Australian Government

Department of Education, Science and Training

Mr Petro Georgiou MP
Chair
Science and Innovation Committee
House of Representatives
Parliament House
CANBERRA ACT 2600

Dear Mr Georgiou

Thank you for your letter of 23 March 2005 seeking a submission from the Australian Government Department of Education, Science and Training, to your Committee's Inquiry into Pathways to Technological Innovation.

I trust that the Committee will find the attached submission useful and I would be pleased to provide more information on request. The contact officer in this matter is Mr Mark Fitt, phone 02 6240 8350 and email mark.fitt@dest.gov.au.

Yours sincerely

Dr Evan Arthur
A/g Deputy Secretary

29 April 2005

Submission No. 20

Australian Government

Department of Education, Science and Training

The Department of Education, Science and Training Submission

to the

House of Representatives Standing Committee on Science and Innovation

Inquiry into Pathways to Technological Innovation

April 2005

Contents

Abbreviations and acronyms

AIMS	Australian Institute of Marine Science
ANSTO	Australian Nuclear Science and Technology Organisation
ARC	Australian Research Council
BAA-BOTFSI	Backing Australia's Ability—Building Our Future through Science and Innovation
CCST	Coordinating Committee on Science and Technology
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEST	Department of Education, Science and Training
DITR	Department of Industry, Tourism and Resources
IP	Intellectual Property
MNRF	Major National Research Facility
MoC	Working Group on Metrics of Commercialisation
NHMRC	National Health and Medical Research Council
NSRC	National Survey of Research Commercialisation
PFRA	Publicly Funded Research Agency (ANSTO, AIMS and CSIRO)
R&D	Research and Development
RDCs	(rural) Research and Development Corporations
SMEs	Small to Medium Enterprises
TTOs	Technology Transfer Officers (university commercialisation specialists)

Executive Summary

Australia's capacity to generate new knowledge is fundamental to the strength and health of our economy and society.[1] Publicly funded research institutions play a pivotal role in achieving this goal through the development of technological innovations; through commercial translation of inventions and ideas they can provide significant benefits to the nation.

Working through a range of diverse, often non-linear pathways, publicly funded research provides commercial benefits to industry and society both directly and indirectly.

The direct mode—through commercialisation of specific intellectual property (IP) in the form of patented inventions processes and ideas—is one way of delivering benefits to industry, research institutions and the wider community. The indirect commercial benefits of publicly funded research are equally important. Australia's innovating businesses draw on ideas, skills and experience of those within our research institutions. They actively seek out their expertise to consult, contract, or to collaborate to test hypotheses or develop ideas or processes that are not appropriate or perhaps not ready for the direct route of patenting and licensing.

Pathways to commercial impact and benefit tend to fall into three broad models of knowledge transfer.[2]

- Knowledge production—the direct route of producing tangible benefits through the standard commercialisation process of identifying, protecting and exploiting IP.
- Knowledge diffusion—generally consists of broad industry adoption of the results of research, emphasising communication and adoption of research results.
- Knowledge relationships—encompasses the provision of services to businesses based on a broadly defined intellectual property platform, including trade secrets, know-how and other forms of tacit knowledge; it emphasises collaboration, partnership and joint ventures. Many examples of interaction under this model employ contract research and consultancy activities.

In many instances there is combination of two or more models of knowledge transfer. While the models are ideal conceptions of the workings of the innovation system as a whole, they can provide a vantage point of how the system is functioning.

Factors that appear to determine commercial success include:

- a good skill base, in researchers and industry
- access to early stage capital
- awareness of the opportunities and the different cultures within research institutions and industry
- a willingness to collaborate, between researchers, industry, business and investors
- strong industry and business receptors to adopt and carry innovation through
- a willingness to take risks, be flexible and to persist in the face of delays, complexity and uncertainty
- a strong legal framework for IP.

Understanding how the pathways to commercial success function and how researchers and industry interact allows better evaluation of the national innovation system. This enables government to gain a broader and deeper understanding of the dynamics of the system as a whole.

The information gleaned from this understanding also equips government with knowledge of how to adapt or structure current and future policies and programmes in regard to research commercialisation so that they are flexible and reflect the multiplicity in the ways that technological innovations are brought to market.

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[1] *New Knowledge, New Opportunities*, June 1999, A discussion paper on Higher Education Research and Research Training, p.v. Department of Education, Science & Training.

[2] Howard refers to four conceptual models in his report. .For the purpose of this submission the examples of commercialisation will be presented under the three models referred to above. See Howard Partners (2005), *The emerging business of knowledge transfer: Creating value from intellectual property and services*, Report commissioned by the Department of Education, Science & Training.

Introduction

This submission responds to the Inquiry's terms of reference (see Figure 1) by providing examples of successful technological innovations that have arisen through the interaction of Australia's publicly funded research institutions (including universities) with industry and investors, and by placing these examples in the context of the national innovation system and the Australian Government's policies and programmes that aim to support and grow that system.

The Education, Science and Training (EST) portfolio has a national leadership role in education, science and training, and has the primary responsibility for funding and policy-making in the higher education and science sectors. The relevant responsibilities of the Department and the Portfolio are listed at **Appendix 1.**

This submission relates to the Department's roles and responsibilities. Other agencies in the EST portfolio will be making separate submissions to the Inquiry. A summary of key concepts has been prepared and is at **Appendix 2**. Details of the main policy considerations and background detail are provided in **Appendix 3**.

This submission focuses on a number of the issues set out in the terms of reference. There is a specific emphasis on the different pathways to commercialisation, as well as the role of intellectual property and patents, skills and business knowledge, and research and market linkages in determining the successful commercialisation of research outputs.

Figure 1: Inquiry terms of reference

Terms of Reference

The House of Representatives Standing Committee on Science and Innovation seeks to compile a series of case studies of successful technological innovations, and the pathways to commercialisation. Submissions are sought detailing successful examples of Australian technological innovations.

Submissions are also sought with particular reference to successful innovations, on issues such as:

- pathways to commercialisation;
- intellectual property and patents;
- skills and business knowledge;
- capital and risk investment;
- business and scientific regulatory issues;
- research and market linkages;
- factors determining success; and
- strategies in other countries that may be of instruction to Australia.

Context

Policy framework

The majority of basic research and a considerable proportion of applied research undertaken in Australia is conducted within publicly funded research institutions, funded largely through the EST portfolio.[3] This funding is distributed via block and project-specific research grants as well as programme funding to individual researchers, collaborative research projects, universities, Publicly Funded Research Agencies (PFRAs), Co-operative Research Centres (CRCs) and Centres of Excellence, Major National Research Facilities (MNRF), etc.[4]

The Australian Government established the policy framework for research and research training through its 1999 Research White Paper *Knowledge and Innovation—A policy statement on research and research*

[3] See *Mapping Australian Science & Innovation: Main Report* (2003), Australian Government, Canberra.

[4] For more discussion on the publicly funded research organisations see **Appendix 1.**

training.[5] The principles laid out in the White Paper underpin the Government's approach to research and innovation, including research commercialisation.

In 2002 the Government established the National Research Priorities (NRPs). These priorities encompass and focus efforts in research, science and innovation.[6] The priorities provide a clearer vision for research by focusing Australia's research effort, building on strengths while seeking new opportunities in emerging areas. The NRPs are designed to strengthen collaboration between research bodies and with industry, and build critical mass of excellence in those key research areas.

This framework for research, science and innovation is backed by a ten year funding commitment through the *Backing Australia's Ability* packages—*An Innovation Action Plan for the Future 2001*[7] and *Building our Future through Science and Innovation* (BAA-BOFTSI),[8]announced by the Prime Minister in 2001 and 2004, respectively.

'Commercialisation—the commercial application of ideas' is one of the three key themes of the BAA-BOFTSI package. The other two key themes are 'research and development—the generation of new ideas' and 'skills—developing and retaining skills'. Together, the two BAA packages constitute $8.3 billion in funding from 2001–02 to 2010–11. Implementation of the BAA packages is shared across a number of portfolios, and a significant proportion of the funding is administered through the EST portfolio.

The Government's objective is to build a world-class innovation system. An important aspect of this is the generation of commercial applications of research produced by Australia's publicly funded research institutions. To ensure success this agenda depends on effective partnerships between governments at all levels, researchers and industry/business, to share the substantial financial investment necessary and to ensure that ideas move smoothly from generation to end use.

Pathways to commercialisation

Commercialisation of innovative technology be it in the form of products, services or processes, is rarely a linear path to success. The possible routes are diverse, and often complex, and some innovations arise from a familiar pattern only to metamorphose into applications not even remotely considered at their inception. In discussing examples of successful technological innovation and their pathways to commercialisation, it is important to first look at some of the main pathways or processes that innovation takes before ultimately gaining commercial benefit.

Research undertaken in publicly funded institutions provides commercial benefits both directly and indirectly. The direct path—through the commercialisation of specific intellectual property (IP) in the form of patented inventions processes and ideas—is strongly encouraged by the Australian Government as a way of generating demonstrable benefits to industry and the wider community, and as a way of generating income for research institutions.

The indirect commercial benefits of publicly funded research are also very important. Australia's innovating businesses draw on ideas and experience emerging from universities and PFRAs though a wide variety of means. These include recruiting high quality researchers and scientists trained in universities, commissioning specific research through consultancies and contracts, drawing on new research findings published in learned journals and elsewhere, and participating in industry conferences, seminars, workshops and the like.

Experience suggests that in many individual instances both the direct and indirect modes can come into play. Researchers, businesses, entrepreneurs and investors collaborate to identify, protect and exploit IP, but they will also often use research consultancies and contracts to develop and test ideas that have been identified or are embryonic and not quite ready for patenting. Alternatively, ideas and commercial opportunities will develop through publishing and reading research papers, conducting meetings, conferences and workshops, or developing longer term partnerships and collaborations. For this reason the Australian Government looks to support and encourage researcher–industry linkages across the full breadth of direct and indirect modes.

[5] More information available at: <http://www.dest.gov.au/archive/highered/whitepaper/default.asp>

[6] ~~More information available at: <http://www.dest.gov.au/priorities/>~~

[7] More information available at: <http://backingaus.innovation.gov.au/default2001.htm>

[8] More information available at: <http://backingaus.innovation.gov.au/default.htm>

Different commercialisation models

A recent DEST-commissioned study[9] identifies four 'models of knowledge transfer' to describe the different processes and interactions of participants in commercialising research innovation, especially in Australia's university sector. The main attributes of these models and the way in which they impact on measures of commercial outcomes are outlined in Table 1.

Table 1: Models of the different processes of research commercialisation

- ***Knowledge production model***—sees transfer as the sale of 'knowledge products' embedded in intellectual property (IP) and other explicit or codified formats, and manifested in sale and or licensing of intellectual property rights to new businesses (spin-outs) or existing businesses which may be in the public or private sector
- ***Knowledge diffusion model***—approaches transfer from the perspective of encouraging broad industry adoption of the results of research; it emphasises communication and adoption of research results.
- ***Knowledge relationship model***—sees transfer as the provision of services to businesses based on a broadly defined intellectual property platform, including trade secrets, know-how and other forms of tacit knowledge; it emphasises collaboration, partnership and joint ventures.
- ***Knowledge engagement model***—sees transfer as a by-product of a convergence of interests between science and society and in particular, the interests of higher education, industry, and government.

