SUBMISSION TO THE PRODUCTIVITY COMMISSION RESEARCH STUDY ON PUBLIC SUPPORT FOR SCIENCE AND INNOVATION

DEPARTMENT OF COMMUNICATIONS, INFORMATION TECHNOLOGY AND THE ARTS

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OVERVIEW

The Department of Communications, Information Technology and the Arts (DCITA) has responsibility for a range of public policy issues which are relevant to innovation in, and the efficiency of, the Australian economy and society more generally. These include:

- National policy issues relating to the information economy
- Application of information and communications technology (ICT), including broadband and electronic commerce
- Information and communications industries development
- Communications infrastructure
- Cultural affairs
- Sport and recreation.

This submission sets out some of the key issues relevant to the Productivity Commission's study from the perspective of DCITA's responsibilities.

In considering the impacts of public support for science and innovation, it is important to take account of the key role of ICT in the economy and contemporary society. Recent economic research concludes that ICT is a fundamental general purpose technology, driving a major transition and enabling a very wide range of other innovations throughout the economy. The rapid development of ICT means that further structural and social changes are inevitable. For example, broadband-based services are developing rapidly and the next generation of broadband will lead to major changes in the economy, particularly the services sector.

ICT, including connectivity through high speed communications infrastructure, has been of central importance to Australia's strong economic growth. DCITA's research program into the relationship between ICT, innovation and productivity growth has shown that ICT has emerged as the main technological driver of productivity growth in Australia over the last twenty years. The ICT-related productivity growth was spread across the economy, with the strongest in the heavy ICT user industries.

DCITA forward projections suggest that the main sources of productivity growth over the period 2004 to 2024 will be more capital expenditure on ICT per worker combined with technological progress in ICT, with a smaller, additional contribution from biotechnology and nanotechnology.

Research, including DCITA's, has shown that simply installing ICT will not necessarily provide the productivity benefits essential to our economic growth. Learning, skills and innovation in the Australian context are needed for continuing economic development and ongoing productivity gains and for yielding better social and environmental outcomes.

In view of the complexities of the innovation process, DCITA's research has used a mixture of macro and micro modelling to assess the broad impacts of ICT and the implications for policy development. Estimates of the social rate of return from

Australian business R&D were found in the range between 10% and 30% and the social rate of return to ICT investment in the range of 8% to 35%.

The high social rate of return and the ICT-related economy-wide productivity gains would suggest strong reasons for ensuring investment particularly in ICT R&D and innovation. Australia needs a world-class public and private ICT research base with critical mass to sustain our ongoing ability to effectively deploy ICT. However, there are several additional reasons:

- ICT makes a fundamental contribution to all research disciplines, all the National Research Priorities and it has a significant involvement in the high priority areas for government. Case studies and references provided in this submission illustrate some of the ways that Australian ICT R&D and ICT innovation capability underpins our economic growth, security, healthcare, transport and our ability to achieve sustainability in the management of our resources.

- ICT has complementarities with other, emerging enabling technologies such as nanotechnology, biotechnology and material sciences and consequently Australia's ICT skills and infrastructure will be important to our ability to capture opportunities from advances in these technologies.

- A strong ICT R&D and innovation capability in Australia can establish a positive cycle of reinforcement, attracting leading edge customers, talented researchers, foreign investment in technology development and linkages to major international centres of research and innovation.

- Most research is done overseas and the ICT infrastructure and capability is part of the entrée for Australian scientists to global research and information colleges.

- Many countries are endeavouring to link the research effort and bolster data resources and computing facilities in order to build a high capacity ICT infrastructure (e-research). This infrastructure will be important for addressing big scientific and "real world" problems such as climate change and resource management.

In developing a world class public and private ICT research base, policy makers need to keep several issues in mind. Size matters and smaller countries like Australia need to focus in areas of importance and forge collaborative links to optimise returns from investment in ICT R&D.

Patient investment is required to develop a strong capability in ICT R&D and the various complementary capabilities essential for capturing the benefits of public research and innovation, including physical infrastructure, accumulated local knowledge, linkages, technology development and management capability, technology diffusion capability and a range of other skill sets. There is a need for a comprehensive view of the different aspects of that capability, understanding that a weakness in one part of the system may constrain the scope and extent of benefits that can emerge from public investment in innovation and R&D.

In the context of ICT, continuing attention is needed to building scale, fostering collaboration and strategically focusing on high priority areas. Developing an internationally competitive infrastructure through initiatives such as the National Collaborative Research Infrastructure, the Advanced Networks Program and e-research strategy is essential to ensuring Australian researchers have the infrastructure to engage with their peers internationally.

Key impediments include:

- Institutional and other barriers to research collaboration;
- Too narrow a view of the innovation system;
- Insufficient attention to skills, including advanced network management expertise;
- Insufficient effort put into technology diffusion;
- Insufficient attention to standard setting and forecasting

DCITA considers that there needs to be ongoing monitoring of the performance of the innovation system and its individual components as well as further study into the inter-relationships within the system. In particular, additional work is needed to refine our understanding of how productivity benefits are generated and the involvement of the Australian ICT capability. Another feature of interest is the emergence of new business models within the public sector as it responds to the pressures to enhance commercialisation and address public good issues.

There needs to be a better evaluation of government interventions with a view to understanding what does and does not work and the broader impact of funding frameworks. Metrics need to be further developed and used with a deep appreciation of time scales, gaps and complexities. For example, commercialisation, as measured by the number of spin-off companies, may be adversely affected by several factors, such as an industry downturn, a lack of local commercialisation skills or the presentation of an under-developed technology to the market.

There also needs to be a better understanding of the long lead-times required for sustainable R&D outcomes. It is unhelpful to all interests if there are unrealistic expectations about quick commercial returns from all institutions. A more soundly-based view would be gained by a clearer understanding of the different roles played at different levels by a range of research institutions eg NICTA and CRCs.

AUSTRALIAN GOVERNMENT ICT POLICY FRAMEWORK

In the context of ICT in science and innovation policy, the Government's key policy objectives are to facilitate Australia's growth as an information economy and to develop Australia's capability in ICT to maximise the benefits this group of technologies.

Policy issues which impact on ICT capabilities and their application are pursued through a number of Commonwealth portfolios and at the State, Territory and local government level. The key elements of the strategic framework and major activities under those elements are:

- **Government and industry leadership**
    - Initiatives being pursued through the COAG process (via the Online and Communications Council chaired by the Minister for Communications, Information Technology and the Arts) include ICT skills, trade and investment, and communications infrastructure.
    - Research and analysis of ICT productivity and innovation, as detailed in this submission.
    - Consultation with a range of industry groups, reflecting both ICT "demand" and "supply" side perspectives, on further refinement of national ICT priorities.
- **Enabling appropriate infrastructure**
    - Significant funding for high speed communications infrastructure, particularly in regional areas, through the Connect Australia initiative.
    - Development of a Broadband Blueprint to provide a strategic framework for continuing broadband development.
    - Funding initiatives such as the Advanced Networks Program for specialised high-speed communications and research.
- **Developing the ICT R&D base**
    - Establishment of NICTA (National ICT Australia) as the national ICT centre of excellence.
    - Establishment of an ICT Roundtable to facilitate research collaboration by publicly funded ICT research bodies.
- **Developing the skills capability base**
    - Conducting broadly-based stakeholder forums such as the PartiICipaTion Summit.
    - Establishment of an ICT Skills Foresighting Working Group to address ICT-specific issues.
- **Building a supportive environment for innovative ICT businesses**

- Release of a Digital Content Industry Action Agenda
- Implementation of an Electronics Industry Action Agenda
- Enabling the capping of supplier liability in ICT government contracts
- Initiatives for the venture capital sector announced in the 2006-07 Budget.
- Strategic development of international trade and investment opportunities for Australian ICT through the Committee Marketing ICT of Australia (COMICTA).

