the CRC Programme. It can be expensive in time and cost and the seven-year commitment is unattractive to many SMEs. To many SMEs the ARC Linkage programme is more attractive on the basis that the research is highly focussed on their need, and has only a three year (or shorter) duration. Moreover, many CRC research projects are too large for an SME to participate in – and often beyond their needs or interests.

The difficulties facing SMEs are not a reflection of Programme design per se – the Programme guidelines do not insist on companies being involved for seven years. However, applicants who can offer partnership and funding over a seven year research programme may be advantaged in the selection process. As has already been noted, SMEs are less able to plan years ahead - high-technology start-ups rarely have more than two years operational funding.

The CRCs that do have a strong focus on technology diffusion (for example, the CRC for Welded Structures and the CRC for Microtechnology) have extensive involvement with SMEs, often through outreach activities. A number of CRCs use a collegiate and an associate framework for SME engagement.

In the ICT Sector, which has a large number of SMEs, most are not aware of, or involved with, the CRCs. ICT SMEs often have short time horizons. By their nature,

most SMEs are not generally well placed to play a major, continuing role in a CRC. Nevertheless, it is important that ICT CRCs engage with the SME community to achieve technology transfer and to identify opportunities for research and commercial collaboration where they exist. CRCs should be pro-active in this area, and it is pleasing to note that several of the ICT CRCs clearly are.

If small business participation is to remain a core requirement in the selection criteria for CRC funding it is important to encourage a flexible mechanism for achieving this aim. The clustering of small businesses to ensure that they are able to participate in the CRC Programme is one way this could be achieved. Similarly, allowing small businesses to become 'associate' members of a CRC whereby they provide little in the way of resources to the CRC but are able to access elements of the IP developed, commensurate with their input, could also achieve this.

The NSW Department of State and Regional Development noted that not many CRCs have sought the Department's help to commercialise their own research or to reach out to small businesses. State development agencies have a great deal of contact with small businesses, but they receive few comments or inquiries about CRCs. The NSW Department considers that CRCs could be contributing more to upgrading the innovative capacity of existing small businesses.

Recommendation

II-18. The CRC Programme give adequate recognition to the efforts made by CRCs to build relationships with SMEs and NGOs through the objective to upgrade the innovation capacities of Australian business enterprises. The Programme actively seek proposals involving SMEs and NGOs through "associate agreements" which provide benefits without the associated administrative, legal and taxation problems.

9.3 Support for regional innovation

The involvement of higher education institutions in promoting regional economic development is well documented. The contribution of CRCs in supporting that role is a highlight of the Programme.

The CRC Programme could make a major contribution to helping to create critical mass and synergy among diverse and somewhat uncoordinated existing research facilities in the regions.

Recommendation

II-19. The CRC Programme should communicate the contribution of collaborative research in regional economic development and encourage Commonwealth and State regional development agencies to become participants in developing investment proposals that would deliver investment outcomes and build capability in regional communities.

9.4 Involvement of the social sciences and humanities. [131]

There is little support for CRCs being established specifically for the social sciences. However, the interdisciplinary nature of research necessarily invites and involves participation from the social sciences and the humanities in addressing research with a national economic, social and/or environmental outcome.

A Deputy Vice Chancellor observed:

> The CRC Programme should recognise the economic impact of research in the social sciences. It has repeatedly and convincingly been pointed out in research forums around the country that the effective take up of innovation requires strategic approaches and that this is the stuff of many of the social sciences. In addition, the social sciences make a direct economic contribution to national development (for instance, the export income of education and the impact of heritage industries). Both of these elements should be captured in appropriate CRCs.

The trend for including expertise from research in economics is already established. There is also scope for greater involvement of researchers with expertise in human settlements, particularly in relation to CRCs concerned with the natural environment.

As the investment outcomes of many CRCs involve adoption and application in public policy and programmes, consideration should be given by the partners to include people with skills in policy analysis and advocacy as a way of developing a pathway to application and implementation.

9.5 Collaboration between participating organisations

As the organisations involved in the CRC Programme become more strategically orientated towards their involvement in CRCs there is a need for collaboration between organisations to be managed at a higher level. This follows from the dynamic of collaboration moving from the "opportunistic" to the "integrative" as discussed in Section 3.

Effective collaboration at the strategic level requires arrangements to ensure that participating organisations share the objectives and purposes of the CRC Programme and ensure that collaboration delivers benefits to all. To this end, it is appropriate for participating organisations to consider ways in which they can develop ground rules and arrangements to ensure that collaborative arrangements deliver value to all.

The current CRC Association is representative of CRC Boards and managers. It is not representative of CRC participants – that is, executive managers in universities, public research organisations, businesses and participating government agencies.

The major participants in the CRC Programme might consider establishing a forum to facilitate the development of an integrated approach to collaborative arrangements within the CRC Programme. The Forum would consist of representatives from the higher education sector, the Publicly Funded Research Agencies, participating businesses (perhaps represented by an appropriate industry organisation), government

[131] Research fields relating to the social sciences and humanities include: Education, Economics, Commerce, Management, Tourism and Services, Policy and Political Science, Studies in Human Society, Behavioural and Cognitive Sciences, Law, Justice and Law Enforcement, Journalism, Librarianship and Curatorial Studies, The Arts, Language and Culture, History and Archaeology, Philosophy and Religion

agencies across the industry sectors, small business and non-government organisation interests, the Department of Education, Science and Training, and the CRC Association

Issues to be addressed by the Forum would relate directly to matters of concern at the level of policy, strategy, and organisation of engagement with CRCs. Specific areas of interest in the present environment could cover, for example, matters concerned with CRC constitution, taxation, calculation of in-kind contributions and vision and priorities, the involvement of small to medium enterprises, and non-government organisations working in the natural capital restoration and repair and biodiversity areas.