These models are to some degree ideal representations. 'Real world' examples of research commercialisation will often have elements from two or more of the models. Nevertheless, this way of describing the process helps policy makers and those working in the research and innovation system better understand the breadth and diversity of ways in which the research sector interacts with industry and businesses. This in turn provides a deeper and broader understanding of the dynamics of the innovation system as a whole.

Barriers and enablers to commercialisation

Howard's models help in describing the possible routes of knowledge transfer. Australia's capacity to transform the outcomes of publicly funded research into products, services and processes can contribute significantly to long-term economic prosperity, jobs growth and better living standards. There are, however, both barriers and enablers in the process of commercialisation. **Appendix 6** provides some analysis of these.

Examples of successfully commercialised innovations from publicly funded research

The examples presented in this part of the submission have been organised broadly in accord with the models of knowledge transfer.[10] We have, however, combined the last two models under one heading—'Knowledge Relationships'—as the distinction in practice is often blurred.[11]

Examples of the knowledge production model

'Knowledge production' is essentially the 'standard model' of research commercialisation. It involves the identification of an idea or invention that can be sequestered as a piece of IP that is sufficiently unique to qualify for patenting. The patent owner can then seek to exploit the IP by licensing rights to apply the patent to a product, service or process, assigning those rights, and/or developing a commercial vehicle in the form

[9] Howard Partners (2005), *The emerging business of knowledge transfer: Creating value from intellectual property and services*, Report commissioned by the Department of Education, Science & Training. The Executive Summary is at Appendix 4.

[10] The examples presented in this submission are based on material prepared by Cortext Pty Ltd for the *National Survey of Research Commercialisation 2001-2002*, (2004), Department of Education, Science and Training. The examples are mostly current or very recent. As such the final results are not always known or clear. Nevertheless, DEST is keen to emphasise the current and emerging patterns beyond those that are better known through examples such as ResMed, Cochlear, etc.

[11] Over time the distinction may well become more defined, as research institutions develop more sophisticated, long term and broad ranging relationships with industry and the wider community.

of a start-up or 'spin-out' company to develop and market the new product or service. Commercialising IP in this fashion can be high risk, but it can also have high pay-offs for those who invest their time, effort and money in the exercise. It is especially common in medical and biotechnology fields, which tend to be more amenable to IP sequestration and exploitation.[12]

Cancer Vac

Melbourne-based Cancer Vac Ltd is developing and commercialising a breakthrough immunotherapy technology which, in a clinical trial, stabilised disease and showed no toxicity in patients with advanced cancer. The basis to the technology could serve to combat a variety of infectious diseases as well as cancers.

Cancer Vac Ltd was established in 2001 by the listed company, Prima BioMed Ltd, after the immunotherapy was invented by Melbourne's Austin Research Institute (ARI).[13] Prima BioMed has exclusive rights to commercialise many new technologies developed at ARI. The ARI scientist in charge of the project, Associate Professor Bruce Loveland, says the cancer vaccine has the potential for a hugely beneficial impact on public health.

A 2001-2002 a R&D Start Grant,[14] worth $465,000, was crucial to both the development and commercialisation of the cancer treatment. In 2002, Cancer Vac Ltd began negotiating its present contract with another company, Progen Industries Ltd, to produce a cancer vaccine that meets the requirements of both Australia's Therapeutic Goods Administration (TGA) and the United States' Food and Drug Administration (FDA).

ARI's Director, Professor Mark Hogarth, says: 'We could not have done the critical and successful Phase I trial of the vaccine, which commenced in 2001, without the Start Grant. On top of this, we've been able to start our larger Phase II trial comparatively quickly because adequate R&D funding enabled us to conduct Phase I to very rigorous standards.'

The success of the Phase I trial allowed elements of Cancer Vac's product to be patented in Australia and the United States, further strengthening the company's commercial prospects. Other countries, including Japan, Canada and members of the European Union, are also expected to grant patents.

In addition to therapeutic benefits, Cancer Vac is likely to generate commercial benefits first through trade income, then a consequent boost to Prima BioMed's share value and the value of Cancer Vac, in which it and the ARI have equity. The ARI might also benefit financially from royalties.

Key points

- A dedicate medical research institution develops an immunotherapy, which is spun out by a commercial arm of the institution with the establishment of Cancer Vac Ltd, a typical knowledge production model.
- A 2001-2002 Start Grant was crucial in the preparation of 'proof of concept'. This period is often one of the most difficult for prospective products or processes to bridge, particularly in terms of access to capital, most venture capitalists prefer to enter when the risk has been mitigated.
- Subsequently, with successful clinical trials the product has been prepared for patenting globally.
- The benefit is apparent not just in terms of revenue flow and increase share capitalisation, but also in direct impact on the health and well being on millions of cancer suffers globally if the vaccine finally enters the market. This has direct impact on the society and economy.

[12] Howard (2005), p. 25.

[13] Austin Research Institute is a is a publicly funded medical research institute (MRI) See: <http://www.ari.unimelb.edu.au/about/overview.html>

[14] R&D Start is an Australian Government fund designed to support research and development commercialisation. With the introduction of BAA-BOFTSI the new Commercial Ready programme will bring together R&D Start and the Biotechnology Innovation Fund and elements of the Innovation Access Programme into a single streamlined product for the business community, See: < http://backingaus.innovation.gov.au/2004/commercial/commercial_ready.htm>

Gene Guard

Gene Guard, based on the research in the 1980s of Associate Professor Leigh Burgoyne of Flinders University in South Australia, is a platform for genetic analysis that is now used worldwide by law enforcement and military agencies for forensic and identity testing. Using an extremely pure laboratory-grade paper as the matrix, Professor Burgoyne's work led to the invention of a new way to safely collect, store, transport, purify and analyse DNA in blood samples.

Associate Professor Burgoyne took his invention to the university's technology investment and commercial arm, Flinders Technologies Pty Ltd. At the time of his invention, the potential of the powerful new polymerase chain reaction (PCR) technology was just being realised. PCR allows tiny samples of the nucleic acids that make up DNA and RNA to be amplified many times, to help identify and analyse genetic material.

"We could see from the outset that there would be broad applications for Leigh's technology," says Dr John Turner, managing director of Flinders Technologies. "If PCR took off, as seemed likely, then this would take off as well. It is far more efficient than the standard methods that have been available for years." It not only replaced the need for liquid samples – with all their potential infection risks to handlers – but the paper could be stored at room temperature for years, obviating the need for costly refrigerated storage.

When a PCR analysis was required, the operator could simply punch out a piece of the paper – just two square millimetres in area – and drop it straight into the PCR amplification vessel, with no need for complex intervening steps of isolation and purification.

Dr John Turner, managing director of Flinders Technologies, saw an opportunity when he heard the US military was intending to create a DNA database of all its serving personnel. US military officials put Dr Turner in touch with the US-based Fitzco paper-making company with whom a commercial and technical development deal was made.

Protected by a number of patents and sold under the commercial name the FTA Gene Guard System (FTA stands for Fast Technology for Analysis of nucleic acids), the invention proved to be a hit in the latter part of the 1990s as PCR technology came into routine laboratory use. Fitzco was then taken over by a larger rival, Whatman PLC, which manufactures paper and chemical separation products. The takeover proved to be a major turning point, increasing the technical and sales development of the FTA Gene Guard system throughout 2001 and 2002.

While exact details of the arrangements made with Fitzco and Whatman are commercially confidential, Dr Turner says that Flinders Technologies invested less than $1 million in the project. Flinders Technologies and the university have received millions from commercial deals and sales royalties.

Several offshoot technologies have flowed from that takeover and the FTA Gene Guard system has been adopted worldwide, including by the Royal Canadian Mounted Police, the FBI and the US military, as well as forensic agencies in Australia.

Dr Turner says that the partnerships formed enabled global commercialisation, and the example of Gene Guard supports the need for novel technologies to have strong intellectual property protection and to reach the marketplace as soon as possible.

Key points

- This example not only highlights the well trodden path of inventor creates technology—patents it and licenses product—a critical issue was the recognition that paralleling Gene Guard technology was another far more important technology, PCR, and that if PCR was adopted it would become the industry standard meaning the market relevance of Gene Guard would increase dramatically.
- The identification of dovetailing into this possibility was critical not just making it but making it big! To set a standard or be come an integral part of a standard brings enormous reward to the innovation.
- Flinders Technologies invested less than $1 million in the project and the university has received millions from commercial deals and sales royalties.
- This example highlights the importance of publicly funded research institutions ensuring they have the necessary skilled staff in their commercialisation units capable of understanding the science and spotting such opportunities.

BattleModel

BattleModel is a framework for connecting model components together, including 'agents', which are artificially intelligent systems that model human operators' thought patterns at a tactical level.

Defence Science and Technology Organisation (DSTO) analysts initiated development of the BattleModel simulation framework. While BattleModel was originally created to evaluate tenders for the Airborne Early Warning and Control system in 1999, it became apparent that the framework could be adjusted and developed for other applications.

In 1998 the organisation contracted the further development of BattleModel to a group of software engineers. The group, together with an expert IT manager consulting to Telstra, formed a company called KESEM International.

The development team was lead by Dr Gil Tidhar, a former member of the former Australian Artificial Intelligence Institute (AAII) who was teaching software project management at the University of Melbourne.

DSTO signed a licence agreement with KESEM International under which KESEM will develop, market and sell the BattleModel technology to both government and commercial clients in Australia and overseas. In return, DSTO will have access to any improvements developed by KESEM, which will provide ongoing upgrades and system support, as well as be paid royalties on sales.

The system was demonstrated at the 2003 Australian International Air Show in Avalon near Melbourne, and since then there have been discussions with Boeing and leading defence organisations in the United States along with a range of other organisations based in Asia and Europe.

Key points

- The technology was developed 'in-house' by DSTO analysts for a purpose, the product's value was realised and was spun out with further development contracted to KESEM International.
- In development it became apparent that the BattleModel framework could be adjusted for many other applications. Under the licence agreement KESEM will develop, market and sell the BattleModel technology to both government and commercial clients in Australia and overseas bring benefit to DSTO and Australia.
- DSTO gains royalties on sales and any improvements to BattleModel developed by KESEM.
- The example demonstrates the 'classic' path of 'knowledge production' of developing a technology, and spinning the item out gaining a revenue stream thus allowing the researchers to concentrate on their core work. The example also highlights the serendipity of discovery that often the initial design purpose opens up the possibilities to multiple uses and commercialisation opportunities.