Additional information on portfolio initiatives is provided at **Attachments C and D.**

THE SIGNIFICANCE OF ICT IN CONTEMPORARY SOCIETY

We are now seeing a new fundamental general purpose technology radically transforming economies, societies and institutions globally. This transformation is being brought about by the group of technologies collectively known as information and communications technology.

ICT is the group of technologies that capture, transmit and display data and information electronically.

The genesis of this transformation was in the development of communications devices such as the telegraph, telephone and wireless. Subsequent developments such as computers, the digitisation of communications, the Internet and mobile phones have spread rapidly. The result is an increasingly integrated global information network that is still developing quickly and which is transforming economies and societies worldwide.

> *The Internet has been the most fundamental change during my lifetime and for hundreds of years. Someone the other day said, "It's the biggest thing since Gutenberg," and then someone else said "No, it's the biggest thing since the invention of writing."* Rupert Murdoch

The capability to create, collect and use information has always been central to competitive advantage for individuals, businesses and nations. However ICT enhances our cognitive and organisational abilities - the capability to create, collect, analyse, manage, utilise, distribute and exchange information, to communicate and to organise economic and social activities – in new and powerful ways. One description of this transformation is the “information economy”.

The widespread use of ICT is driving innovation and productivity growth in Australia and other economies. It brings firms, governments and other organisations a number of information and productivity gains in cost and effectiveness in dimensions such as accuracy, timeliness, sophistication, storage, access and transmission. ICT has become a pervasive component in the processes and products and services of all industries, from “low tech” through to “high tech”. It can enhance the accessibility of government services, while at the same time improving efficiency and reducing costs.

ICT is a key part of the innovation process and an enabling technology across the science and innovation system.

ICT supports and drives organisational innovation, with better coordination of activities leading to major changes to horizontal and vertical integration, flatter hierarchies, more active teamwork and international service delivery. In commerce, the multiple user innovations are driving changes at the firm level and cumulatively changing industries and supply chains.

ICT is changing the delivery of key Government services such as information, health and education, significantly enhancing their integration and capabilities. Similarly, ICT underpins our ability to achieve national goals, such as national security, managing our resources, achieving greater energy efficiency, responding to climate change and dealing with our ageing population. It is a fundamental part of scientific research and much of our entertainment.

There are also significant impacts on communities, the way individuals interact and their access to government services. ICT can play a role in building stronger communities, increasing economic productivity and contributing to rural and regional rejuvenation.

The communications network originally developed for voice communication has been extended and overlaid and now supports a much wider range of communication services, including data, audio, video, and financial transactions. Broadband is increasingly part of life for Australians. The Internet is providing a new national and international information infrastructure and the range, reach and extent of the services built on this infrastructure is expanding rapidly.

Broadband capacity will underpin future connectivity requirements of the whole economy, especially in respect of service delivery and peer to peer interactions. There is significant potential to achieve substantial savings as well as extend the quality, range and scope of broadband-based services.

Digital technologies have also transformed the way in which text, audio visual and other content is created, managed, stored and distributed. The application of digital technologies, the creation and manipulation of digital content and resultant industry transformations have also moved beyond the traditional content sectors of the economy to online entertainment, health, education and others[1]. In the wider economy, digitisation and digital content are adding value to industrial processes and production in areas such

[1] Appendix D within the Digital Content Industry Action Agenda Report contains a series of examples demonstrating the impact of digital content across other industry sectors.

as design, production, marketing and sales and are increasingly associated with innovation.

Many industries and areas of research are becoming increasingly dependent on the advances in ICT to support their leading edge research and applications. The delivery of National Research Priorities is ICT dependent. The ubiquity of ICT also means that many ICT-based innovations will come from non-traditional areas such as individuals and the arts. Along with nanotechnology, materials science and biotechnology, ICT is considered one of the platform technologies which will underpin future innovation across research and industry sectors.[2]

Governments, business and other organisations are investing heavily in ICT-based innovations and ICT R&D, and as a consequence new waves of ICT-based technologies are widely anticipated. Being applicable across a very broad range of uses and having strong complementarities with existing and potential new technologies, the impacts of ICT will continue for some time and they may occur in new and surprising ways.

> "*The number one benefit of information technology is that it empowers people to do what they want to do. It lets people be creative. It lets people be productive. It lets people learn things they didn't think they could learn before, and so in a sense it is all about potential*." Steve Ballmer, CEO of Microsoft Corporation

Australia has begun the transformation to an information economy well, and in particular, ICT has significantly enhanced our productivity growth in recent decades. A statistical overview of key aspects of ICT in the Australian economy is at **Attachment A**.

The ongoing roll out of ICT and new waves of ICT development will ultimately be reflected in new business models, new industry structures, new kinds of social interactions, and new forms of regulatory arrangement in Australia and elsewhere. These challenges need a coherent response, comparable with that of our global peers if Australia is to maintain the international competitiveness of its industries, to enhance social wellbeing and to meet environmental, security and other challenges.

ICT is highly traded internationally as ICT *per se* as well as being incorporated into many other goods and services. While all countries utilise ICT produced overseas, there are significant synergies between local ICT producers and sophisticated users. A strong ICT science and innovation capability focusing on areas of importance to Australia is essential to maximising the opportunities from ICT.

Government interventions to bolster ICT capability and provide strategic focus to public ICT R&D will succeed only with long term investment and if collectively they address a variety of impediments and an appropriate decision-making framework is in place.

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[2] See for example UN Millennium Project 2005 *Innovation: Applying Knowledge in Development* Taskforce on Science, Technology and Innovation

DCITA RESEARCH – ICT AND INNOVATION, PRODUCTIVITY GROWTH AND R&D PERFORMANCE

DCITA has undertaken research into innovation *per se* as well as the interrelationship of ICT, innovation and productivity growth.

Earlier models of innovation as a linear process flowing from basic research to research and development to commercialisation are no longer universally relevant. Innovation is a complex, creative, adaptive, symbiotic, learning process whereby knowledge and new ways of generating additional value are developed and applied through product, process and organisational innovation. Innovation is also a complex social process, characterised by continuous feedbacks rather than linear transitions. It is continuous rather than intermittent, in which capability and performance develops cumulatively over time.

Innovation arises in numerous domains, including in products, processes, marketing, services, management and use. Firms do not innovate alone, but by interacting with customers, suppliers, competitors, consulting companies, technological institutes and universities in ways that are complex and uncertain but which seeks to exploit knowledge and reduce risk. The relevant knowledge is distributed across many sectors and agents.