Such a Forum would not duplicate or diminish the important role of the CRC Committee, which includes among its membership many of the CRC participant groups.

9.6 Assistance and support for the CRC Association

With a time frame of 12 years and 123 CRCs supported, a CRC "industry" has emerged. Effective industries require leadership and have strong industry representation on matters relating to policy advocacy and member support and assistance.

It is also a feature of contemporary public policy that governments like to communicate with "industry" through an appropriate and relevant industry association. It is understood that CRC CEOs have agreed to increase the funding for the CRC Association.

The CRC Association needs to develop to a point where it is in a position to offer high-level advice to Government on complex issues including those relating to taxation and the impact of the corporations law. Moreover, the CRC Association is in the best position to promote the achievements of CRCs to industry – collectively and individually.

Recommendation

II-20. The Department of Education, Science and Training provide targeted financial assistance to the CRC Association for specific projects developed by the Association related to implementing recommendations in this Report, including contribution to the development of the CRC entity framework, case studies, communication strategy and implementation and a commercialisation brokerage.

Attachments

1: Terms of Reference

The Terms of Reference consisted of two Elements:

Element 1

A *Do the Programme's outputs and outcomes demonstrate that it has been effective in meeting its objectives including by:*

- Contributing to Australia's economic growth, social well-being and environmental outcomes;
- Developing Australia's public and private research capacity in the areas of national need or global opportunity;
- Producing research of an excellent standard that would not have been undertaken otherwise;
- Adding to the nation's intellectual property and its commercialisation or utilisation;
- Enhancing collaboration among public and private researchers, and between public researchers and commercial or community interest;
- Increasing the proportion of public researchers who are commercially oriented; and
- Upgrading the innovative capacities of Australian business enterprises?

B *Do the administrative arrangements for the Programme enable it to be delivered as efficiently and flexibly as possible, in particular the:*

- Selection criteria and procedures;
- Funding arrangements;
- Accountability framework; and
- Departmental processes and resources?

Element 2

A *Do the programme objectives and key design features provide a clear and appropriate framework for achieving successful outcomes within the broader Australian science and innovation system in the medium and longer term?*

B *Are any changes needed to the objectives to strengthen the Programme in future and what implications would they have for programme design and change management?*

The above Terms of Reference specified the matters that had to be addressed in the Evaluation. A number of additional questions were included in the project brief.

The following additional questions are contained in the project brief.

Element 1

In relation to <u>effectiveness</u>, the methodology will need to include:

- an appropriate framework for assessing the impact of the CRC Programme (and, where appropriate, particular groups of CRCs),
  - what impacts can be determined using the available data and are any trends observable?
  - are these data sufficient to make an overall judgement about the impact of the Programme or are additional data required and, if so, how could they be obtained in a cost-effective way?

  - what are stakeholders' views on the impact of the Programme and do these vary for different types of CRCs?
  - are there any international or other benchmarks with which to compare the impact of the CRC Programme?
- an assessment of whether the outcomes of the Programme have demonstrated that it has achieved the stated Programme objectives:
  - has the selection process for CRCs resulted in an appropriate choice of CRCs with the capability to achieve the stated Programme outcomes?
  - to what extent have public research outputs been successfully commercialised or transferred to commercial or other users?
  - has the Programme supported an appropriate mix of CRCs (across research fields and types of research users – individual enterprises, industry sectors, enterprises of different size and type and government agencies)?
  - are CRCs' education and training programmes producing high quality graduates/post-graduates with skills that are valued in industry-oriented research, including through the provision of career paths?
  - has the Programme strengthened collaboration between public and private researchers and between public researchers and commercial and community users of research, including through direct participation in the research and through leveraging contributions from industry and others?
  - has the Programme encouraged CRCs to develop international links and linkages with small and medium enterprises?
  - have the governance arrangements within CRCs been effective in ensuring that CRCs achieve their objectives (across all aspects of CRCs' activities including financial, research, education and intellectual property management)?

In relation to <u>efficiency</u>, the methodology will need to cover:

- the value for money achieved by the Programme
  - has the Programme delivered outputs at an appropriate cost?
  - has the Programme produced outcomes (not confined to economic outcomes) that represent a positive return on the value of inputs?
- the appropriateness of Programme management arrangements
  - are the processes for selection and contracting of CRCs efficient?
  - does the CRC visitor scheme contribute to the efficient administration of the Programme and achievement of Programme outcomes?
  - are the processes for monitoring (through first year visits and periodic reports) and reviews (2^{nd} and 5^{th} year) cost-effective and would there be value in harmonising any aspects with the accountability frameworks for related programmes (eg, ARC, CSIRO)
  - are the funding arrangements (including size, duration and phasing of grants) flexible enough?

Element 2

In relation to the Programme objectives, the evaluation will need to cover:

- The <u>clarity</u> of the objectives:
  - do the individual objectives provide a coherent overall framework for the Programme?

- is there a clear relationship between the Programme objectives and the selection criteria?
- is there any conflict between any of the objectives or selection criteria?

- The appropriateness of the objectives in light of developments in related Australian programmes and policies, developments in related overseas programmes and policies, and current understanding of the nature of industrial innovation:
  - do the objectives, including the balance between them, provide the basis for an effective CRC Programme over the medium and longer term, taking account of developments in:
    - related programmes including those implemented under *Backing Australia's Ability* (eg, Centres of Excellence, ARC research programmes);
    - taking account of any preliminary results of the mapping of Australia's science and innovation activities across the public and private sectors to be undertaken by the Commonwealth.
    - policy on research and innovation, including National Research Priorities;
    - developments in the research 'culture' in universities and public sector research agencies;
    - structural aspects of Australian industry; and
    - technological and industrial trends?
  - does the mix of economic and social objectives for the Programme remain appropriate?
  - are there overseas programmes and policies that provide a basis for changes to CRC programme objectives?