Examples of knowledge diffusion model

This model has been of major importance for knowledge transfer and innovation in Australian primary industries, through the levy-funded rural research and development corporations (RDCs), and in mining through industry-funded research. Understanding the diffusion model requires going beyond the individual examples described below.

GeneSTAR© Tenderness

The GeneSTAR Tenderness for beef test identifies a tenderness gene in beef cattle, allowing breeders to selectively improve the quality of their herds. The test detects two different forms of the bovine calpastatin gene – one associated with increased tenderness and the other with increased toughness. Calpastatin is a naturally occurring enzyme that inhibits the normal tenderising of meat as it ages post mortem.

The DNA marker test was the result of collaborative research undertaken by a team of five scientists led by Dr Bill Barendse, on behalf of a consortium comprising the Cattle and Beef Quality CRC, CSIRO Livestock Industries and Meat and Livestock Australia.

It was made possible by an investment of more than $32 million of Commonwealth CRC funds, producer levies and CSIRO project funding to study genetic traits in animals.

In late 2002, after the University of New England provided an independent analysis of the results, Genetic Solutions an Australian private company, which had an established relationship with the consortium, licensed the patent. After developing a version of the test for commercial use, Genetic Solutions launched GeneSTAR Tenderness in November 2002.

In addition to the initial exposure of the media launch, the education of stud-breeding associations and societies about the technology proved to be an important part of the marketing strategy for the product.

GeneSTAR generated more than $500,000 in the first 12 months after its launch, according to Genetic Solutions' scientific director Dr Jay Hetzel. In the first 12 months 10,000 tests were sold in Australia, the United States, South Africa, Brazil, Argentina, Korea, Japan and Germany.

GeneSTAR's success has contributed to an increasing awareness among cattle breeders of the use of DNA markers in producing top quality products and it is expected that over the next few years GeneSTAR Tenderness will be marketed as part of a suite of meat-testing products.

Genetic Solutions announced in March 2005 that they had received $2.5 million from Nanyang Ventures Pty Ltd to accelerate new product development and international marketing initiatives.

Key points

- Diffusion in this example is very much about a shared goal. An aim is set and a collaborative research effort is undertaken. Due to the unique levy-raising nature of a the rural Research and Development Corporations (RDCs) they are able to access pooled R&D investment funds which they are then able to contract research for specific goals.
- This project involved investment of more than $32 million of Commonwealth CRC funds, producer levies and CSIRO project funding to identify and develop to market a tenderness gene in beef cattle.
- The objective of the RDCs is to use the levies they gather to fund research solutions to problems. Once a solution is found facilitate the technology transfer to its sector (back to the levy payers), through industry associations and workshops ensuring quick take-up and real time impact and benefits are return to the sector for its investment. The technology is then marketed bring in additional revenue streams and licensing deals.
- The impact is realised quickly through increased productivity and the benefits are realised through the economic return to GDP through increased exports and revenue.

Grain breeding

In June 2002 the Australian Grain Technologies (AGT), an incorporated joint venture between the University of Adelaide, the South Australian Government through the South Australian Research and Development Institute (SARDI), and the Grains Research and Development Corporation (GRDC) was formed. Its focus is the development of new wheat varieties for the Australian market.

Prior to the *Plant Breeders Rights Act,* in the early 1990s, new varieties were publicly released with no financial return to the breeder. New varieties are now released via commercial partners who collect royalties per tonne on the delivery of grain by the farmer to the silos (end point royalties). Currently more than 12 field crop varieties have been licensed to Australian companies for distribution throughout the world using this process.

As well as being regarded as an international leader in research and development of plant varieties, it is estimated that the University of Adelaide's breeding programs underpin approximately 30 per cent of Australia's annual wheat production, which is worth about $1.44 billion and 50 per cent of annual barley production, worth $576 million.

The university has also been instrumental in the growth of Australia's faba bean industry as well as the recently developed cereal crop, triticale, a cross between wheat and rye which is widely used as a high-quality stock feed and in some specialty food products.

AGT is to play a role as a collaborator and supporting partner for leading edge groups such as the Molecular Plant Breeding Cooperative Research Centre. Its stated aim is to build a world-leading wheat breeding programme, as well as develop new varieties with higher yields and quality characteristics that meet market requirements.

Key points

- This example, like the beef GeneSTAR© Tenderness demonstrates the collective approach to commercialisation by RDCs, in this case not just addressing a specific problem like GeneSTAR, but in maintaining a competitive advantage as the world leader, which after all is one of the main driving goals of R&D commercialisation.
- The introduction of the *Plant Breeders Rights Act* has also facilitated commercialisation allowing protection on the investment in the initial R&D to develop certain plant technologies that can then be licensed.
- Again, like the beef example, the GRDC represents its sector with a focus to develop new wheat varieties for the Australian market. The benefit to Australia is massive when the combined wheat & barley production reaches $2 billion dollars annually, including the direct impact of greater variety and productivity to the growers and ultimately choice and quality to consumers.

Examples of knowledge relationships model

This model has been particularly important in natural science areas, such as chemistry, physics, certain branches of engineering, economics and finance. The model has a strong interdisciplinary character. The recent ABS Innovation Survey[15] highlights the importance of developing relationships, for instance, over 40 per cent of Australian businesses are innovating, with 27 per cent of these businesses involved in some form of collaborative activities, mostly collaborating with suppliers, clients, competitors or consultants (25.1per cent) were involved in some form of collaborative work with researchers.

HPV vaccine

A vaccine created by University of Queensland researchers aims to prevent the Human Papillomavirus (HPV) that causes genital warts and to combat HPV-related cancer, including cervical cancer. The vaccine created by immunologist Professor Ian Frazer is a conventional one, designed to prevent infection with high risk papillomavirus by inducing antibodies against the virus, which mediate its destruction.

Professor Frazer and his team began work on the vaccine in 1986, with a National Health and Medical Research Council (NHMRC) grant of $200,000 over three years.

CSL, a biotechnology company, which was seeking new human vaccine opportunities, entered into a research collaboration venture with Professor Frazer in 1991, providing funds to help advance his work on virus-like particles (VLP) of human papillomavirus.

In 1995, CSL negotiated an exclusive worldwide licence from the University of Queensland's commercialisation company, Uniquest, which gave CSL the right to exploit and commercialise the intellectual property created by the research collaboration.

On publication of the key patent application, Merck Ltd, which is a global research-driven pharmaceutical company, approached CSL in 1995 expressing interest in working together to further develop and commercialise the vaccine. Merck entered into an exclusive worldwide licence with CSL to develop a vaccine based on the VLP technology.

CSL has been granted patents for the vaccine in both the US and Europe. Industry experts estimate that, to date, Merck has spent in excess of $US200 million on the vaccine's commercialisation, which recently completed phase II of its world-wide trails of the drug called Gardasil™, using the licensed technology.

The vaccine, which could be as close as two years away from commercial release, has proven successful in clinical trials. A proof of principle study undertaken by Merck in 2002 found the vaccine demonstrated 100 percent protection against HPV 16, the type of HPV commonly associated with cervical cancer. The results of the study were published in the *New England Journal of Medicine* in November 2002. Phase three trials are currently underway in several countries. In April 2005, the British medical journal *The Lancet Oncology* also published favourable reviews of the outcomes of the phase II study of Gardasil™.

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[15] More information is available at: 2003 ABS Innovation Survey

Key points

- The mode of research commercialisation described here relates more to a collaborative approach whereby research excellence has been identified by an industry player. This player seeks out a relationship with the researcher/s and indicates either that they wish to work on a specific problem or know of the work the researcher/s is undertaking and would like to partner in the work and rewards.
- The initial work on the vaccine began with Australian Government support of an NHMRC grant. Once the collaborative venture progressed to publishing its patent application a multi-national R&D pharmaceutical company indicates that would like to take on an exclusive worldwide licensing deal.
- The initial path to commercialisation is a collaborative joint venture—an example of knowledge relationships. This can be a fellow researcher/ organisation or an investor with a structure exit plan. The research process or product is proven for market, perhaps through some form of IP protection and then a larger investor or industry player enters, a buy out may occur whereby the initial investor may exit and the new player takes it to market through a exclusive licensing arrangement.
- This is where there is a bend in the path of knowledge relationships and the path begins to resemble the traditional knowledge production route. This redirection is common in this style of commercialisation.

Pyrolex® Ceramifiable™

The Cooperative Research Centre (CRC) for Polymers and an industrial manufacturing company, Olex Australia, jointly developed a unique power cable, Pyrolex® Ceramifiable™ that enables essential services to be maintained during a fire. Unlike conventional polymers, or plastics, Pyrolex® Ceramifiable™ does not catch alight or melt when exposed to heat or flames. Fire transforms the polymer into a ceramic – a hard and protective barrier that shields electrical supplies.

Olex and CRC for Polymers project began in 1997, after Opex began losing the local market to cheaper overseas imports.

During 2001 and 2002, Pyrolex® Ceramifiable™ cable increased its competitive edge in overseas markets by demonstrating that it met the circuit integrity tests of British Standard BS6387. The first Pyrolex® Ceramifiable™ products were launched in July 2003 with others expected to follow. The new technology will put Olex in a strong position to resupply Australia's fire-performance cable needs; it will create an Australian export product with great potential; and it will help sustain Australia's manufacturing industry.

The Pyrolex® Ceramifiable™ project required an investment of $6 million, including cash and know-how from Olex and "in kind" resources from the CRC. These included a large team of leading Australian scientists and R&D facilities at the CSIRO, RMIT and Monash Universities, the University of New South Wales and DSTO, as well as assistance with administration and coordination to help harness the resources of a large number of research institutions.

With a wide range of potential applications, including developing the polymer for products other than cabling, these include "passive fire protection", where it would be incorporated into panels and used to enhance fire, heat and smoke resistance in a variety of settings such as buildings, for example, or aircraft.

Ceramifying panels would literally form an unpassable firewall. Another prospective spin-off involves using the polymer to replace the rubber seals, which break down in the presence of intense heat, currently employed to connect oil pipes.

Olex, which has total ownership of the product, estimates it will generate sales worth $75 million and create 20 new jobs over five years.

Key points

- This example of a Knowledge Relationship shows an Australian firm that is finding it difficult to compete with cheap imported products decides to seek out the services of a researcher/CRC to help develop a better product and increase its competitive advantage.
- The collective approach to the research enables an established Australian company through the combined know-how and investment in the R&D and the CRC arrangements to develop a superior product that the company then goes on the own and ensures its competitive advantage internationally.
- The impact of this discovery it immediate, its uptake will be quick because of it ability to set a benchmark above all of its competitors. Its benefits to society are safer wiring in a multitude of applications.

Plantic Technologies

Plantic™, a biodegradable packaging product, was invented, developed and produced in Australia by the Cooperative Research Centre for International Food Manufacture and Packaging Science, and has been commercialised by Plantic Technologies Ltd[16].