Innovation depends on the accumulated array of learning and investments in the economy over time, including the past technological sophistication of firms and the size of the technical and scientific workforce. Consequently, a country's or a region's industrial and innovative capacities tend to be path dependent with significant barriers to moving to another trajectory. In particular, increasing returns reinforce path dependency by benefiting prime movers rather than latecomers. Innovation also involves occasional major transitions, as technologies change in discontinuous and fundamental ways. In this regard, we view ICT as such a major transition, seeing it as a fundamental general purpose technology enabling a very wide range of other innovations throughout the economy. Thus DCITA sees its impact as being far more important than most other technologies[3].

Given these complexities, DCITA's research into the nexus between innovation, ICT and economic growth has been multifaceted, using case studies, surveys and macroeconomic analysis to approach a better understanding of the interactions, outcomes and issues. Some key papers are listed below, and a more complete list is provided in **Attachment E**. All relevant papers will be provided to the Productivity Commission as they are published.

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[3] For discussion, see for example Lipsey, Richard G, Kenneth I Carlaw & Clifford T Bekar, 2005, Economic Transformations: General Purpose Technologies and Long Term Economic Growth, Oxford University Press, Oxford

* These research papers are being prepared for publication.

Table 1: DCITA research publications

1.	***Year***	*2.*	***Title***	*3.*	***Research***
4.	*2004*	*5.*	*Productivity Growth in Australian Manufacturing*	*6.*	*DCITA*
7.	*2005*	*8.*	*Achieving Value From ICT: Key Management Strategies*	*9.* *10.*	*Opticon/ANU* *Grigor et al*
11.	*2005*	*12.*	*Productivity Growth in Service Industries*	*13.*	*DCITA*
14.	*2005*	*15.*	*ICT and Australian Productivity: Methodologies and Measurement*	*16.*	*DCITA, Meyrick & Associates Prof Erwin Diewert and Dr Denis Lawrence, and Dr Kenneth Carlaw*
17.	*2006*	*18.*	*Estimating Aggregate Productivity Growth for Australia: Role of ICT*	*19.*	*Meyrick & Associates Prof Erwin Diewert and Dr Denis Lawrence*
20.	*2006*	*21.*	*Forecasting Productivity Growth: 2004 to 2024*	*22.*	*DCITA*
23.	*2006**	*24.*	*The economic impact of ICT R&D*	*25.*	*DCITA*
26.	2006*	*27.*	*ICT and Australia's Labour Productivity: A structural analysis*	*28.*	*ANU Centre of Law and Economics: Dr George Barker, Prof Leonard Waverman, Pro Melvyn Fuss, Richard Tooth.*

Key findings from DCITA's research program – the contribution of ICT to productivity

Macro Studies

Importantly, DCITA's research is showing that ICT and associated innovation has played a much more significant role in Australian productivity growth than previously realised, and significantly greater than earlier Australian estimates[4]. These earlier estimates were based on growth accounting studies that did not take into account the contribution of ICT to multi-factor productivity (MFP) growth. When this contribution is taken into account in addition to that of capital accumulation, DCITA research into the contribution of ICT to productivity growth in the manufacturing and the services sectors over the 17 years from 1984-85 to 2001-02 found:

- in manufacturing, technology (much of it ICT) has contributed between 56 and 80 percent of non-capital related productivity growth over that period with the rest attributable to education and institutional factors.
- in services, technology (mainly ICT) has contributed between 59 and 78 percent of non-capital related productivity growth over the period with the rest again attributable to education and institutional factors.

Together, these studies cover 53 percent of GDP. The following table shows the estimated labour productivity growth in service industries and manufacturing.

[4] See for example, Parham, D, 2004, Sources of Australia's Productivity Revival, The Economic Record, Vol 80, No 249, pps 239-257..

Table 2 Drivers of labour productivity growth: 1984–85 to 2001–02

29. *LP growth attributed to*	*30.* *Lower estimate*		*31.* *Upper estimate*	
	3. Annual contribution	*. Share*	*5. Annual contribution*	*. Share*
	38. %	39. %	40. %	41. %
Service industries	43.	44.	45.	46.
Increased capital spending per worker	48. 1.02	49. 46	50. 1.02	51. 46
Falling ICT prices	53. 0.45	54. 20	55. 0.45	56. 20
MFP growth due to technical change	58. 0.27	59. 12	60. 0.50	61. 22
MFP growth due to institutional change	63. 0.50	64. 22	65. 0.27	66. 12
Annual LP growth	68. 2.24	9. 100	70. 2.24	1. 100
Manufacturing	73.	74.	75.	76.
Increased capital spending per worker	78. 0.75	79. 34	80. 0.75	81. 35
Falling ICT prices	83. 0.28	84. 13	85. 0.28	86. 13
MFP growth due to technical changes	88. 0.51	89. 24	90. 0.85	91. 39
MFP growth due to institutional change	93. 0.62	94. 29	95. 0.28	96. 13
Annual LP growth	98. 2.16	9. 100	100. 2.16	01. 100

The sectoral data indicates that productivity growth was particularly strong in industries that are heavy users of ICT equipment and software. In services, these industries include telecommunications, finance, wholesale trade and electricity. In manufacturing, ICT intensive industries include electronics, medical and scientific instruments, basic metals and motor vehicles.

The close correlation between sectoral ICT intensity and productivity growth suggests that over the last twenty years ICT has emerged as the main technological driver of productivity growth in Australia. Apart from capital spending and ICT, other important contributors to productivity growth were microeconomic reform, education and non-ICT related technological innovations.

The reports also review in some detail the composition of manufacturing and service industries and structural changes that occurred in these sectors since 1984-85. Some descriptive material is presented on new ICT and non-ICT technologies introduced over the last twenty years.

In addition, DCITA has concerns about the methodologies used in conventional analyses and their inability to accommodate delayed impact of a general purpose technology like ICT. These concerns are taken up in *ICT and Australian Productivity: Methodologies and Measurement* and in follow up work.

The research shows that for industries with sufficiently robust data, ICT investment ultimately provides users with greater gains than reflected in the observed market price, after adjusting for quality. Consequently, conventional growth accounting analysis is likely to understate the multi-factor productivity benefit from ICT use.[5]

The finding about the large contribution of ICT to productivity growth is supported by further research *General Purpose Technologies and the Information Economy: An Evolutionary Approach to Macroeconomic Modelling*[6] that showed, from cross-country data, that in recent years ICT investment and 'spillovers' were major drivers of productivity growth in Australia and other OECD countries. These results suggest that the greater ICT capital per worker in the US and its diffusion explained around 44% of the Australia-US productivity gap in 2000, but by 2003 this had fallen to 28%.

The report, *Forecasting Productivity Growth: 2004 to 2024*, used general equilibrium modelling (MONASH model) to generate forecasts of productivity growth in 12 major market sectors of the Australian economy. The report suggests that the main sources of productivity growth will be capital deepening (ie more capital per worker) combined with technological progress in ICT and to a lesser extent biotechnology and nanotechnology. Productivity growth will also be strongly influenced by changes in workplace relations, competitive conditions and the social environment. As the report notes

> "…..in order to realise the predicted productivity benefits it will be necessary to support an appropriate level of investment in skill formation and ICT related R&D. Falling international prices are not sufficient by themselves to ensure strong economic growth. The introduction of new ICT technologies involves an extensive learning process that generates significant knowledge and innovation related externalities to the Australian economy which are reflected mainly in MFP growth."