In relation to key programme design features, arising from the examination of the clarity and appropriateness of the Programme objectives, the evaluation will assess the following:

- Selection criteria and procedures
  - how should the selection criteria and procedures (including the collaboration model implied in these) be modified to give effect to any proposed change to the objectives for the Programme?
- Funding arrangements
  - how should funding arrangements (eg, size and duration of grants, funding for 'new from existing' CRCs in successive rounds) be modified?
- Accountability framework
  - how should the accountability framework (including reporting and review processes) be modified to ensure the achievement of any proposed change to the objectives for the Programme?

2: Approach to the Project

Programme Evaluation

Element 1 of the assignment involved using the methodology of programme evaluation.

Evaluation is one of the three basic forms of disciplined enquiry (the others being research and policy analysis). It has a focus on an "evaluand" – what is being evaluated – eg, a program, process, organisation, position, etc – which results in "merit" and/or "worth" constructions (judgements).[132]

- Merit constructions concern the *intrinsic* quality of what is being evaluated, irrespective of the setting in which it may find applications
- Worth constructions concern the *extrinsic* usefulness or applicability of what is being evaluated and in a concrete local, regional or national setting.

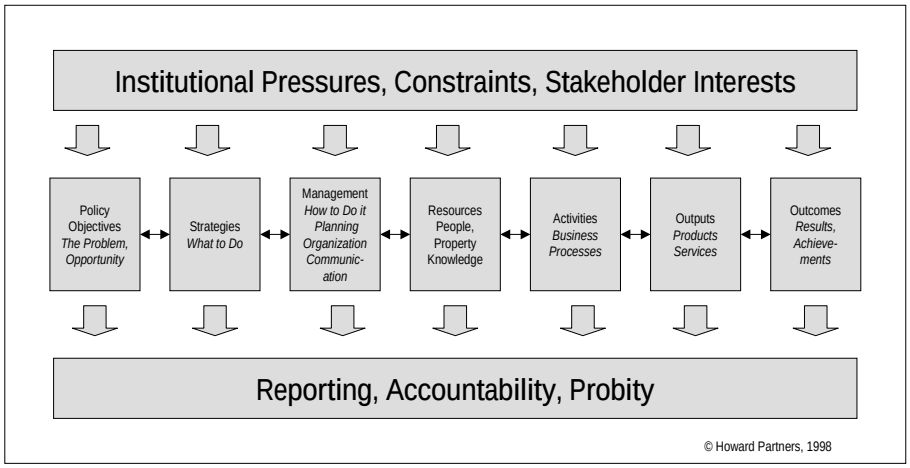
In this framework an evaluation is undertaken having regard to three sets of understandings:

- Understanding and presenting the context of what is being evaluated so as to make it comprehensible, understandable and explainable – for example, the policy, strategic and institutional environment in which the CRC Programme operates (sometimes referred to as the "programme logic")
- Understanding the basis, logic and sophistication of policies, strategies, structures and actions, and the way in which they have been formulated, developed and implemented; for example, the ways in which the idea for creating a CRC is developed by proponents, the processes of formation, applying for and receiving funding, setting up, creating a management infrastructure, establishing and funding research priorities, deciding on projects, teaching arrangements, creating awareness, implementation and/or commercialisation of results and reporting; case study approaches are applicable in this context
- Understanding the way in intrinsic and extrinsic usefulness, as understood by stakeholders, are first identified, examined for meaning, and then confronted, compared and contrasted in encounter situations. This involves both "discovery" and "assimilation" methodologies and approaches; methodologies can accommodate both quantitative and qualitative methods; it is a matter of finding out what has (or has not) been achieved and whether the actions and tasks were worth doing and whether there is a case for continuation – with or without modification.

The discovery phase is an endeavour to identify "what is going on", in terms of both what is being evaluated and the context. The assimilation phase involves presenting new, alternative and/or different perspectives about how the existing arrangements might be approached and improved in terms of developing, suggesting and recommending new understandings.

[132] Egon G Guba and Yvonna S Lincoln, *Guidelines and Checklist for Constructivist (a.k.a. Fourth Generation) Evaluation*(Evaluation Checklists Project, 2001, accessed); available from www.wmich.edu/evalctr/checklists.

Howard Partners has developed an evaluation methodology that reflects these considerations and which uses the following framework:



The model focuses attention on the linkages between what is intended and what is achieved, and reflects a supply chain or "value chain" approach. Recently there has been a great deal of interest in the concept of a "knowledge supply chain".

Thus, from the perspective of value chain improvement, an important task in evaluation is to ensure a close connection between the policy objectives and the outcomes and results and to ensure blockages or brakes on the elements or links are identified and resolved. In the evaluation of the CRC Programme, attention is required to each element in the "value chain". That is:

- The policy purpose – why CRCs were established, what was intended
- The implementation strategies - the number of CRCs, the science, technology and innovation coverage, industry involvement
- The management of CRCs (as well as management of the program) – a point that is often overlooked, but critical to achieving performance and outcomes
- The resources available – public, university, private
- The way in which work is undertaken – projects, teaching, awareness
- The outputs – what is produced in the way of tangible and intangible products and services
- The outcomes – what has been achieved – in relation to the overall purpose and in relation to other beneficial outcomes.