Plantic™ materials match or exceed and are commercially competitive to petrochemical plastics in strength, stability and shaping characteristics but will break down to stable and safe carbon dioxide and water in outdoor environments. They are also not subject to the dramatic price variations petrochemical products may be exposed to on the global market. Plantic™ is suitable for rigid thermoformed products for dry goods packaging including biscuit and confectionery trays, blister packaging and trays for electronic components.

The key partners during the seven year development phase were CSIRO's Division of Manufacturing Science, the University of Queensland's Department of Chemical Engineering and Swinburne University's Centre for Applied Colloid and BioColloid Science.

Founded in 2002 by David McInnes, Plantic Technologies was recently listed at 28th on the BRW Upstarts list, a survey of Australia's fastest growing start-up companies, based on its revenue for the financial year of 2003-2004 of $1,040,000.[17] In August 2004 Plantic Technologies was awarded the prestigious Australia Museum Eureka Prize for Industry 2004 for its biodegradable plastic.

In April 2005 Plantic Technologies reported that it had raised $11 million in capital to fund the expansion of the business, the research and development of new products and applications of Plantic® materials. German certification authority DIN CERTCO and Belgium AIB-Vincotte recently certified Plantic® thermoformed trays for the European Packaging Standard EN1342:2000-12 that certifies that the products are biodegradable/ compostable.

Key points

- Demonstrating the Knowledge Relationships model of research commercialisation, the invention and development of Plantic™ involved a number of partners including CSIRO's Division of Manufacturing Science, the University of Queensland's Department of Chemical Engineering and Swinburne University's Centre for Applied Colloid and BioColloid Science, CRC for International Food Manufacture and Packaging Science.
- The resilience of the product and is ability to compete against its petrochemical rivals placed it an excellent position to commercialise with the added benefit to the environment of its biodegradability.
- The subsequent commercialisation of Plantic™ by Plantic Technologies reflects the 'standard' Knowledge Production model of research commercialisation. Plantic Technologies now has offices in Australia, the UK and Germany.

[16] ~~http://www.plantic.com.au~~

[17] Amanda Gome, *The start-up megastars*, BRW, March 31-April 6 2005, p.37

Discussion

Against the background of the foregoing examples and reflecting on the Department's responsibilities, and drawing on the information in the appendices to this submission, DEST makes the following comments against the points of focus in the Inquiry's terms of reference.

Pathways to commercialisation

The possible pathways to commercialisation are diverse and complex and each case will typically have its own specific variations. Understanding the linkages in and the influences on the innovation system and the process of commercialisation is important for policy design. It is important for policies and programmes to be structured so that they reflect the need for flexibility and multiplicity in the ways in which ideas are brought to market. It is also equally important to be responsive to the system as a whole. By understanding the pathways and interactions we are better able to evaluate the progress of research innovation and capture the impact and benefit of this work, particularly in regard to the return to the economy and the society on the investment in publicly funded research.

The Coordinating Committee on Science and Technology's (CCST) working group (WG) on metrics of commercialisation (MoC) recently completed its report examining the current measures employed by publicly funded research institutions for reporting on their performance and benefit. The WG concluded that current metrics for commercialisation of publicly funded research need to be extended to reflect a broader understanding of the commercial and economic benefits of research commercialisation, this include a broadening of the definition of research commercialisation (See Appendix 5: Measuring the impact of research commercialisation). [Note: This will be confirmed on publication of the WG Report early in May.]

Intellectual property and patents

The sequestration and protection of IP through the patenting and plant breeders rights system is essential to the research commercialisation process. The critical issue, however, is that researchers, their institutions and their commercial partners need to take a strategic approach to patenting and licensing, to ensure that they do not close off the opportunity to patent through premature publication, nor impede the innovation process by creating excessive secrecy around an idea, discovery or invention.

This includes sometimes unrealistic expectations by researchers as to the value and equity share of potential IP of an innovation. These expectations can have the effect of dissuading potential investors and hinder the progression of commercialisation. Researchers/universities need a greater understanding of the commercialisation process and risk that investors have to manage. Likewise investors also need a better understanding that researchers need realistic reward for their innovation.

Issues of IP management and regulation are dealt with in the section on Business and scientific regulatory issues.

Skills and business knowledge

As highlighted in the case studies, skills are essential to the commercial success of knowledge transfer. By skills we refer to a raft of abilities (commercial management, entrepreneurship, adequate knowledge of IP development and IP legal management) that can identify and take a technological innovation and its associated risks—the entrepreneurial ability—to turn that innovation into a commercially viable proposition. Awareness too, for both industry and researchers, to understand the other's environment and culture, to have the capacity to be able to work and understand the constraints of each other's field is an important skill. There is also a demand for commercialisation experts with experience in scientific fields.

Business knowledge in the research sector is improving. The number of technology transfers officers (TTOs) located within research institutions, for example, increased by approximately 40 per cent between 2000 and 2002.[18] However, most university researchers continue to lack the skills and/or the motivation to become entrepreneurs. Part of this issue has been a perceived lack of information regarding commercialisation

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[18] *National Survey of Research Commercialisation years 2001 and 2002*, (2004), Department of Education, Science and Training p. 5.

practices and procedures, another is the culture of the researchers in particular the perception that by commercialising 'you're selling out'. Alternatively they see little real incentive or reward to undertake the commercialisation of their work. And there is no real peer or professional advancement currently associated with commercialisation involvement.

The Gene Guard example demonstrates the need for researchers to have access to experienced TTOs and business advisors in house. The critical element with Gene Guard was the university employed TTO identifying the potential of the product and the opportunity of possible integration with another piece of technology that would become an industry standard thereby ensuring Gene Guard's success.

The development of researchers' ability will further be improved by the BAA-BOFTSI package that allocates approximately $23 million towards a Future Innovators Fund. This fund will enable the placement of 250 postgraduates in commercialisation training courses to provide them with some understanding of commercial management practices. Further discussion on skills is provided by way of a list of barriers & enablers of research commercialisation at Appendix 6: Research commercialisation barriers and enablers.

Capital and risk investment

The process of commercialisation is expensive and high risk. Generally Australian companies and the Australian venture capital (VC) community are known for their risk adverseness.

It is still evident that there is an early stage funding gap for commercialisation of research outputs. Without access to funds to bridge the 'proof of concept' stage an innovation stands a higher chance of failing to attract investors, leaving the innovation in a virtually impossible position and the research investment wasted constituting a market failure.

The current debate tends to be cyclical: researchers will claim the VC community is too risk adverse and that they need to become more involved if they what a slice of the action. The VC community would prefer the research sector to fund more of the 'proof of concept' stage mitigating the financial risk to them.

Research developed within publicly funded research institutions needs to be transferred to industry at a market price. Industry can not expect not to carry part of the early stage risk. The Australian Government provides a number of early stage finance schemes to support early stage research commercialisation, such as Pre-Seed Funding, Start and Commercial Ready administered through the Department of Industry, Tourism and Resources.

These schemes play an important role in helping publicly funded research institutions develop their innovations to a 'proof of concept' stage enabling a greater chance of attracting an investor or buyer. The use of these early stage funds was extremely important as indicated in the successful commercialisation stories, particularly the Cancer Vac and HPV vaccine, both of which require 'proof of concept' through early trials to help attract a large multi-national company and fast track further clinical trials. However, this can not be expected to cover all innovation. The private sector must participate too.

Business and scientific regulatory issues

A pressing issue for Australia's research commercialisation sector is the national legal and regulatory framework for IP. The research sector and business community have both signalled in a recent joint report that there is a need for a clear policy or framework on the ownership and management of IP policies in publicly funded research institutions, particularly universities. And, that if such a centralised system were to be introduced, it is imperative that systems for timely disclosure of IP to the university's commercialisation entity are implemented and enforced.[19]

The BCA/AVCC report and the CCST report advocate the reviewing of the *National Principles of Intellectual Property Management for Publicly Funded Research*, including ways to encourage greater utilisation of the IP, including that they reflect current and emerging IP practice and the needs of the research and innovation system.

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[19] *Building Effective Systems for the Commercialisation of University Research*, August 2004, Business Council of Australia and the Australian Vice-Chancellors Committee, A report by the Allen Consulting Group, p. xvii.

Research and market linkages

As discussed in the skills section above, the need for greater awareness among researchers and industry to create linkages is paramount to the success in commercialising research outputs. The knowledge diffusion and relationships models rely heavily on the ability of both parties to develop linkages to enable engagement and exchange of ideas. The example of Opex developing the unique power cable, Pyrolex® Ceramifiable™, highlights the usefulness of being able to approach a range of researchers to produce outstanding world class products that will now ensure Opex's competitive position in the global market place.

These linkages are often developed through consultancy or contract work whereby a business will seek a solution like Opex to a problem—this sort of work provides confidence for all involved and can lead to repeat business and bigger ventures. Encouraging industry and researchers to collaborate on a small venture to gain this sort of confidence is extremely important and is a central plank of the Government's policy.

Strategies in other countries

The United Kingdom Government has recently placed a greater emphasis on improvement and return on public investment in the UK:[20]

> The Government is encouraging Research Establishments to increase the application of their research, in co-operation with the private sector, to stimulate greater economic and social benefits for the nation. This "commercialisation" of research is, nevertheless, intended to remain subsidiary to Research Establishments' core function of conducting research in support of the public interest.

The Higher Education Funding Council for England (HEFCE) have developed a dedicated 'third stream' funding - so called because it supports the third element of an HEI's mission alongside teaching and research - began in 1999 with the Higher Education Reach Out to Business and the Community (HEROBC) scheme. Since 1999, HEFCE and the Office of Science and Technology have committed over £400 million for HEI business and community activities to generate culture change, build capability and capacity, and deliver beneficial outcomes.

HEROBC was followed by two initiatives: the Higher Education Innovation Fund (HEIF) which committed £265 million over the years 2002-03 to 2005-06 (a further £238 million is committed for 2006-2008), and the Higher Education Active Community Fund (HEACF) which committed £37 million over the same period.

HEFCE also conducts an annual survey to gain an understanding of the volume, development and outputs of third stream activity. The Higher Education-Business and Community Interaction Survey (HE-BCI) collects key data to inform policy, support continued public funding of third stream activities and stimulate HEI benchmarking.

Factors determining success

As will be apparent from the foregoing examples of research commercialisation, and the above discussion, the critical factors leading to success include:

- a good skill base, in researchers and industry
- access to early stage capital
- awareness of the opportunities and the different cultures within research institutions and industry
- a willingness to collaborate, between researchers, industry, business and investors
- strong industry and business receptors to adopt and carry innovation through
- a willingness to take risks, be flexible and to persist in the face of delays, complexity and uncertainty
- a strong legal framework for IP.

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[20] Fifty-Ninth Report, The Committee of Public Accounts has agreed to the following Report: Delivering the commercialisation of public sector science *http://www.publications.parliament.uk/pa/cm200102/cmselect/cmpubacc/689/68903.htm*

Conclusion

This submission has aimed to respond to the Inquiry's terms of reference (see Figure 1) by providing examples of successful technological innovations that have arisen through the interaction of Australia's publicly funded research institutions (including universities) with industry and investors, and by placing these examples in the context of the national innovation system and the Australian Government's policies and programmes that aim to support and grow that system.