Other DCITA research presented in *ICT and Australian Productivity: Methodologies and Measurement* addresses ICT externalities (or spillovers), that is, the difference between social and private returns to ICT investment. The econometric work suggests that at the aggregate national level ICT inputs are worth 40% more to users than the prices paid for them.[7] Analysis at the sectoral level also indicates a consistent undervaluation of ICT inputs in major sectors of the Australian economy.

Some of this work has sought to deal with issues to do with the ABS data encountered in earlier studies of productivity growth such as the quality of ABS productivity data, particularly at the sectoral level and for MFP growth[8]. The estimates in *ICT and Australian Productivity: Methodologies and Measurement* show that the Australian productivity bonus does not occur immediately with investment in ICT, but occurs later as learning within individual businesses about the ICT and innovation maximises the productivity of ICT. Estimates from the conventional growth accounting analysis do not allow for such delayed effects.

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[5] *ICT and Australian Productivity: Methodologies and Measurement* Chapter 5
[6] Barker, Fuss, Tooth and Waverman – to be provided separately
[7] *ICT and Australian Productivity: Methodologies and Measurement* Chapter 3
[8] *ICT and Australian Productivity: Methodologies and Measurement*

The Department's research has found that in looking for a simple relationship between increased productivity and the use of ICT tools, it is important to take into account the nature of general purpose technologies. ICT is an enabler: a necessary but not sufficient condition for productivity growth. Unless the policies and the environments are in place to support transformation – be that at the macro or micro economic level – simply installing and using ICT will not necessarily provide productivity benefits. Some of the key issues relating to policy and ongoing work needed for the strategic development of an appropriate environment are discussed in a later section of this submission.

These macro studies are complemented by *The economic impact of ICT R&D: a literature review and some Australian estimates* which will be provided separately. This work indicates that:

- the social rate of return to Australian business R&D (BERD) is in the range between 10% and 30%. This is derived from regression estimates based on Australian national accounting data for 12 market sectors between 1987-88 and 2002-03.
- from the majority of the labour productivity regression results, the social rate of return to ICT investment is quite high, in the range of 8% to 35%, (which compares favourably with an estimated private return of around 10 per cent).

The high social rate of return would suggest strong reasons for investment particularly in ICT R&D. Moreover, on grounds of positive externalities, this works provides support for providing government subsidies to some ICT work that is not classified as R&D, such as assisting technology diffusion.

DCITA's case studies of Australian public ICT R&D

DCITA has interviewed public sector researchers, government organisations and firms about the impacts of Australian public ICT R&D and has written several case studies based on the interviews and some additional research. With the current economic theories, data and modeling limitations, case studies are the only approach that can demonstrate the wide range of social, environmental and economic impacts flowing from Australian public ICT R&D. The case studies also provide a basis for developing an understanding of the conditions needed to generate the outcomes, with some implications for policy development.

These case studies represent a small fraction of the public ICT R&D being undertaken. Many organizations conducting significant amounts of ICT R&D were not interviewed and many of the multi-disciplinary projects in which ICT was a key component were not investigated. Nevertheless, the case studies demonstrated widespread and significant impacts of Australian public ICT R&D.

Key findings are summarized below and supporting extracts from the case studies are provided in **Attachment F**.

Business models in ICT R&D organisations

Leaders of ICT R&D organisations are developing new business models to respond to pressures to enhance commercialization as well as address public good issues. To some extent, these business models fill niches not addressed by the activities of private sector agents. The new public sector business models build on the traditional public sector strengths in collaboration, rigorous analysis and bring a longer term and wider perspective to research. In some cases:

- These business models target particular users (such as health sector and e-government) and the delivery of knowledge-intensive services. As a result close relationships can be developed.
- The research organization brings together multidisciplinary teams (for example in addition to ICT researchers, social scientists, psychologists, educators and regulatory experts) to deliver 'public good' research and to develop strategic IP relevant to commercial outcomes.
- An emerging trend for public ICT R&D organizations is to develop relationships with users by providing highly applied research services. As the user-provider relationship develops, so does the opportunity for the development of new technologies and IP.
- ICT R&D organizations structured to deliver advanced services to users can amplify their capacity to deliver positive returns to the Australian economy and community. Highly applied advanced ICT research delivers productivity improvements by enabling user organizations to innovate as well as delivering IP which provides commercialization opportunities.

Impacts of the R&D

1. Governments are one of the primary users of public sector ICT R&D and they use it in a variety of ways to
   - Guide ICT and defence procurement decisions
   - Develop intellectual property in-house (when proprietary products and overseas ICT R&D do not address needs and priorities)
   - Inform policy development, regulation and priority-setting.

   Some of this research is done by the government organizations in-house (eg Bureau of Meteorology and DSTO) and the rest by other public sector research organizations which compete for government innovation and education funding. In view of the role of government, the impacts of such R&D are widespread and often substantial but also frequently indirect and not quantifiable in a rigorous way.

2. Over the past 10-15 years Australian public sector ICT R&D has developed IP that has been successfully spun-off in new companies or licensed to existing Australian and international companies. The research organisations income streams have not been sufficient to provide financial independence from government within the timeframes of programs such as the CRC program.

3. Some economic benefits outside the ICT sector can be quantified on a case-by-case basis where data is available. Sources for this data are the non-ICT industries in which the ICT R&D has had the impact. However the ICT-related benefits are generally difficult to distinguish from the contribution of the other (non-ICT) knowledge. Other measurement issues include the time delay before the impact is observable and the unexpected domains in which impacts may be observed over time. Nevertheless, it is clear from the available data that ICT R&D is increasingly important in delivering benefits to industries outside the ICT sector.

4. As the case studies show, many ICT projects are pitched to deliver social and environmental outcomes. The beneficiaries of this ICT R&D are spread across the community and the value of many of these outcomes can only be measured in subjective terms. Whilst, in theory, it may be possible to assess the value of this ICT R&D in some instances, little data is available. The anecdotal evidence from the case studies demonstrates that the social and environmental outcomes are significant.

5. Public ICT R&D builds Australia's ability to innovate more efficiently and productively by transferring ICT skills and technology and by sharing research data. The impacts of these projects are often diffused across many sectors and over many years. It is impossible to accurately quantify these impacts.

6. High quality public sector ICT R&D attracts international interest in establishing R&D facilities in Australia and extends collaboration networks. This has economic benefits and also builds Australia's ICT capability by acting as a conduit for leading edge skills and technologies from overseas.

7. Australia's ability to collaborate on international ICT projects is dependent on the country maintaining leading edge ICT R&D capabilities. As a small country, Australia competes on the basis of strengths in niche areas. Public sector ICT R&D generates new niche capabilities and enriches existing ones. Niche capabilities are generated in a number of ways by investing in skills, investing strategically in projects addressing specific government needs and through the applied research business models discussed above.

Additional case studies and economic modelling have been undertaken by a consultant and the key findings from these will be provided to the Productivity Commission once the work is completed.