In terms of contemporary interest in value chains, and more recently in knowledge supply chains, the framework also draws attention to elements and linkages in the overall policy and programme structure. Specifically, the model draws attention to:

- The importance of "value" being added to the programme outcome in each element
- The potential influence of pressures, constraints and stakeholder interests in all elements and linkages of the "chain" - which can in turn impact on the outcome
- The importance of reporting, accountability and probity matters – again in all elements of the "chain".

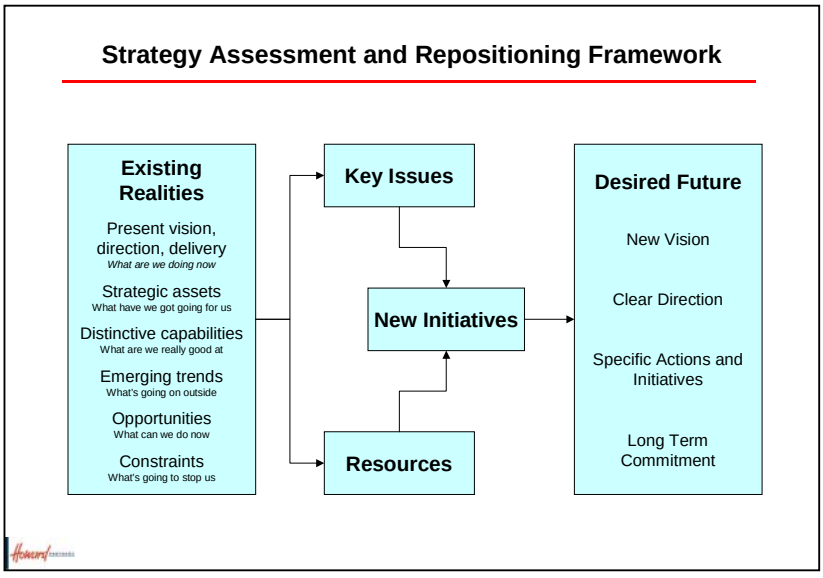
The framework assists in identifying and linking the many dimensions of a programme structure - planning, organisation, resource allocation and delivery arrangements, etc - and the way in which these contribute to programme outputs and outcomes. In this way, we are able to link the questions identified in the project brief to the specific terms of reference relating to efficiency, effectiveness and improvement for the program.

The framework also draws attention to the underlying importance of *management capacity and capability* in moving from policy objective to outcome. That is, the process does not occur automatically or exogenously. Management input is required in all facets and the key determinant of programme success is management capacity and capability in terms of the ability to drive the process as well as cover stakeholder interests and meet accountability requirements.

This approach to evaluation places a very high priority on consultative mechanisms and the collection of documentary and statistical "evidence" to support, redirect (or refute) judgements about what is being done and how to go about it in the future. The Evaluation/Review of the CRC programme involved an extensive process of consultation and collection of documentary material.

Strategic Assessment

While Element 1 involves the methodology of *programme evaluation*, Element 2 involves the tools and techniques of *public policy analysis and management strategy review*. The approach is built around examination of the existing situation, drawing on the Evaluation, analysis of key issues in the policy and programme environment, identification of a "desired future" state, and working out ways to get there. The methodology is depicted below.



The two approaches were conducted in parallel The key tasks involved are canvassed below.

Preliminary and Awareness Raising

Howard Partners confirmed with the relevant project managers in the Department of Education, Science and Training, their expectations and requirements of the evaluation, and confirmed understanding of the stakeholder base.

Press releases and others forms of awareness raising were undertaken to alert all stakeholders and other interested parties to the inquiry.

Review of Background Documents, Data and Materials

The evaluation included assembly, analysis and review of all existing background documentation and data. This included:

- Documents and data collected by AusIndustry and the Department of Education, Science and Training in their management of the programme, including past CRC Programme evaluations
- CRC programme guidelines and operating documents
- CRC Centre Annual Reports
- Management Data Questionnaire (MDQ) information
- CRC Review Reports including 2nd and 5th year reviews
- Reports, papers, articles prepared and published
- Publicity and promotional material prepared by the CRC Association.

Submissions

Submissions and comments were invited from stakeholder organisations and people involved in the Programme through a letter from the Department of Education, Science and Training and media profile. A special e-mail address was established for the evaluation.

A list of submissions received is at Attachment 3.

Consultation Instruments

Throughout the evaluation Howard Partners prepared a number of background briefing papers relevant to Element 1 and Element 2 of the Evaluation. These documents provided background information and described the purpose, procedures and programme of consultations to be undertaken at each stage.

When approved by the CRC Programme Evaluation Steering Committee and the Department of Education, Science and Training for public distribution, these consultation documents were widely circulated, to stakeholders. They were also placed on the Department of Education, Science and Training web site. They served as primers to any discussion or workshop.

Consultation Processes

Consultations - Element 1

Element 1 examined the programmes outputs and outcomes and whether these demonstrate the programme had been effective in meeting its objectives. It included examining efficiency and effectiveness of programme delivery.

Consultations included:

- Workshops with stakeholders in all mainland capital cities
- Arranged face to face meetings with key stakeholders in all categories
- Telephone conferences with key stakeholders in all categories
- Attendance at the CRC Annual Conference in Canberra (21-23 May 2003)

Consultations - Element 2

Element 2 considered the framework and structure of the programme, examining the clarity of its present objectives, the appropriateness of these objectives in the light of national/international developments in innovation policy and funding, and any flow on implications for future programme design, and Centre selection, funding and accountability.