In addressing the terms of reference the submission has set out a number of the issues. There is a specific emphasis on the different pathways to commercialisation, as well as the role of intellectual property and patents, skills and business knowledge, and research and market linkages in determining the successful commercialisation of research outputs.

Recent analytical studies[21] have begun to provide a broadening and deepening of the our understanding of the influences that affect the national innovation system, particularly in regard to the return to the economy and the society on the investment in publicly funded research.

In terms of a policy considerations, the information gleaned from understanding the interplay of the national innovation system and all its stakeholders, including the Australian public, equips the Government with a knowledge of how to structure current and future policies and programmes in regard to research commercialisation so that they reflect the need for flexibility and multiplicity in the ways in which technological innovations are brought to market.

[21] Howard (2005) CCST MoC Report (2005), and BCA & AVCC Report (2004).

Appendices

Appendix 1: EST Portfolio responsibilities

As part of its portfolio interests, the Department of Education Science and Training (DEST) has responsibility for ensuring Australia has a strong science, research and innovation capacity and is engaged internationally on science, education and training to advance Australia's social development and economic growth. The Department is responsible for implementing the Government's objectives through its investment in research, science and innovation to support the development and use of new knowledge, and to encourage utilisation and commercialisation of public sector research.

The Portfolio comprises:

the Department of Education, Science and Training (the Department);

the Anglo Australian Telescope Board (AATB);

the Australian Institute of Marine Science (AIMS);

the Australian National Training Authority (ANTA);

the Australian National University (ANU);

the Australian Nuclear Science and Technology Organisation (ANSTO);

the Australian Research Council (ARC); and

the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

To advance education and training systems, the Australian Government works with the States and Territories through the Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA), and with education and training providers, industry and other agencies. The education and training sectors comprise:

- schools – including preschools, primary schools, secondary and senior secondary schools;
- vocational education and training – which involves publicly owned TAFE institutions and other registered training organisations; and
- higher education, including research – public and private universities and other higher education institutions.

The States and Territories have primary responsibility for school education. The Australian Government, through MCEETYA, provides leadership in identifying national standards and priorities to achieve the agreed National Goals for Schooling in the 21st Century. The Australian Government also provides State, Territory and non-government school authorities with substantial additional funding to improve student outcomes.

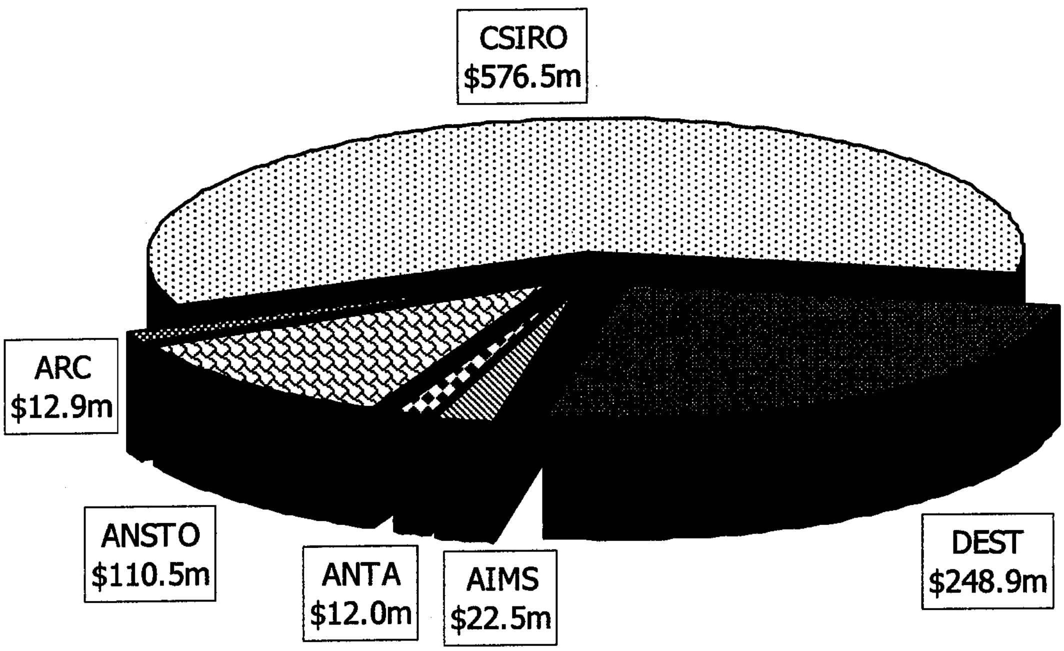
States and Territories also have primary responsibility in the vocational education and training sector. The Australian Government works with the States and Territories, through the ANTA Ministerial Council, and with industry to ensure that the vocational education and training sector promotes: high quality outcomes for students; national consistency and coherence; and a system that is responsive to industry needs. Australian Government funding for vocational education and training is provided through ANTA and through programmes administered directly by the Australian Government.

The Australian Government has the primary responsibility for funding and policy-making in the higher education sector. Apart from the Australian National University and the Australian Maritime College (legislation for the Australian Maritime College is administered by the Department of Transport and Regional Services), the States and Territories are responsible for legislation to establish universities and for the accreditation of higher education courses by private providers.

The Australian Government's policy objectives for science, research and innovation have been expressed through its Innovation Action Plan - Backing Australia's Ability, and through its further investment in Backing Australia's Ability - *Building our Future through Science and Innovation.* The Australian Government supports the science and innovation framework through such bodies as the Prime Minister's Science, Engineering and Innovation Council (PMSEIC), , the Co-ordination Committee on Science and Technology (CCST) and the Chief Scientist and through targeted funding and international promotion of Australia's scientific and technological capabilities. The Australian Government also directly supports the work the Publicly Funded Research Agencies (CSIRO, ANSTO and AIM).

Figure 2 provides a break-up of departmental appropriations across agencies in the Portfolio for 2004-2005.

Figure 2: Departmental Appropriations for agencies in the EST portfolio



Source: The Education Science and Training Portfolio Budget Statement 2004-05, p11.

Appendix 2: Key concepts

The following terminologies and accompanying definitions represent the current state of thinking regarding research commercialisation, innovation and collaboration within the Department. It should be noted that this list is evolving and can be somewhat ambiguous. For the submission's purposes, the following terms have been used as indicated:

- **Research commercialisation**: originally limited to 'knowledge production' (idea–patent–license–spin-out), this term is coming to encompass the notion of the commercial 'benefits' of publicly funded research, whether those benefits accrue to the research institution or not.[22] This means that the term is now often applied to other modes and activities, such as 'diffusion' (e.g., through publications, conferences, information seminars, etc), research contracts and consultancies, the training of research graduates for employment in industry, and various forms of joint venture and partnership.
- **Innovation:** developing skills, generating new ideas through research, and turning them into commercial success—is a key driver of productivity and economic growth.[23]

  Innovation occurs through a complex set of institutions and interactions—the 'national innovation system'. This system includes major institutions involved in innovation, such as businesses, government, the education and training sector, and public research institutions; the role of these institutions in key innovative activities; the innovation linkages between these institutions; and cultural norms, such as attitudes to entrepreneurship and change. Sound economic framework conditions that encourage productivity and innovation are also an essential element.
- **Technology**: knowledge of how to organise people and tools to achieve specific ends

  An important concept of innovation and technology is that while all technologies have their uses, they do not necessarily have an economic 'market' and they are not necessarily first generated to serve economic purposes. They may nevertheless come to have significant economic 'impact' and in turn benefit for the society and the environment.
- **Collaboration**: a partnership, alliance or network involving public sector researchers and the private sector, aimed at a mutually beneficial, clearly defined outcome. The components essential for successful collaboration are trust, cooperation and mutual benefit.[24]
- **Linkages**: refers to the myriad ways in which industry interacts with the research sector, often involving multifaceted communications and relationships.
- **Publicly funded research institutions**: universities and Commonwealth PFRAs.
- **Industry**: the Australian industry sector as a whole, particularly those under the ambit of DITR.
- **Research sector**: the publicly funded research sector in Australia, encompassing universities, PFRAs and the various other programmes and institutional arrangements (e.g. Cooperative Research Centres, Medical Research Institutes, rural Research & Development Corporations, etc).

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[22] The Coordinating Committee on Science & Technology's Working Group on Metrics of Commercialisation has recommended a definition of 'research commercialisation' that stresses commercial benefit, for example.

[23] The Australian Government's Innovation Report 2003–04, Backing Australia's Ability: Real Results, Real Jobs, p.11.

[24] DEST (2004), *Review of closer collaboration between universities and major publicly funded research agencies*, p.1.

Appendix 3: Australia's research system

The majority of basic research undertaken in Australia is conducted within Australia's publicly funded research institutions, which consist of: 38 universities, the Publicly Funded Research Agencies (PFRAs) (which includes: the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australian Institute of Marine Science (AIMS), Australian Nuclear Science and Technology Organisation (ANSTO)); Co-operative Research Centres (CRCs); Medical Research Institutions (MRI), Centres of Excellence; rural Research and Development Corporations (RDCs); and Major National Research Facilities (MNRFs).

In 1999 the Government released the Research White paper: *Knowledge and Innovation - a policy statement on research and research training*. This Paper sets out the priorities, arrangements and reporting requirements for funding university research and research training through performance and competitive block grants.

The main change that occurred under the White paper was the commencement of performance-based block funding. Performance-based block funding was introduced to support institutional research and research training. The Government believes that this approach will best recognise and reward those institutions that provide high-quality research training environments and support excellent and diverse research activities.

Two new performance-based funding schemes were introduced: an institutional grants scheme (IGS) providing block funds for general research and research training infrastructure, and a scheme providing grants to institutions for research training scholarships (RTS). Both schemes are administered by the Department and are distributed to recognised Higher Education Providers as prescribed by the *Higher Education Support Act 2003.*

The other main feature of K&I, was the establishment of the Australian Research Council (ARC) as an independent agency within the EST portfolio.

The ARC plays a key role in the Government's investment in research and innovation which contributes significantly to the future prosperity and well-being of the Australian community. The Council has responsibility for administering the National Competitive Grants Program (NCGP), an international and national peer-reviewed selection funding process to universities, individual researchers and joint university/industry research projects. There is also a dedicated medical research council, under the Health and Aging portfolio—the National Health and Medical Research Council (NHMRC) which provide similar funding for researchers to apply for.

The overall objective of this funding is to provide public funds to support research, particularly basic research in order to reap social, economic and environmental benefits to the community that would not be forthcoming from funding from private sources alone.

The National Research Priorities

The National Research Priorities are an important component of the Government's strategy for focusing research effort.[25] It is in these areas of priority that the Government has identified the opportunity to deliver benefits that will be most important to Australia's future. It is worth noting that while there are broad research priorities there are no industry research priorities.