Micro Studies

While competition drives much of innovation, ICT has opened many opportunities for innovation in businesses and other organisations, including government. Many studies have shown that it not just about ICT: there are often significant organisational changes that need to follow as companies seek to realise the benefits of ICT.[9] For example, the 2003 Ovum study, *Productivity and Organisational Transformation: optimising investment in ICT,* concluded that sources of productivity improvement (in addition to the actual adoption of ICT) included fundamental changes such as process re-engineering, new process subsuming old and changes in the business model and business objectives.

Once users become accustomed to new ICT then informational benefits start to emerge, which may accrue from sharing information more easily between colleagues, suppliers and business partners, better monitoring of customer needs and market developments and an improved knowledge base for business decision making. In economic terminology, there is much 'intangible investment' in learning associated with the assimilation of new ICT technologies. A multitude of factors such as culture and organisational and workplace flexibility as well as ICT skills and management's knowledge and expertise influence the way ICT can be adopted, applied, and used in a business and commercial context and may determine the speed, pathways and outcomes of adoption of ICT.

Digital Factories - the Hidden Revolution in Australian Manufacturing

For this study, Howard Partners conducted in-depth interviews with some 20 manufacturing firms that were not classified as ICT producing firms on their ICT use, innovation and production.

According to the report, how ICT is managed is the critical success factor – there is no technology fix *per se*. Many of the companies were found to be designing, developing and enhancing ICT applications. Australian capability in ICT, including skills, firms and public sector researchers made significant contributions to the competitiveness of these firms.

Some companies relied on external providers of proprietary software and their service providers, as well as a range of specialised software developers, to develop that capacity through contract and partnership arrangements. Companies in highly technical areas of manufacturing developed that capacity in-house. The research outputs of many public centres are ICT software, hardware, tools and products designed for adoption in manufacturing processes.

Digital content industries

In Australia, and internationally through the OECD Working Party on the Information Economy[10], work on the digital content industry is providing important information about emerging innovation and productivity growth opportunities involving creative industries.

The Digital Content Industry Action Agenda Report, *Unlocking the Potential*, (DCIAA Report)[11] highlights digital content as a driver of growth throughout the wider economy.

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[9] See for example *Achieving Value from ICT: Key Management Strategies* Opticon and ANU 2005

[10] http://www.oecd.org/document/62/0,2340,en_2649_34223_32160190_1_1_1_1,00.html

[11] http://www.minister.dcita.gov.au/media/media_releases/unlocking_the_potential__an_action_agenda_for_australias_digital_content_industry

The DCIAA Report emphasises the role of the ‘core production’ sector within the digital content industry as a market-based driver for innovations which are helping to transform business models and value chains across the economy.

The DCIAA Report concluded that an effective R&D system and industry access to R&D are critical to the development of the digital content industry in Australia The industry’s objective is to improve the industry’s access to research and development opportunities through:

- mechanisms for industry to have input into the setting of priorities by research and development institutions; and
- mechanisms for researchers to be placed within industry to boost commercialisation.

The Digital Content Industry Action Agenda now enters its implementation phase. This will involve industry building its linkages with major Australian research and development organisations and programs such as the Smart Internet CRC, NICTA, ACID, CENTIE, the Advanced Networks Program organisations and the Centre of Excellence in Creative Industries and Innovation.

POLICY ISSUES

There are two key policy areas to maximise the contribution of ICT to innovation and economic and social growth. These are the continued development of high speed communications infrastructure for a wide range of business, home and research users; and the development of a world-class public and private ICT research base with critical mass.

High speed communications infrastructure

An advanced communications infrastructure is essential to meeting the needs of the business, residential and research sectors. Broadband services are rapidly taking over from dial-up Internet services as the preferred technology for users of Internet and other online services. According to McKinsey, broadband is the fastest-ever growing technology[12].

Broadband can support a large number of applications that range from small business applications such as basic email and IP telephony, through to giga-bit hungry activities, such as virtual reality, tele-presencing for advanced health applications, interactive classrooms and research into climate change.   High broadband capacity and speed are essential to enable the use of more advanced applications. Increasing broadband speeds are stimulating the rapid development of advanced online applications across the full range of business, social, entertainment, research and e-government activities.

As these applications are taken up, they are rapidly expanding the utility and value of the Internet and online environment for business, innovation and community development alike. This means, for example, that businesses are able to operate more efficiently and

[12] *Making sense of broadband* The McKinsey Quarterly 2003, Number 2

to compete effectively in the increasingly global market. Researchers can link more closely into global networks and engage in large-scale modelling research.

Australia's future economic prosperity and the next generation of broadband services are linked[13]. However, the increasing complexity and functionality of online tools are requiring that users move to higher levels of broadband capacity. DCITA considers that the widespread availability of "next generation" broadband will be particularly critical as communications services (voice, broadband and TV services) converge onto a single technology platform, the so-called 'triple play'.

The Government's approach has been to:

- foster an open, commercial and competitive market for the supply of broadband and other telecommunications services;
- provide a legislated safety-net in relation to important consumer and regional issues; and
- target financial assistance to areas of market failure or other need such as in rural or remote areas, for indigenous communities and specialist users like health, education, research and government.

There is no one-size fits all broadband solution as different users have different needs. Australia needs to improve the capacity of the broadband available for innovation generally. It also needs high capacity (multi-Gigabits per second to Terabits per second) leading edge broadband connectivity and communications infrastructure if we are to stay at the forefront of global economic development. This capacity is needed both for research and education, but is increasingly needed for high technology industry and other sectoral applications. International capacity at this level is also required so that Australian companies and the Australian arms of MNCs can participate fully in the world economy.

The manufacturing, health, finance, mining, agriculture, transport, construction, media and environment sectors in particular are making increasing use of cutting edge ICT and now require the bandwidth and transmission technology to realise the full benefits of the new ways of working. DCITA considers that it will be particularly important to ensure Australia has the advanced infrastructure comparable with other advanced countries to meet the capacity and speed demands of this innovation.

Most developed countries are investing in upgrading their national research and education networks. In recent years the Australian Government has invested more than $128 million to provide a multiple gigabit per second optic fibre network connecting most university and research institutes within Australia and with substantial trans-Pacific connectivity. According to the roadmap of the National Collaborative Research Infrastructure Strategy,

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[13] In *Innovation delivered – Broadband for Australia, An economic stimulus package* (2001) Accenture estimates that next generation broadband could produce economic benefits of $12-30 billion per annum to Australia.

> "The quantum of this investment has brought about a step change in the bandwidth of the network. There will need to be further modest level of investment to maintain and extend the network. Investments will be necessary, for example, to improve connections to more remote research activities and to substantially improve international connections to Asia and Europe."

DCITA considers that it is particularly critical to monitor developments overseas with a view to ensuring that Australia's advanced networks infrastructure retains its international competitiveness and our scientists will be able to participate in leading edge research based on next generation networks. The advanced network infrastructure also needs to be accessible to industry, with encouragement to collaborative engagement in strategic research and innovation to enhance the opportunities for economic and social benefits.