Consultations included:

- Workshops with stakeholders in all mainland capital cities
- Arranged face to face meetings with key stakeholders in all categories
- Telephone conferences with key stakeholders in all categories
- Attendance at meetings of Deputy Vice Chancellors (Research)
- Attendance at the CRC Annual Conference in Canberra (21-23 May 2003)

Some of the consultation documents were abbreviated and used to construct, for example, telephone survey instruments processed by ORIMA Research.

Surveys

Performance Information Survey

A survey was undertaken by Orima Research to provide performance related information related to the outcomes of the Programme. The objectives of the survey were to:

- Assess the clarity and appropriateness of the proposed performance indicators for the CRC Programme
- Provide quantitative data to complement the development of recommendations for future strategic directions for the programme

Questionnaires were developed in consultation with Howard Partners, the Department of Education, Science and Training and the CRC evaluation Steering Committee. Separate questionnaires were used were used for each of the three categories of respondents sought:

- CRCs

- CRC participants in their capacity as research users
- Businesses who invest in innovative research, but not through CRCs

Questions for the CRCs and research users were based on the objectives of the CRC Programme and the performance indicators developed by Howard Partners as approved by the Steering Committee.

Several of the questions for the CRCs and Participant research users were mirrored to provide different perspectives on particular issues. The majority of the questions were force-choice questions supported by a number of open-ended questions to enable respondents to elaborate or comment on issues. All interviews were conducted via telephone by senior researchers. The survey was conducted from mid-June to end-June 2003.

The statistical confidence limits of the Survey are indicated in

Table 54: CRC Performance Survey - Statistical Confidence Limits

	Population	Sample	Confidence Interval @ 90%
CRCs	62	54	+/-4pp
CRC Participant Businesses	220	28	+/-15
Businesses that invest in industrial research, but not via CRCs	*	40	+/-13pp

* Randomly selected from listings of Research performing businesses

Of the 54 CRC survey interviews:

- 49 (91%) of the participants were at the CEO, Director or Deputy CEO level in the organisation
- The remaining 5 were: 3 Business Managers, 1 Research Manager, 1 Technical Transfer and Education Manager.
- Interview times ranged between 19 and 87 minutes, with the average time taken overall being 41 minutes.

Of the 28 research user survey interviews

- 11 (39%) of the participants were at the CEO or Managing Director level in the organisation
- The remaining 17 were: 10 Researcher Directors or Senior scientists; 4 Technical Managers or equivalent; 3 Chief Engineers or equivalent
- Interview times ranged between 20 and 47 minutes, with the average time taken overall being 34 minutes

Of the 40 survey interviews of businesses that invest in innovative research, but not through CRCs

- 7 (17.5%) of the participants were at the CEO level in the organisation
- The remaining 33 were: 14 Research Managers; 10 Technology Managers; 3 Financial Managers; 3 Production General Managers or equivalent; 2 Chief Engineers; 1 Public and Investor Relations Manager.
- Interview times ranged between 5 and 20 minutes, with the average time taken overall being 10 minutes.

The Performance Information Survey Instruments used in the Evaluation are appended to this Report

Expert Opinion Survey

People contacted in the consultations process relating to Element 1 were invited to complete an electronic survey based on the questions raised in the Issues Paper for Element 2 consultations. The responses are contained in the Evaluation Working Papers.

Interim Reports and Other Working Papers

Howard Partners prepared two progress reports, a draft final report, supplementary materials as working papers, appendices and a range of other organisational or management frameworks or diagrams.

All these interim reports and other works were considered at periodic meetings between the CRC Evaluation Steering Committee and Howard Partners, whilst Element 1 and 2 consultations were in progress.

3: Submissions Received

Commonwealth Government

Australian Research Council

Department of Communications, Information Technology and the Arts (DCITA)

Department of Agriculture, Fisheries and Forestry – Australia

Department of Industry, Tourism and Resources

Department of the Environment and Heritage, including individual input to the Department from

CRC for the Great Barrier Reef World Heritage Area (submission from the Great Barrier Reef Marine Park Authority)

CRC for Antarctica and the Southern Ocean

CRC for Waste Management and Pollution Control

CRC for Catchment Hydrology (CRCCH)

Australian Greenhouse Office

Bureau of Transport and Regional Economics, Department of Transport and Regional Services

Universities

The University of Melbourne

The Group of Eight

The University of Sydney

Curtin University of Technology

The University of the Sunshine Coast

The University of New England

The University of Tasmania

Industry

AMIRA International Limited

Australian Chamber of Commerce and Industry

Australian Industry Group

Australian Mineral Industries Research Association Limited

Australian Venture Capital Association Limited

GlaxoSmithKline

Melbourne Water

SGS Lakefield Oretest Pty Limited

Telstra Corporation Ltd

State Government

Department of Innovation, Industry and Regional Development, Victoria

Department of Agriculture, Government of Western Australia

Department of Primary Industries, Queensland Government

NSW Agriculture

Department of State and Regional Development, New south Wales

Queensland Department of Natural Resource and Mines

CRC Visitors and Other Parties

M J Murray

John Yencken

Dr Bob Brown

Ian H Pitman

Brenton Hamdorf

Douglas Graham, PhD

Professor Trevor Cole (The University of Sydney)

Grant Consulting Services Pty Ltd

CRCs

CRC Association

A J Parker CRC for Hydrometallurgy

Australian Photonics CRC

Coastal CRC

CRC for Catchment Hydrology (Professor Dr Rob Vertessy)

CRC for Clean Power from Lignite

CRC for Sustainable Sugar Production

CRC for Sustainable Tourism (Dr Terry de Lacy)

CRC for Freshwater Ecology

CRC for Micro Technology

Publicly Funded Research Agencies

CSIRO

DSTO

CSIRO – Phoenix Group

Learned Societies

Federation of Australian Scientific and Technological Societies

Australian Geoscience Council Inc.