There is no simple, linear relationship between economic investment in research and economic return.[26] Research and its ultimate benefits can be far removed from each other, with various factors contributing to (or detracting from) the conversion of research findings into innovation outcomes including that benefits to the wider community.

~~[25] The National Research Priorities are available at: <http://www.dest.gov.au/priorities/>.~~

[26] See the Chief Scientist's Report, *The Chance to Change*, 2000, p. 23.

The commercialisation of research outputs is best understood within a wider context which includes the character and direction of Australia's research system and its place in the national economy.

Backing Australia's Ability 2001 and 2004

The Australian Government's goal is for Australia to build a world-class innovation system as a critical element in promoting our nation's productivity and competitiveness. Achieving this includes establishing effective partnerships between governments, researchers and business, to ensure the necessary investments are made, the potentially significant returns are realised, and to ensure that ideas move smoothly from generation to end use.

The two innovation statements—*Backing Australia's Ability—An Innovation Plan for the Future* (2001) and *Backing Australia's Ability—Building Our Future through Science and Innovation* (2004)—constitute a $8.3 billion integrated 10-year commitment to science and innovation.

Backing Australia's Ability—Building Our Future through Science and Innovation continues and strengthens the substantial investment made in Backing Australia's Ability by targeting the three key elements of the innovation system:

1. Strengthening Australia's ability to generate ideas and undertake **research**
2. Accelerating the **commercialisation** of ideas
3. Developing and retaining **skills.**

In regard to publicly funded research, the overall goal for the Australian government is to manage research and innovation as a *system* that will generate the greatest possible return to the community in the form of economic, social and environmental benefits.

Impact and benefit

In considering final research outcomes, a broad understanding of research impact/benefit is important because there are many routes by which research can make a contribution to societal objectives.

An important concept of innovation and technology is that while all technologies have their uses, they do not necessarily have an economic 'market' and they are not necessarily first generated to serve economic purposes. They may nevertheless come to have significant economic 'impact' and in turn benefit for the society and the environment. For instance, these can range from:

- creation of new knowledge that is translated into new products and processes which can serve to reduce costs (in both time and money) or improve public policy and societal structures
- adaptation of existing technologies to new uses and markets
- incremental improvement in existing products, processes or services
- education and training of research workers and business professionals, and also university graduates and the community more generally
- increased ability to participate and integrate cutting edge research knowledge developed elsewhere in the world at a very early stage.[27]

National research and innovation policy is continuing to evolve and complement the BAA-BOFTSI initiative. Our growing understanding of the multiple benefits of research and the multiple paths by which it is brought to adoption or to otherwise have impact and therefore value for society and the economy is expanding rapidly. This is borne out in the 2005 DEST-commissioned Allen Consulting Group report on *Measuring the Impact of Publicly Funded Research*. The Report attempts to

[27] Allen Consulting Group (2005), *Measuring the impact of publicly funded research*, Report for the Department of Education, Science & Training, Canberra. Available at: <http://www.dest.gov.au/resqual/publications.htm>.

capture the range of indicators that would be necessary to measure both the quality and diffusion of publicly funded research.

Government initiatives administered through the EST portfolio designed to facilitate better commercialisation outcomes

The **Cooperative Research Centres (CRC)** Programme promotes long-term strategic links and collaboration between researchers and research users from universities, the public sector (including CSIRO) and industry. The Programme encourages partnerships that enhance Australia's international competitiveness in fields as diverse as mining and energy, manufacturing technology, information technology, agriculture and rural based manufacturing, the environment and medical technology.

The Australian Government established the CRC Programme in 1990 to forge closer links between Australian industry and researchers and since backed a diverse array of innovative CRCs that have improved the effectiveness of Australia's R&D effort. CRCs have led to the introduction of innovative processes and practices and created new business built around the commercialisation of research. The close interaction between researchers and end users of research at all stages is a key feature of CRCs. Industry and users engage in all aspects of CRC activities, including planning and undertaking research programmes, utilisation and commercialisation of research outputs, and education and training.

The **Major National Research Facilities (MNRF)** Programme provides better access for Australian researchers to world-class specialised research facilities which would not otherwise be available; increases opportunities for excellence in scientific research and development; and aims to attract overseas researchers and firms to Australia as well as retain local expertise and talent.

MNRFs are expensive, large equipment items or highly specialised laboratories that are vital for conducting leading-edge research in science, engineering and technology. MNRFs generally involve a consortium approach with contributions from participating organisations in the private and public sectors. Through adding strategic capability to Australia's research infrastructure, these facilities enhance the scope and opportunity to exploit Australian science and technology innovation.

The MNRF Programme was launched in March 2001, as part of the Australian Government's Backing Australia's Ability initiative with $155 million provided over the 5 years from 2001-02 to 2005-06 to establish fifteen facilities around Australia.

Publicly Funded Research Agencies (PFRAs) include the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australian Nuclear Science and Technology Organisation (ANSTO) and the Australian Institute of Marine Science (AIMS). All three science agencies operate in accordance with their respective Acts and the *Commonwealth Authorities and Companies Act* 1997. They receive the bulk of their revenues from Australian Government appropriations, though the revenue that is derived from research activities is important. CSIRO has a diverse remit, conducting research across industry sectors as well as in areas of community interest. However AIMS and ANSTO focus their respective research efforts on tropical marine science and nuclear science. ANSTO, in addition to conducting research, is the main producer and supplier in Australia of radiopharmaceuticals and industrial isotopes.

The science agencies conduct applied research. Their research activities are determined with regard to potential end uses of the research and in applications that may be of benefit to industry directly or provide other benefits to the Australian community. To this end, science agencies often work collaboratively with industry, universities and state research agencies.

Appendix 4: Executive Summary from Howard Report

The emerging business of knowledge transfer—Creating value from intellectual products and services

The ways in which universities and research organisations benefit the economy and society is a long-standing and important concern both for policy-makers and the general community. Over recent decades a particular perspective has arisen in prominence—the notion of research commercialisation. 'Research commercialisation' refers to the treatment of knowledge as a commodity—an asset over which property rights can be, and are, asserted. The increased prominence given to this 'capitalised' knowledge and the role played by universities and research organisations in generating this asset mirrors the attention paid to the 'knowledge economy' by economic and social commentators.

This report has been prepared for the Department of Education, Science and Training by Dr John Howard, the founder and Managing Director of Howard Partners. The report proposes a framework for identifying, tracking and understanding the economic contribution of universities and research organisations in the twenty-first century. This framework is characterised by the emphasis placed upon the plurality and the complexity of the channels and mechanisms through which universities and research organisations generate economic benefits.

The report argues that the 'standard' research commercialisation model, associated with a linear sequence linking basic research to commercial outcomes, is largely specific to the biomedical sciences. Like the 'linear model' of research and development (R&D) itself (basic research—applied research—experimental development) to which it relates, the standard model is easily grasped, and the outputs easily measured, which in turn helps to secure funding. A range of external interests also benefit from the promulgation of this model as *the* model of how universities and research organisations generate economic benefits.

Lawyers, consultants, venture capitalists and the biomedical researchers themselves all stand to gain from increased resources devoted to this type of commercial focus within universities and research organisations. The standard model also has the advantage that it is compatible with the current emphasis on performance metrics within government. As 'capitalised knowledge', patents and licenses are easy to count—and the temptation to set targets, such as a planned numbers of patents and associated spin-out companies, can be hard to resist.

The challenge for policy-makers is that the standard model does not in fact adequately reflect the wide range of circumstances through which universities impact upon the economy. Consequently, if performance measures are based exclusively on this standard model, then there is a risk that other, perhaps more important channels for generating economic benefits, will be given insufficient recognition, thereby potentially distorting policies and practice, including misallocation of resources across the spectrum of research-industry interaction.

The report addresses this challenge by proposing a more comprehensive and realistic framework for understanding research commercialisation and knowledge transfer. The framework consists of the following four ideal typical models:

Knowledge production	Universities and research organisations generating useful economic and social outcomes by selling or licensing the results of research in the form of commodified knowledge—directly exploiting 'knowledge products' embedded in intellectual property and other explicitly codified formats. This is a 'standard' model of research commercialisation.
Knowledge diffusion	Universities and research organisations

	generating useful economic and social outcomes via encouraging the broad industry-wide adoption of research findings through communication, building capacity within industry through extension, education and training, creating standards relating to production and distribution.
Knowledge relationships	Universities and research organisations generating useful economic outcomes by providing services that indirectly exploit broad intellectual property (IP) platforms consisting of trade secrets, know-how and other forms of tacit knowledge. This approach centres on cooperation, collaboration, joint ventures and partnerships.
Knowledge engagement	Universities and research organisations generating useful economic outcomes as a by-product of shared interests and concerns that transcend the boundaries of the university per se.

The report shows how current Australian Government support for science and innovation covers all four of these areas. It is therefore not desirable to restrict measures of performance to 'knowledge production' processes—the easiest area to measure performance.

The report argues for separate approaches to performance measures and performance indicators. Performance measurement is undertaken on the basis of assessment of overall program performance, having regard to purpose, resources, processes, impacts and effects. This involves using a range of program evaluation methodologies and techniques.

Performance indicators, by contrast, are intended to inform policy-makers, managers and stakeholders at regular intervals about progress in relation to purpose and objectives. Typically, performance indicators relate to processes (throughput) and outputs, and substantial movements in those categories, which can provide comfort—or raise concerns—about the extent to which program performance results will be achieved in the medium-to-longer-term. Interpretation of performance indicator information is often a skill in its own right.

The report argues that indicators should be kept to a minium and adopted only when they can provide relevant and useful information about program performance. Indicators should not be seen as performance measures in their own right. Moreover, availability of large amounts of information generated through administrative processes should not necessarily be seen as constituting performance indicators. *It does not follow that just because data are available, they are going to be useful in assessing performance.* It may be necessary to establish cost-effective data collection procedures to obtain relevant, accurate and timely data.

Howard summarises categories of output indicators for the four research commercialisation processes as:

Knowledge production	Academic publication activities
	Patenting and licensing activities
	Income streams relating to the above
	Spin-off company formation activities

Knowledge diffusion	Communication activities
	Capacity-building activities
	Extension and education activities
	Standard setting activities
	Industry output data
Knowledge relationships	Contract research and consultancy activities
	Income streams
	Staff and students working on interchange with industry
	Industry research staff with sessional and adjunct appointments in universities
	University-appointed 'visitors' from industry
Knowledge engagement	Participation in non-academic community and economic activities
	Jointly owned and operated technology property infrastructure—technology and research parks, buildings, equipment, instruments etc.
	University-organised events for community and regional economic and social benefit (workshops, seminars etc.)
	University facilities available for non-academic purposes (for example, libraries, cultural centres, sportsgrounds)

The report argues that performance measurement for research funding programs should be approached at four levels, depending on the purpose of the program:

- the level of the *economy*: covering contributions to wealth, indicated by growth in national production (output), investment, and the contribution to research to economic performance
- the level of the *industry*: relating to factors such as industry productivity and enhanced industry competitiveness and indicated by reference to baseline industry measures
- the level of the *enterprise*: relating to specific commercial outcomes relating to profitability, viability and sustainability and indicated by factors such as sales, employment, exports and investment
- the level of the *region*: relating to regional performance through clustering of activities and the formation and performance of networks and networking.