A robust public ICT R&D base, particularly in universities is needed

In 2000 the Prime Minister's Science, Engineering and Innovation Council (PMSEIC) reported there was a significant under-investment in strategic ICT research by the public sector, a situation which was likely to continue in the long term. The lack of scale, concentration of effort and commercial focus in Australia's ICT R&D efforts (in comparison with other key technologies that underpin innovation and productivity across the economy) could not be effectively addressed through existing Australian Research Council and CRC programs.

These findings have been confirmed in the subsequent research for the *ICT Framework for the Future* report and mapping of Australia's science and innovation system in the lead up to the Government's May 2004 Science and Innovation Statement. Economically sub-optimal public ICT R&D could lead to a shortage of researchers with the necessary skills, reduce the capacity of the economy to absorb effectively leading-edge ICT technologies from abroad and adversely impact on Australia's ability to address national goals and the problems unique to Australia.

The analysis has also shown that the Australian public sector has built an international reputation for excellence in many research fields, but most particularly in biological research fields such as agriculture and medicine. This stems from long term research investment, with much of it in stable institutions such as CSIRO.

The ICT Centre of Excellence (NICTA) was established in October 2002. The Government's objective for NICTA is that it will be a world-class, world-scale ICT research and research training institute that takes Australia's ability to create and exploit information and communications technology to a new level. While NICTA has met all its milestones to date, it will take some time before the payoffs from investment in NICTA will become evident and its effectiveness can therefore be assessed.

Preliminary modelling by consultants to DCITA (to be provided separately) suggests that the reasons for investing in NICTA to bring greater scale, focus and linkages to ICT R&D efforts in Australia remain valid. Indeed organisations such as NICTA and CSIRO are particularly critical to the future of Australian ICT capability.

In such organisations, internal competition for project funding and astute recruiting practices can assist in maintaining and building excellence. Consistent, strong funding is important if high quality research capability and research infrastructure is to be maintained and the variety of infrastructures, networks and collaborative relationships established that support international knowledge flows and the accumulation of local competencies for technology development and its effective transfer. Long term funding also provides the opportunity for investing in the more strategic projects with potentially higher pay offs and considerable social benefits.

However, the university ICT research base continues to struggle to improve its position *vis a vis* more established sciences and gain a share of funding more in line with its significance both to the wider economy and the performance of research. For example:

- ARC support for ICT R&D (including ICT in multi-disciplinary projects) through the Discovery projects grants program rose sharply between 2001 and 2002 from 6.8% to 9%[14] of the total funding in those years. However the percentage has since declined (to under 8% in 2004).[15]

- no applications for ICT CRCs were successful in the 1994 and 2005 rounds, and only 1 in 1996. No other sector[16] has been totally unsuccessful in any rounds.

Another important area for policy development is Australia's research infrastructure which needs to be internationally competitive if Australian researchers are to undertake the research that will have important economic consequences in agriculture, the environment, health, finance, mining and manufacturing. e-Research is starting to underpin all scientific disciplines as well as the social sciences and humanities. It is also emerging as a significant element in advancing the Information economy more broadly because of the strong symbiotic relationship between e-research and the next generation of advanced services and e-transformation.

The Government made an election commitment to implement a coordinating structure for e-Research, modelled on the UK e-Science Programme in September 2004 (in *Information Technology: Connecting an Innovative Australia*). In April 2005, the e-Research Coordinating Committee was established jointly by the Minister for Communications, Information technology and the Arts, and the Minister for Education, Science and Training to provide expert advice to the Government about developing Australia's e-Research capacity. The Committee has now submitted its Final Report: *An Australian e-Research Strategy and Implementation Framework*, to the Government following extensive consultations in conjunction with the National Collaborative

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[14] DCITA calculations based on ARC data provided to DCITA.

[15] The ICT-rich priorities introduced for the ARC's 2002 grant round only were complex and intelligent systems and photon science and technology.

[16] CRCs are notionally grouped according to six relevant "industry" sectors – ICT, manufacturing technology, environment, mining and energy, agriculture and rural-based manufacturing and medical science and technology.

Research Infrastructure Strategy (NCRIS) Committee. More information on this initiative is in **Attachment G**.

Obtaining better economic and social outcomes from investment in ICT R&D

The Framework for the Future report identified several issues that DCITA considers may still need attention in addition to the relatively small amount of public ICT research, including:

- priority setting to focus the research areas
- closer engagement between research organisations and business
- the development of a culture more attuned to entrepreneurial activity
- the need to bring a consideration of commercial outcomes to every stage of the research chain.

The Minister for Communications, Information Technology and the Arts is working with industry and the research community toward the identification of priorities for ICT. Priorities for ICT could deliver a more detailed agenda within the national research priorities and assist in focusing government and industry resources on the most realistic opportunities for development and to meet national needs.

The Framework for the Future report also noted that[17] funding must be allocated not only to support excellence but also to build new capabilities and critical mass in high priority areas. ICT research requires funding priorities to be focused from a strategic viewpoint, including:

- Focusing on areas where Australia has world-class ICT strengths, or the clear potential to develop them. These strengths can be found where ICT intersects with other areas of technology and application such as security, environmental management and health or strengths relating to Australia's particular characteristics;
- Focusing resources on projects that attract national and international collaboration;
- Focusing resources in areas where there are existing commercial strengths in Australia or where there is clear potential to create them; and
- Areas of national interest such as solving problems of importance to Australia such as defence and dealing with an ageing population.

Priority setting is a difficult exercise though there have been some steps forward through the leadership shown by the major ICT research organisations. For example, since 2003 NICTA, DSTO and CSIRO's ICT Centre have jointly supported an annual ICT Outlook forum for the ICT research community to discuss their research and issues such as key new technology trends and user research needs.

[17] *Enabling our Future* 2003

NICTA, DSTO, CSIRO's ICT Centre and the ICT CRCs are working towards new collaborative efforts. An outcome of this process may be a focus on specific areas within the National Research Priorities, with industry and researchers working more collaboratively on key long term issues. Some of the impediments identified in the early discussions are of a systemic nature[18] and include differing institutional objectives and priorities, time horizons, incentive structures and IP.

NICTA is establishing an infrastructure for commercialization and linkages with the Australian ICT industry as well as new research programs in key areas of national benefit. NICTA has also established new research training with a commercial context for its students, including a program of awareness and commercialisation training, an "entrepreneur in residence" program.

The December 2005 PMSEIC Report, *The Role of Creativity in the Innovation Economy*[19] (PMSEIC Report) examined mechanisms for fostering creativity and highlighted the potential of creative industries to contribute further to the economy and deliver increased national benefits. The PMSEIC Report proposed that Australia's innovation policy framework be expanded to take account of creativity and creative industries.

As the PMSEIC Report states, 'increasingly, it is intangible inputs like design which produce the value-added elements of manufactured products'. It also points out that 'successful enterprises are showing the way in innovation by harnessing new creative and cultural knowledge resources and by adopting a cross-disciplinary skills mix across technical, creative and managerial fields'. Similar themes and case studies about the incidence of R&D and innovation activity within firms are contained in the recent Business Council Report, *New Concepts in Innovation*[20] and *Unlocking the Potential,*[21] the Report of the Digital Content Industry Action Agenda.

These studies are helpful to government, the research sector and industry when considering the development of future policies and programs to support next generation innovation frameworks. For the Australian Government some opportunities presented through these studies may be taken into account in progressing development of a comprehensive Digital Content Strategy.