Technology Advisers

CRC Assist

4: People and Organisations Consulted

A listing of people and organisations who have participated in meetings as part of the Consultations Programme for the Evaluation, is listed below.

John Angove, General Manager, SGS Lakefield Oretest Pty Ltd, Perth

Liz Armstrong, Technology Transfer and Training Director, Distributed Systems Technology Centre

Jim Arthur, Commercialisation and Intellectual Property Manager, Cooperative Research Centre for Cast Metals Manufacturing

Dr Michael Barber, Executive Director, Science Planning, CSIRO, Canberra

Associate Professor John Barker, Divisional Research Manager Division of Science and Engineering, Murdoch University Western Australia

Dr Thomas Barlow, Science Adviser to the Hon Dr Brendan Nelson MP, Minister for Education, Science & Training

Megan Barrett, Director, Office of Research Central Queensland University

Dr Bevan D Bates, Head Strategic Programs Systems Sciences Laboratory, Defence Science & Technology

Dr Robin Batterham, Chief Scientist, DEST, Canberra

Clive G. Bennett, Principal Consultant, Clive Bennett & Associates Metals Industry Consultants

Tricia Berman, Department of Industry, Tourism and Resources, Canberra

Peter Blamey, Chief Technical Officer, Dynamic Hearing, Richmond, Victoria

Dr Gopal Krishna Bose, Statistician, Research Surveys & Mathematical Statistics Team, Office of Economic and Statistical

Professor Gary Bouma, Deputy Vice-Chancellor and Vice-President (Research and Development), Monash

Simone Braakhuis, Policy Adviser - Commercialisation, Science, Technology and Innovation Department of Innovation Industry and Regional Development

Dr Mark Bradley, Chief Executive Officer, ATP Innovations Pty Ltd

Hugh Bradlow, Chief Technology Officer, Telstra, Melbourne

Professor Max Brennan

Richard Brookes, Managing Director, National Food Industry Strategy, Canberra

Chris Buller, Business Manager, Pest Animal CRC, Canberra

Harry Buskes, Science, Technology and Innovation Department of Innovation Industry and Regional Development

Garry Butler, Business Development Director, AIC

Anne Campbell, Executive Director, CRC Association, Canberra

Reg Christiansen, Acting Assistant Commissioner Community Safety and Training Department of Emergency Services, Rural Fire Service, Queensland

Ric Clark, Managing Director, Ericsson Asia PacificLab Australasia, Melbourne

Grahame Cook, Deputy Secretary, DEST Executive, Canberra

Craig Copeland, Director, Wetland Care Australia, Ballina

Professor Edwina Cornish, Deputy Vice-Chancellor (Research), The University Of Adelaide

Peter Cottingham, Knowledge Broker, CRC for Freshwater Ecology, Melbourne

Dr Bob Cowan, Director and CEO, CRC for Cochlear Implant and Hearing Aid Innovation, Melbourne

Professor Lawrence Cram, Australian Research Council, Canberra

Andrew Crowe, Business Manager Office of Commercial Services, QUT

Karen Curtis, Director Industry Policy, Australian Chamber of Commerce and Industry

Prof Matthew Cuthbertson, Chief Executive Officer, Cooperative Research Centre for Sensor Signal Information Processing

Ian Dagley, Chief Executive Officer, Cooperative Research Centre for Polymers

Clive Davenport, Chief Executive Officer, CRC for MicroTechnology

Frederick Davidson, Chairman, CRC for Cochlear Implant and Hearing Innovation

Dr Dick Davies, Executive Director, AMIRA International Limited

Rob Delane, Executive Director Plant Industries, Department of Agriculture Government of Western Australia

Andrea Douglas, Chief Executive Officer, The Cooperative Research Centre for Discovery of Genes for Common Human Diseases

Ruth Drinkwater, Senior Manager, Australian Institute For Commercialisation

Dr Roger Edwards, Chief Executive, Australian sustainable industry Research Centre

Elizabeth Elanius, Photonics CRC

Ros Engledow, Director Research Funding Policy, Australian Vice-Chancellors' Committee

A/Professor Mike Ewing, Deputy CEO, CRC for Plant--Based Management of Dryland Salinity

Professor L D Field, Acting Pro-Vice Chancellor, Research, the University of Sydney

David Fenwick, Research Office, UTS

Nell Finlayson, Biotechnology Business Director, BiolnnovationSA Government of South Australia

John Flack, Director, Cooperative Research Centre for Cellular Growth Factors

A/Prof Simon Fleming, Director, Australian Photonics Cooperative Research Centre

David Garman, Executive Director, CRC for Waste management and Pollution Control, Sydney

Professor Paul Gatenby, Dean, Medical School, ANU, Canberra

Mark Gibson, Chief Executive Officer, DSTC Pty Ltd

Professor L Murray Gillin, Professor Emeritus, Australian Graduate School of Entrepreneurship (AGSE) Swinburne University of Technology

Dr Ross Gilmour, Programme Manager, Grains Research & Development Corporation

Dr Barney Glover, Director, Research and Development, Curtin University of Technology

John P Grace, Director, Ibio Pty Ltd

Dr Miriam Goodwin, ANSTO

Neil Grant, Director Office of Innovation, Department of Further Education, Employment, Science & Technology Government of South Australia

Carole Green, Business Manager, CRC Construction Innovation

Bronwyn Greene, Executive Officer, Office of the Pro Vice-Chancellor (Research) The University of Sydney

Prof Rod Griffin, Director, CRC For Sustainable Production Forestry

Dr Brenton Hamdorf, Business Development manager, Business Liaison Office, The University of Sydney