All of the classifications and typologies involve measurement issues. The forms of measurement are identified as:

- analytical/conceptual modelling of underlying theory
- surveys
- case studies—both descriptive and economic simulation
- econometric and statistical analysis
- sociometric and social network analysis
- bibliometrics—including counts, citations and content analysis

- historical tracing
- expert judgement.

Each measurement approach has a specific relevance to the level of analysis and the commercialisation processes identified in the report. Moreover, the level of analysis and the measures will vary in their significance among universities and research organisations. Universities that receive a substantial amount of public funding through competitive grants might have a different indicator and measurement profile from institutions that receive substantial levels of funding from state governments and through project research and consultancy.

Universities and research organisations should be encouraged to develop measurement and indicator profiles that are representative, and indicative, of their missions and strategies. Universities in particular should be encouraged to develop profiles relevant and appropriate to their core competencies and distinctive capabilities in the increasingly segmented higher education industry.

It is a matter for funding agencies to decide on the structure, timing and resourcing of program performance measurement and evaluation approaches, and the indicators they wish to collect on a national basis. Those indicators should be limited in number, be consistent in definition, free from ambiguity in interpretation, and relevant to assessing program performance. A 'minimum data set' should be developed with a requirement that universities and research organisations design systems that will generate sought-after information in an efficient and timely manner.

Recognition of the different research commercialisation processes creates the conditions for richer and more powerful economic (and social) impacts from universities and research organisations. This will be achieved by avoiding the imposition of a single, and often inappropriate, model of what research commercialisation and knowledge transfer involves in practice, and by encouraging effective *proprietary* strategic management in our universities and research organisations.

Appendix 5: Measuring the impact of research commercialisation

National Survey on Research Commercialisation

The most recent *National Survey of Research Commercialisation Years 2001 and 2002* was released in October 2004. The survey provides a number of measures of the commercialisation activity carried out by publicly funded research organisations in 2001 and 2002. It is based on information reported by them in surveys commissioned by the DEST and conducted on its behalf between October 2003 and February 2004 by the Australian Institute of Commercialisation. It updates information relating to the Year 2000 survey that was reported in September 2002 by the Australian Research Council (ARC), the National Health and Medical Research Council (NHMRC) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

The survey for the Year 2000 provided a number of measures of commercialisation activity undertaken in universities, medical research institutes (MRIs) and CSIRO. For the 2001 and 2002 surveys, coverage was extended to include the Australian Institute of Marine Science (AIMS), the Australian Nuclear Science and Technology Organisation (ANSTO) and the Defence Science and Technology Organisation (DSTO).

In addition, the 2001 and 2002 surveys collected data directly for the first time from cooperative research centres (CRCs). Separate figures for CRCs are provided in the report. Given that CRCs are collaborative ventures between universities, MRIs, PFRAs and industry, the outputs attributed to CRCs are outputs from the collaborating partners in addition to the ones directly attributed to them.

Overall, 113 organisations responded to the 2001 survey (with a response rate of 70 per cent) and 124 to the 2002 survey (with a response rate of 75 per cent), up from 50 responses for the 2000 survey. The extra responses reflect the extension of survey coverage noted above together with a significant increase in the number of responses received from MRIs, up from 15 responses for 2000 to 33 for 2001 and 35 for 2002.

The survey report presents information provided by all the organisations which responded in 2001 and 2002. It also presents results for 2000, 2001 and 2002, relating to those 45 organisations which responded to the surveys for all three years, to provide an indication of changes in the level of commercialisation activity over time.

The report benchmarks the level of patenting, licensing and start-up company formation activity carried out by Australia's universities against that of their counterparts in other countries, drawing on the results of similar surveys conducted overseas. For the Year 2000, the comparisons related to the United States and Canada. For 2001 and 2002, some comparisons are also provided with the United Kingdom.

Key messages

For those responding in all three survey years the stock of income-yielding licences held by Australia's publicly funded research organisations has increased, as has the active stock of start-up companies formed by them and the overall value of their equity holdings. Their employment of commercialisation and commercialisation support staff is increasing. Income earned from licences has remained reasonably steady, after taking account of a single, very large transaction reported in the 2000 survey which inflated the figure reported for that year. Their number of new invention disclosures grew between 2000 and 2002, but there were declines in the number of new patents applied for and issued.

In Australia, the university sector earned about 59 per cent of total licence income in 2002, compared with medical research institutes (22%), CSIRO (13%), CRCs (5%) and other PFRAs (1%). Licence income as a proportion of research expenditure was higher for medical research institutes (6%) than for the publicly funded research sector as a whole (1.7%). A striking feature of the results is that across all sectors and all measures used, a small number of organisations accounted for the bulk of the commercialisation activity reported.

Overall, the international comparisons of patenting, licensing and start-up company formation activity suggest that, relative to their peers in the United States, Canada and the United Kingdom, and taking into account differences in levels of research expenditure and countries' GDP, Australia's universities:

- have fewer United States patents issued to them than the United States or Canada
- execute fewer licences than the United States, Canada and the United Kingdom
- earn income from licences at a rate which is greater than the United Kingdom, roughly comparable to Canada but less than the United States
- form more start-up companies than the United States, but fewer than Canada or the United Kingdom.

Measuring the benefits of research commercialisation

The data collected in the survey represent an early effort to measure the commercial benefits flowing from public investment in research. The data, however, is subject to a variety of qualifications and it does not capture the full range of commercial benefits flowing from publicly funded research.

Further work on developing commercialisation metrics is being undertaken under the aegis of the Government's Coordinating Committee on Science and Technology. This work, will feed into the development of the Quality and Accessibility Frameworks for publicly funded research announced as part of *Backing Australia's Ability – Building our Future through Science and Innovation* (Commonwealth of Australia 2004). The international commercialisation community shares the view that further work is needed to develop commercialisation metrics.

Development of metrics for research commercialisation

The Coordinating Committee on Science and Technology (CCST) established in November 2003 a Working Group (WG) on Metrics of Commercialisation (MoC).

As the discussion above outlines, current metrics emphasised the commercialisation of intellectual property (IP), especially through patents, licenses and spin-outs etc. These data capture only a small portion of the commercially significant interactions that take place between the publicly funded research sector and private enterprise (i.e. including current and emerging business). The WG therefore proposed that the metrics be expanded to include measures relating to research consultancies and contracts, and the development and deployment of appropriate skills. The WG also believed that consideration needs to be given to ensure that the metrics reflect a broader understanding of the commercial and economic benefits of research commercialisation

In addition to making three recommendations, the WG has identified several areas for further examination including:

- further develop policy and performance monitoring methodologies to capture researcher-industry interactions, including the role of knowledge and skills transfer to private sector enterprises
- examine the links between policy, funding decisions and research commercialisation metrics
- review the *National Principles of Intellectual Property Management for Publicly Funded Research* to ensure they reflect current and emerging IP practice and the needs of the research and innovation system.

Redefining research commercialisation—Recommendation One of the MoC

In examining and broadening the classes of metrics WG recommended in its report to the CCST, that the definition of 'research commercialisation' needed to be recast better to reflect the potential impacts on the Australian economy and Australia's global trade and investment. The current DEST definition for statistical purposes is:

> '*the processes that generate commercial returns via income and capital gains, income from licences and revenue from sales of new products and processes from research conducted.*'

This definition is somewhat narrow, especially as it does not reflect the range of ways in which publicly funded research activity can provide commercial benefits for industry.

In considering this issue, the WG was informed by DEST-commissioned work by Dr John Howard. Howard identifies four models of commercialising research outputs in Australia's university sector, (See Appendix 5).

Howard argued that the current emphasis placed on the 'standard model' (which he refers to as 'knowledge production') as the path to adoption of research outcomes is restrictive and counter productive. He states that while the 'standard model' is 'easily grasped' and its 'outputs easily measured' it does not adequately reflect the wide range of circumstances through which universities impact, or produce benefits, to the economy and society. Nor does it adequately describe the complex set of relationships, linkages and interactions by the various players, including private enterprise, universities and publicly funded research agencies.

Aside from stating that there need to be separate approaches to performance indicators for different funding programs, Howard argues that indicators still need to be kept to a minimum and adopted only when they can provide relevant and useful information about the performance of those programs.

Howard's analysis and work of the WG demonstrate there is considerable complexity in defining what research commercialisation means, and should mean, in Australia. It is also evident that commercialisation encompasses far more than 'the processes that generate commercial returns', as identified in the DEST definition above. Therefore, the WG considered the diversity and complexity of the Australian research and innovation system, and taking into account the proposed metrics classes the following definition was recommended.

Recommendation One of the MoC Report

That for Australia's publicly funded research, '*research commercialisation*' be defined as the means by which universities' and PFRAs' research generates commercial benefit, thereby contributing to Australia's economic, social and environmental well-being. This is achieved through developing intellectual property, ideas, know-how and research-based skills resulting in new and improved products, services and business processes transferable to the private sector.

Metrics of commercialisation—Recommendation Two of the MoC

The primary goal of the MoC WG was to develop a set of metrics for measuring and monitoring the performance of publicly funded research institutions in their efforts to contribute to the commercial success of Australian business and the wider community. Based on its analysis of metrics already in use in Australia and overseas, as well as those suggested in submissions, the WG arrived at a set of 40 potential metrics.

Reflecting its view that the existing definition of research commercialisation is too narrow, it classified these into three main groups, relating to:

1. Intellectual Property (identification, protection, transfer, exploitation)
2. Research Contracts and Consultancies
3. Skills Development and Transfer.

Table 2 relate to measurable factors such as spin-out companies, licensing of IP, contracts and consultancies, and the development of an appropriate talent pool. However, 40 metrics are too many for ongoing monitoring of research commercialisation at a systemic level. For this reason the WG selected a 'core' group of metrics Table 3. The WG believes these ought to be applicable across all public sector research institutions, allowing comparisons and benchmarking.

Recommendation Two of the MoC Report

That the 14 metrics covering IP, contracts and consultancies, and skills development and transfer in Table 3 be adopted as the basis for future data collection and assessment relating to research commercialisation across Australia's publicly funded research institutions.

Data collection and future surveys—Recommendation three of the MoC

The data used in any metrics system needs to be reliable, timely and cost effective to collect. The existing NSRC is expensive both to conduct, report, and respond to. The NSRC for 2001 and 2002—including designing and conducting the survey, compiling the data, interpreting the data and publishing the results—cost in excess of $400,000 (excluding respondents' costs).

Some 700 copies of the NSRC Report for 2001 and 2002 were distributed to stakeholders. The NSRC data has been useful in informing research and analysis within DEST and other Government departments. It has also been used by consultants engaged by DEST to research and advise on aspects of research commercialisation.