Skills

A highly skilled ICT workforce is the key to business productivity improvement through the innovative use of ICT. This in turn provides businesses with the capability to compete successfully for export opportunities.

[18] See also *Rationales for Government intervention in the commercialisation of new technologies* (2002) J-P Salmenkaita and A Salo, Technology Analysis and Strategic Management, 14, 183-200

[19] http://www.dest.gov.au/NR/rdonlyres/B1EF82EF-08D5-427E-B7E4-69D41C61D495/8625/finalPMSEICReport_WEBversion.pdf

[20] http://www.bacs.uq.edu.au/CurriculumReview/New_Concepts_130306.pdf

[21] http://www.dcita.gov.au/arts/film_digital/digital_content_industry_action_agenda

However, there are significant issues emerging relating to the future supply of ICT professionals. The ICT Skills Foresighting Working Group in its report *Building Australian ICT Skills* pointed to the need for targeted and decisive action to enhance Australia's ICT capability in order to maintain competitiveness and maximise the potential of ICT-generated productivity growth across all sectors of the economy. Australia must ensure that productivity gains are secured and built upon by increasing ICT labour force participation levels and building the ICT skills base.

The ICT Skills Foresighting Group identified a number of major inhibitors which threaten Australia's future ICT skills development, productivity gains and competitiveness. These include:

- Apparent declines in industry investment in workforce training and upskilling
- Changes in ICT which force professionals to continually address their skill requirements
- Outmoded and negative perceptions of ICT careers among young people and their influencers including parents and career advisers
- Falling entry level jobs for new ICT graduates and a marked decline in ICT enrolments in undergraduate ICT degrees.

The ICT Skills Foresighting Working Group noted that, while a vast amount of data is available on ICT skills issues, it does not appear to be adequately or effectively consolidated. Along with poor dissemination of the information that is available, this prevents labour market participants gaining a well informed understanding of the ICT skills market and future skills needs.

As with ICT, there is a large body of research which has identified issues and possible actions to improve school science and mathematics take-up and education. Many of the inhibitors to take-up in these disciplines are the same as with ICT: the need for awareness raising of science and mathematics as being worthwhile and rewarding careers; more effectively engaging students in the middle years of school to ensure they continue these subjects; and the need to encourage more senior secondary students to undertake the study of science and mathematics at tertiary level.

The ICT Skills Foresighting Working Group has identified the need for multi–jurisdictional cooperation and information sharing to address these issues.

Technology transfer

The perspective advanced in this submission suggests that far greater emphasis should be placed in the Government's innovation policies on technology transfer and that that emphasis should be reflected in Australia's investment attraction efforts. Clearly, the diffusion of ICT should be strongly encouraged throughout the economy along with the provision of leading edge infrastructure.

The ITOL (IT Online) program, administered by DCITA, encourages industry groups and small business to identify and adopt commercial uses of the Internet to support productivity and profitability. The program is a catalyst for industry groups to work collaboratively to solve common problems on an industry wide basis, rather than working individually and developing multiple solutions and in some cases unnecessarily duplicating efforts.

The program has shifted its priorities as the businesses have progressed toward participation in the information economy to meet changing gaps and weaknesses relating to ICT uptake. For example, the program initially supported projects to demonstrate the benefits to SMEs of having an online presence. It has also provided grants to groups of organisations (hospitals, insurers etc) to explore the possibilities of, and benefits in, a more coordinated approach to ICT. More detail on this program is provided in **Attachment D**.

This policy experience, along with the case studies detailed earlier, suggest that efficiency gains could be made by expanding the scale of such efforts. Additionally, the encouragement of other current general purpose technologies, like nanotechnology and materials science should also be a priority for government innovation policy.

Individuals and organisations tend to underinvest in the generation and assimilation of information that contributes to their ability to act with foresight.[22] Activities particularly relevant to rapidly developing technologies such as ICT include participation in international standards setting and undertaking technology foresighting to inform strategic innovation investment decisions. Businesses tend to be reluctant to engage in such activities because they are expensive and the benefits are hard to appropriate. Public sector organisations may have information about new advances but they are generally not the ones that will develop the commercial projects.

This is an area that has received relatively little policy attention in Australia yet these foresighting and standard setting activites are particularly important in rapidly changing fields. There are a few activities relevant to foresighting, for example the annual ICT Outlook Forum and the Technology Futures Conference[23]. Engagement in international standards setting is limited, with public sector organisations often not resourced to sustain the involvement. The Productivity Commission might consider investigating the merits of government investment in this area.

DECISION MAKING PRINCIPLES - MEASUREMENT AND FUNDING ALLOCATION ISSUES

Innovation is the result of a complex, dynamic system and consequently it cannot be modelled in a reductionist way. The lines of causality between science through to commercialisation and use are not direct. Systemic weaknesses can be broadly identified through high level economic analyses but only pinpointed and understood through case studies.

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[22] *Rationales for Government Intervention in the Commercialisation of New Technologies* J-P Salmenkaita and A Salo Technology Analysis and Strategic Management (2002) 14, 183-200

[23] Supported by the Australian Electrical and Electronic Manufacturers Association

Innovation performance cannot be immediately identified with particular inputs or with particular output measures. The extent of the impacts and successes of individual policy interventions will depend on many factors with gaps and impediments that may not be addressed by individual interventions. Similarly, individual interventions may have many outputs with indirect impacts and outputs and outcomes may be affected by other weaknesses in the innovation system and take considerable time to take effect.

Evaluations of individual policy measures need to be set in the wider context of the innovation system, backed with a sensitive analysis of tangible and intangible outcomes, taking into account timelines, and an associated assessment of contributing factors and conditions. Indeed, if one views the economic system as an emergent complex system, there at least has to be some doubt whether it is possible to model such interactions in a meaningful way.

In the context of emergent complex systems, policy decisions may also be seen as policy "experiments", to be modified in the light of the policy learning acquired. The key issue is what works or doesn't work rather than a narrow and "rigorous" enumeration of the economic outcomes. This perspective also suggests that in policy development more emphasis should be placed on the investigation of previous policy experiments, including in other countries.

ICT shares the measurement difficulties associated with other technologies. However, unlike other technologies, ICT is ubiquitous and often embedded in many processes, R&D and innovation projects and the goods and services produced by firms and research organisations. While Australia imports most of its ICT, it is also active in developing ICT and adapting imported ICT for Australian solutions. The data in **Attachment A** provides an indication of the spread of the ICT activity:

- ABS data shows that ICT professionals are employed across the economy.
- According to a survey by Sensis, about 16% of all small to medium enterprises (SMEs) produce some ICT and there are more of these producers outside the ICT sector than within it.
- DCITA's calculations from ABS data show that about 36% of total Australian business R&D is in ICT and about 33% of ICT R&D is undertaken by firms outside the ICT sector.

DCITA has used a mix of case studies, surveys and macro modelling to address the complexities of the interactions, indirect impacts, data shortcomings and the difficulty in distinguishing the impact of Australian-generated knowledge against the much larger backdrop of imported ICT.