Gordon Hart, CRC for Sustainable Rice Production, Yanco, NSW

Dr Simon E Hearn, Managing Director, Rural Industries Research & Development Corporation

Tony Hill, Managing Director, Capital Hill Consulting

Dr Bruce Hobbs, Chief Scientist Executive Director, Office of Science and Innovation Department of The Premier and Cabinet Government of Western Australia

Dr Mark Hochman, Director, Research Services University of South Australia

Dr. R. Mark Hodge, Manager - Commercialisation, Science, Technology and Innovation Department of Innovation Industry and Regional Development, Melbourne

Professor Peter Hoj, Director, The Australian Wine Research Institute, Adelaide

Shaun Holthouse, Technology Development Manager, CRC for MicroTechnology

Dr Michael Hood, Chief Executive Officer, CRC for Mining Technology & Equipment

Neal E Hooper, Principal Legal Officer Crown Law, Department of Justice and Attorney General, Brisbane

Selena Hooper, Deputy Manager Contracts & Consultancy Adviser Research & Development Office, University of Tasmania

Professor John Irwin, Chief Executive Officer, CRC for Tropical Plant Protection

Dr Peter Jackson, Manager Research, Deputy CEO, Cooperative Research Centre for Clean Power From Lignite

Dr Peter Janssen, Contracts and Intellectual Property Officer, La Trobe University

Dr Ian Johnsson, General Manager Research & Innovation, Australian Pork Limited

Professor Archie Johnston, Pro-VC Research, UTS

Merv Johnston, Managing Director, CVC Reef

Peter D Jonson, Chair, Australian Institute for Commercialisation

Dr Sue Keay, Technical Communications Manager, Cooperative Research Centre for Cast Metals Manufacturing

Peter J Keayes, General Manager – Commercial – CMTE, Brisbane

Professor Anne Kelso, Director, CRC for Vaccine Technology, Brisbane

Dr Rob Keogh, Director Programs, Aimal Health Australia, Canberra

Jeff Kiongwell, Centre Manager, CRC for Satellite Systems, Canberra

Robyn Klepetko, Major Research Programs Coordinator, Melbourne Research and Innovation Office, The University of Melbourne

Professor Frank P Larkins, Deputy Vice Chancellor (Research) and Professor of Chemistry, The University of Melbourne

Michael J. Lee, Technology Transfer and Education Manager, Cooperative Research Centre for Cast Metals Manufacturing

Charles Lindop, Director, Incubator Program, ATP Innovations Pry Ltd

Damian Lismore, CRC for MicroTechnology

Professor Simon Maddocks, Chief Scientist, SARDI Livestock Systems University of Adelaide

Theo Magoulas, Contracts Advisor Research Office, The University of New South Wales

Mary Marko, Senior Policy Adviser Office of Innovation, Department of Further Education, Employment Science & Technology Government of South Australia

John Marshall, Principal, Executive Compass, Melbourne

Julie Martinsen, Manager, ICT Innovation Policy IT Industries Development, Department of Communications Information Technology and the Arts

Oliver Mayo, State Resources, CSIRO Health Sciences and Nutrition Livestock Industries

Michael P McArdle, Head, Research Development Office of Research QUT

Mr Andrew McCreedie, DITR, Canberra

Leanne McDonald, Manager Victoria, AIC

Trudi McDonald, Deputy Director Cabinet Office, Department of the Premier and Cabinet Government of South Australia

Margaret McGrath, Business Manager, CRC for Tropical Plant Protection

Robert A McIntosh, Plant Breeding Institute, The University of Sydney

John Meert, Group Executive Director, Performance Audit Services Group, ANAO, Canberra

Dan Minchin, Commercial Manager, Dairy CRC

Robert Mitchell, General Manager, The Warren Centre

Dr Chris Mitchell, CEO, CRC for Greenhouse Accounting, Canberra

John Molloy, Cooperative Research Centre for Catchment Hydrology

Associate Professor John Mott, Strategic Coordinator Offices of Senior Deputy Vice-Chancellor and Deputy Vice-Chancellor (Research), The University of Queensland

Karen E Mow, Director Research Policy, NH&MRC, Canberra

Neal Muller, Manager, Technology and Service Industry Development Division Department of State Development Queensland Government

John Mullins, Director Strategic Science Initiatives Queensland Government Natural Resources and Mines, Natural Resource Sciences

Professor Mal Nairn, ATSE, Perth

Allan Newton, Director, Rural RDC Chairs Secretariat, Canberra

Suzanne Northcott, Executive Head, Centre for Research Management, NH&MRC, Canberra

Dr Andrew Parfitt, CEO, CRC for Satellite Systems, CSIRO, Canberra

Dr Jim Patrick, Senior Vice President – Research and Applications, Cochlear Limited

Dr. Joseph Patroni, Manager Science Capability Development, Office of Science and Innovation Department of the Premier and Cabinet Government of Western Australia

Dr Peter O'Brien, Executive Director, Bureau of Rural Sciences, Canberra

Dr Robet O'Connor, Policy Officer, Policy and Coordination, AV-CC Secretariat, Canberra

Tony Pensabene, National Manager-Economics, Victoria-Industry Policy, Australian Industry Group

Greg Pickles, Programme Manager Animal Pests, Department of Agriculture Government of Western Australia

Greg Piko, Manager, ICT Centre of Excellence Program, Department of Communications, Information Technology and the Arts, canberra

Dr Mike du Plessis, Innovation & R&D Manager Environment & Innovation, Sydney Water