Data collection gaps

There is a need to ensure that future arrangements for the collection of data on research commercialisation are as streamlined as possible, with third party sources being used wherever possible and appropriate. As also noted in the assessment of the WG's proposed metrics, there are some areas where available data is limited or questionable. In these instances it will be necessary to set in place a process to improve the timeliness, availability and/or reliability of the relevant data.

This work should begin with the core group of metrics set out in Table 3 above, noting that most are reasonably robust in terms of data sources and integrity. This work can be taken further in the process of refining and testing the proposed metrics.

Future surveys of research commercialisation

The NSRC now covers a time series of three years: 2000, 2001 and 2002. It is important that this time series data be continued in relation to the core group of IP related metrics identified in Table 5 above. These continue to be important for performance assessments and benchmarking, both domestically between institutions and sectors and internationally. However, one implication of the WG's proposed framework for metrics of research commercialisation is that some data collected in the first three years of the NSRC will not be collected in the future. For example, the WG does not believe that information relating to the employment of patent attorneys is sufficiently useful in policy or performance terms to warrant the cost of its collection. On the other hand, the WG's proposed framework also implies an extension of the scope and range of the metrics relating to research commercialisation, by covering research contracts and consultancies and skills development and transfer.

Recommendation Three of the MoC Report

Building on the metrics in Table 3, that a comprehensive data collection strategy for research commercialisation metrics be developed. The strategy should:

- maintain the existing time series data for the core indicators developed through the National Survey of Research Commercialisation
- address any deficiencies in data quality so as to improve data timeliness, availability and/or reliability (including those identified in this Report)
- wherever possible, draw upon existing and reliable third-party data to reduce the burden on respondents and to ensure consistency.

Table 2: Matrix of research commercialisation metrics

Main data groups	Supply side: Publicly Funded Research Sector		Demand side: Business & Community	
	Inputs/ Activities	**Outputs/ Deliverables**	**Intermediate Outcomes**	**Final Outcomes**
Intellectual Property (identification, protection, transfer, exploitation)	1. Patent Applications (including Plant Breeders Rights) & Patents Issued (No.) 2. Invention disclosures (No.) 3. Commercialisation Staff (No. & Costs) 4. Commercialisation Administration (Cost) 5. IP policies & practices (Documented & Applied)	6. Licences, Options, Assignments (No. & Value) 7. Royalty agreements (No. & Value) 8. Pilots/ Prototypes/ Clinical Trails (No.) 9. Client relations (No. of contacts/ interactions)	10. Gross revenue from licensed technology 11. New products, services or business processes 12. Start-ups/ Spin-outs (No., capitalisation & revenue) 13. Joint Ventures (No., capitalisation & revenue) 14. Initial Public Offerings (No., & capitalisation) 15. Venture capital deals (No. & value)	Changes in: • GDP • investment • employment • exports • health outcomes • environmental outcomes that can be reasonably linked to research commercialisation intermediate outcomes (using econometric analyses and studies).
Research Contracts & Consultancies	16. Research contracts (No. & Gross Revenue) 17. Consultancies (No. & Gross Revenue) 18. Joint Ventures (No. & Capitalisation) 19. ARC Linkage Projects (No. & Value) 20. Administration (Cost)	21. Reports (No.) 22. Publications (No. & type) 23. Conferences/ Seminars (No. & attendance) 24. Client relations (No. of contacts/ interactions) 25. standards & best practices	26. Business expenditure on R&D (BERD) in the public sector (Quantum & % of total BERD) 27. Repeat business (% of contracts with previous clients) 28. Flow-on business (No. of clients who become patent licensees and/or partners in JVs, spin-outs etc)	
Skills Development & Transfer	29. Commercialisation & entrepreneurial training for researchers (No. of courses offered, No. of graduates) 30. Scientific & research training for Industry (No. of courses offered, No. of graduates) 31. Course design - industry input & endorsement (No. of postgraduate courses with industry input to design and/or industry endorsement)	32. Research graduates employed in industry (No. & % of total cohort) 33. Industry funded postgraduate places 34. Staff exchanges (No. of Researchers to industry; industry to research sector) 35. Research student placements in industry (No.)	36. Industry sector satisfaction with quality of research graduates 37. New practices 38. New products/ services 39. Research postgraduate income 40. Research postgraduate Start-ups & Spin-outs	

Table 3: Core group of metrics

Main data groups	Supply side: Publicly Funded Research Sector		Demand side: Business & Community
	Inputs/Activities	**Outputs/ Deliverables**	**Intermediate Outcomes**
Intellectual Property	1. Patent Applications (including Plant Breeders Rights) & Patents Issued (No.) 2. Commercialisation Staff & Administration (No. & Costs)	3. Licenses, Options, Royalty agreements, Assignments (No. & Value) 4. Pilots/ Prototypes/ Clinical Trials (No. & Value)	5. Gross revenue from licensed technology 6. New products, services or business processes created 7. Start-ups/ Spin-outs, Initial Public Offerings (No., capitalisation & revenue)
Research Contracts & Consultancies	8. Research contracts & Consultancies (No., Gross Revenue, Sectors & Company Size)	9. Peer-reviewed Publications & Reports (No. & type)	10. Repeat & flow-on business (% of contracts with previous clients)
Skills Development & Transfer	11. Commercialisation & entrepreneurial training for researchers (No. of courses offered, No. of graduates)	12. Research graduates employed in industry (No. & % of total graduates)	13. Research postgraduate income 14. Research postgraduates employed in Spin-outs

Appendix 6: Research commercialisation barriers and enablers

The following tables 4 & 5 on the barriers and enablers of research commercialisation are summarised from an extensive literary review undertaken within DEST. These do not represent a definitive analysis of the issues rather they have been included to inform the Inquiry of the range of issues that impact on the success and failure of the research commercialisation.

Table 4: Summary of barriers to research commercialisation

Capacity	Commercialisation skills	Lack of practical experience (researcher & institution) in: • Commercial management • IP identification • Entrepreneurship • Innovation • Business • Legal issues
	Finance	High direct cost of commercialisation Lack of: • seed funding • gap between research outcome & early stage venture capital • *proof-of-principle funding* • funding to secure and maintain IP • funding for prototype development • later stage (product development)
	Information	• lack of info on commercialisation practices & procedures, opportunities, business processes
	Time	• Lack of time for commercialisation, teaching commitments • delays in university decision-making; establishing administrative, legal, IP & financial requirements
	Mobility	• lack of staff mobility between PFRA/uni/industry
	Critical mass	• scale: smaller & regional unis do not have scale for successful commercialisation (sufficient portfolio of research; quality of researchers; breadth & depth of experience in commercialisation)
	Saturation point	• inability to further leverage core resources
Culture/attitude		• Commercialisation activities compromise academic reputation • Culture of academe does not favour entrepreneurs • commercial applications seen as 'dirty' • Inadequate rewards • lack of attributes (desire, incentive, facilitation) • *cultural differences between knowledge creators, entrepreneurs, business partners* • tech push rather than market pull • *unis too risk averse*
Govt regulation & standards	Industry	• less capable domestic industrial base • less absorptive industry due to fragmentation, small size & low R&D investment, industry has a poor capacity to absorb uni & PFRA generated tech. • risk averse business culture • tendency for research institutions to engage offshore companies to develop new inventions due to lack of industry receptors • *perceived market dominance by others*
	Intellectual Property	• national IP principles should be revised (IP ownership, management, enforcement etc) • *IP rights inhibit collaboration* • open or closed IP? different understandings of suitable IP arrangements for commercialisation • differences in application of IP in unis & PFRA • lack of clarity re disclosure of new IP • conflicting perceptions between staff & institutions of IP rights & disclosure duties • pressure to secure IP via patenting, spin offs • TTO have monopoly over IP • conflict between publication & IP protection (*premature publication can prejudice patent applications, yet academic culture often encourages early publication*)
	Universities	• in some cases uni governance (State acts, auditing reqs, structure, authority) do not allow for optimal commercialisation outcomes • lack of visibility of Aust R&D to international players • constraints to taking up directorships in start-ups • lack of clarity re profit sharing arrangements • lack of clarity re rights & obligations • constraints to holding equity • employment, promotion policies (insufficient weight to commercialisation, wtd more to traditional measures – publication, grants recd) • *inexperienced and understaffed TTOs]*

	Taxation	• taxation laws, negative impact of capital gains tax
Linkages		• lack of fully effective linkages between researchers & industry • cultural & operational differences impeding collaboration

Table 5: Summary of enablers to research commercialisation

Capacity	Commercialisation skills	• improve skills, unis offer training to students/researchers, placement in industry • TTOs to employ skilled staff • scholarships/Industry Chairs/place SET grads in SMEs • research institutions have effective strategies in place to 'spot' IP with commercial potential • conduct high quality research
	Finance	• increase amount • venture finance that is sufficient, timely & long term • CSIRO/ANSTO/AIMS access competitive funding • Commonwealth fund 50% new MNRFs • create a cash-out option under the R&D tax concession for R&D expenditure by SMEs • -boost existing/develop new pre-seed capital fund for unis/PFRAs • additional funding for development of research commercialisation infrastructure in the PFRA
	Information	• develop stronger guidelines on commercialisation of research for PFRA • Improved data collection- revamped NSRC
	Time	• isolate the business incubator from daily uni activities
	Mobility	• unis need flexible employment options for researchers pursuing commercial lines of interest
	Critical mass	• enhance collaborations between research institutions & between research institutions & unis to achieve critical mass
	Saturation point	
Culture/attitude		• unis to strongly support entrepreneurship, encourage spin-offs • provide incentives for researchers • top-level commitment to increasing opportunities and rewards for commercialisation (priority in uni strategic plan) • unis address disincentives such as finance allocation and promotion criteria • develop effective commercialisation support structures (legal, contractual etc) & clear commercialisation pathways • create new mechanisms & improve networks to bridge gap between uni & industry
Govt regulation & standards	Industry	• focus on addressing market gaps & market failures that impact on young tech-based businesses • strong local market of business receptors for acquisition & development of commercial applications
	Intellectual Property	• allow ARC-funded researchers to exploit own IP • national legal & regulatory framework for IP; clear IP ownership & management policies in unis • expert group to reconsider the Nat'l IP Principles, including ways to encourage greater utilisation
	Universities	• provide incentives for unis to commercialise research • monopoly position of commercial arms: encourage removal?
	Taxation	
	General	• provide suitable incentives to attract significant R&D projects to Australia • Aust Govt establish a Strategic Research Council to enhance collaboration & coordination across the research system • establish a contestable collaboration fund • fair & motivating distribution of financial rewards from commercialisation • better alignment of industry & institutional needs & interests • provide a clear mandate for unis to engage in research commercialisation; acknowledge as a legitimate 3rd role
Linkages		• build effective relationships at all stages of the res comm. process • enhance networking & communication between res & industry • improve access by companies to uni competencies • develop & expand relationships w business • unis conduct research compatible with industry/business interests