Nigel Poole, Director Commercialisation, CSIRO

Warwick D. Raverty, Manager IP and Commercialisation, CRC for Functional Communication Surfaces

George Rayment, Principal Scientist and Programme Leader Sustainable Sugar and DEAP Queensland Government Natural Resources and Mines,

Lynne Reeder, Manager, Corporate & Community Relations, University Development Division The University of Melbourne

Dr Ian Reinecke, Director, Solutions Strategies and Chair DSTC Pty Ltd

Corrina Richards, Adviser Economic Policy, Department of Premier and Cabinet, Melbourne

Lee Ridge, Chief Operating Officer, Photonics Institute Ply Ltd, Sydney

Professor Dudley Roach, Chief Executive Officer, Cooperative Research Centre for Railway Engineering and Technologies

Angus M Robinson, Chief Executive, Australian Electrical and Electronic Manufacturers' Association, Canberra

Bill Rosewall, CEO Wheat CRC

Professor Ian Ross, Canberra

Professor Paul L Rossiter, Deputy Vice-Chancellor Research & Development, Curtin University of Technology

Chris Rowles, General Manager, Telstra New Wave, Melbourne

Assoc. Prof David Russell, School of Psychology, University of Western Sydney

Professor Vicki Sara, Australian Research Council, Canberra

Neville K. Sawyer, Director, Australian Business k Limited

Professor Mark Sceats, Chief Executive Officer, Australian Photonics Cooperative Research Centre

Professor S W Serjeantson, Executive Secretary, Australian Academy of Science, Canberra

Dr Duncan Seddon, Director, Duncan Seddon and Associates, Mt Eliza, Victoria

Dr Nigel Steele Scott, Deputy Chief, CSIRO Laboratory, Adelaide

Peter Shadbolt, Project Coordinator Industry Liaison, Swinburne University

Dr Richard Sharp, Director - Technology Commercialisation, Unisearch Limited

Dr Ray W Shaw, General Manager, Technology Services, Rio Tinto, Melbourne

Roger Shaw, CEO, CRC for Coastal Zone, Estuary and Waterway Management, Brisbane

Dr Bill Silvey, Manager, Collaborative R&D Centres Coordination Queensland Government Department of Innovation and Information Economy

Dr Mike Skalsky, Director, Sci2Rx Pty Ltd

Dr Frances Skrezenek, Office of the Deputy Vice Chancellor Research, The University of Melbourne

Dr Ralph Slatyer, Canberra

John Sligar, ATSE, Sydney

Chris Smallbone, Executive Director, Welding Institute of Australia

Felicia Smith, CRC Mining Technology and Equipment

John Spathonis, Principal Manager (Research & Development) Capability and Delivery Division, Department of Main Roads Queensland Government

Andrew Stanley, Director, Research and Evaluation Branch Strategic Planning and Policy Division Department of Human Services Government of South Australia

Dr Dennis Steffensen, Deputy CEO, CRC for Water Quality and Treatment

Professor Andris Stelbovics, Acting Pro Vice Chancellor - Research, Murdoch University Western Australia

Professor David St John, CEO, CRC for Cast Metals manufacturing, Brisbane

Michael Sutton, General Manager IT Industry Development Branch, Department of Communications Information Technology and the Arts

Dr Rodney Thiele, Deputy Director Research and Development, Curtin University of Technology

Geoff Thomas, Chief Executive Officer, Playford Capital, Adelaide

Ian Thompson, Executive Manager, Natural Resource Management Department of Agriculture Fisheries & Forestry Australia

Dr Campbell Thomson, Director Research Office Research Services, The University of Western Australia

Dr Richard Thornton, R&D Portfolio Manager, Telstra New Wave, Melbourne

Dr Richard Thwaites, Business Manager, CRC for Bioproducts

Dr Jeffrey Tobias, Managing Director, The Strategy Group

Lorraine Tomlins, Director Programs and People Support, NH&MRC, Canberra

Dr Peter Twine, Manager – Research and Development, Bureau of Sugar Experiment Stations, Brisbane

Rod Urquhart, Chief Executive Officer, CRC for Functional Communication Surfaces

Dr Meera Verma, Vice President & Chief Operating Officer, BresaGen Limited

Ms Virginia Walsh, Executive Director, Group of Eight, Canberra

David Watson, Executive Director, Science and External Relations, DSTO

Stephan J Wellink, Director Research and Development Office, University of Technology, Sydney

Sharon Winslade, Managing Director, Technology Investments Australia Pry Ltd

Dr Arnold Wissemann, Principal Policy Analyst Office of the Chief Scientist, Department of Primary Industries Queensland Government

Mark Woffenden, Chief Executive Officer Adjunct Professor, DSE, Murdoch University, The A.J. Parker Cooperative Research Centre for Hydrometallurgy

Dr Katherine Woodthorpe, Director, People & Innovation Corporate Advisers Pty Ltd

Hon David Wotton, Chairman, River Murray Catchment Water Management Board

Jeremy Wurm, Managing Director, Brooker Consulting, Melbourne

Nick Yazidjoglou, Assistant Directir, Science Industry Relations, DSTO, Canberra

John Yencken, Research Student, Swinburne Graduate School of Management (SGSM)

Tara Young, Research Coordinator, Australian Institute for Commercialisation

5: Project Management

The Evaluation was undertaken by Howard Partners, a Canberra based public policy research and management consulting company.

John Howard, the Managing Director of the company was the project manager and lead advisor to the Department of Education, Science and Training in the assignment. John was responsible for all aspects of the engagement, including consultations, analysis and writing the Progress and Final Reports.

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- Alastair Higham
- Dr Janice Hirshorn
- Prof. Ron Johnson
- Dr Mark Matthews

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