This approach has demonstrated the wide scope and significant impacts of Australian ICT R&D and innovation. In view of the central importance of ICT for Australia's economic growth and social wellbeing, DCITA considers that it is important to continue to investigate the link between Australian ICT capability, the productivity outcomes and the impact of Australian technological innovation relating to ICT.

The case studies of Australian ICT R&D indicated that there were some business models emerging in public ICT R&D organisations which were responding to the pressure of commercialisation as well as the need to address public good issues. This trend may be of particular interest in view of their potential to result in the development of new technologies as well as productivity improvements in the user organisation and merits further analysis.

The robustness of Australia's ICT capability is a key issue for the innovation system. DCITA considers that particular attention may need to be paid to the outcomes in competitive grant processes for strategically important areas such as ICT to ensure that new research directions are seeded and that ICT capability, particularly new skills in important areas, can grow.

ATTACHMENT A

STATISTICAL OVERVIEW

The following section provides a statistical overview of key ICT and ICT-related aspects of the economy relevant to the impact of public support for science and innovation. DCITA can provide some additional and more detailed statistics. Some new ICT data (eg from the ABS) will also be published during 2006.

It should be noted however that statistical analysis relating to ICT *per se* is particularly difficult due to several factors, including:

- Rapid technological developments in ICT (including convergence and integration) continue to challenge definitions of ICT.
- ICT is embedded in many goods, services, innovation processes, training, occupations and R&D and this ICT-related activity is often only partly measured or not measured at all.
- Changing business models and convergence of digital and communications technologies and content are significantly blurring industry boundaries, occupations and R&D definitions.

Nevertheless the statistics point to some significant issues within the science and innovation system that government policies need to address.

1. ICT Market in Australia

The Australian uptake of ICT has been rapid:

- While in 1994 only 46.1% of Australian firms with 19 employees or fewer had a computer, by 2004-05 the figure had increased to 89%.[24]
- Businesses that use the internet have increased from 56% in 1999-2000 to 77% in 2004-05. Importantly businesses with a web presence have increased from 16% to 27% over the same timeframe.[25]
- 72% of households own or lease a computer[26] and the number of households with access to broadband connections is growing strongly, rising from 4% in 2002 to 31% in 2004[27].
- According to Frost and Sullivan, an estimated 10.3% of the value of GDP was spent on ICT in 2003.

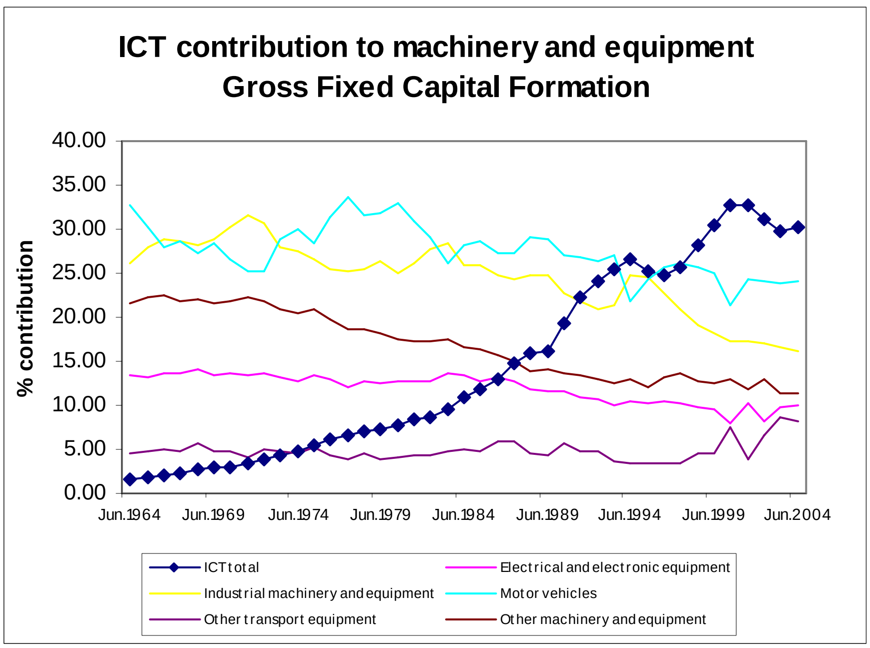
The ABS estimated the value of the Australian market for ICT goods and services to be $80.5 billion in 2002-03[28] while Frost and Sullivan placed it at $92.4 billion in 2003.

[24] ABS Cat. No. 8129.0 for 1993-94 and 2001-02.
[25] ABS Cat. No. 8129.0 for 2003-04.
[26] Nielsen//NetRatings
[27] eMarketeer
[28] ABS Cat 5259.0

From ABS data, it appears that an Australian market of $80.5 billion comprises about $65 billion of domestic products and services and $14 billion of imports.

Business and government invested $26.7 billion in ICT products and services – comprising $10.7 billion on computer hardware, $4.7 billion on telecommunications hardware and $11.3 billion on software. Emphasising the relative importance of ICT to productive capacity, ICT now makes the largest single contribution to machinery and equipment gross fixed capital formation (see Figure below)[29]. Households spent $16 billion on ICT products and services, mostly on phone carrier services ($10.8 billion), computer hardware ($1.8 billion) and telecommunications hardware ($1.2 billion).

Australia imports most of its ICT hardware requirements. In 2002-03, ICT hardware imports were valued at about $12 billion[30].



Australian capability in information and computer services is significant:

- Of business and government software expenditure, $3 billion was for in-house software development and $8.2 billion for packaged and customised products.
- The operating expenses of the computer services subsector included only $1.9 billion for packaged computer software.

This capability supports the implementation of business and government information systems as well as developing and providing specifically tailored solutions to meet Australian needs and servicing overseas markets.

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[29] DCITA analysis of ABS National Accounts data
[30] Estimates are subject to revision

2. ICT Production Capability

The traditionally defined ICT industry[31] represents Australia's core capability in ICT production. According to the ABS[32], the value of Australian production of ICT goods and services by ICT specialist firms is estimated to be approximately $58.8 billion comprising:

- manufacturing $1.8 billion
- wholesale trade $8.9 billion
- telecommunication services $32.6 billion
- computer services $15.5 billion

ICT value added production by specialist ICT firms is 4.6 per cent of total Australian GDP in 2002/03. However this estimate does not take into account the full contribution of ICT tools and enhancements across the economy through improved operational efficiency, product and service innovations, and new business models and markets.

According to the ABS, over 90% of ICT production occurs in the specialist ICT sector[33] though other reports suggest a more substantial production base outside the sector. The annual survey by Sensis (Business Index Special Report, *ICT Production in Australian SMEs* 2004-2006) has consistently found that there is considerable ICT production in firms from all industry sectors – for sale as ICT goods and services, for use within the business or for embedding in non-ICT goods and services. Such figures are however not directly comparable to ABS results because of differences in business unit definitions and industry coding.

Sensis estimates further suggest that the proportion of ICT producing SMEs has been rising across the economy – from 16% in 2004 to 21% in 2006. Of this ICT production, only 17% of the firms were in the ICT sector.[34] This reflects a shift of the ICT production capability into domains which it services, the integration of ICT in economic activity and the increasing reliance of all economic sectors on ICT-based goods and services.[35]

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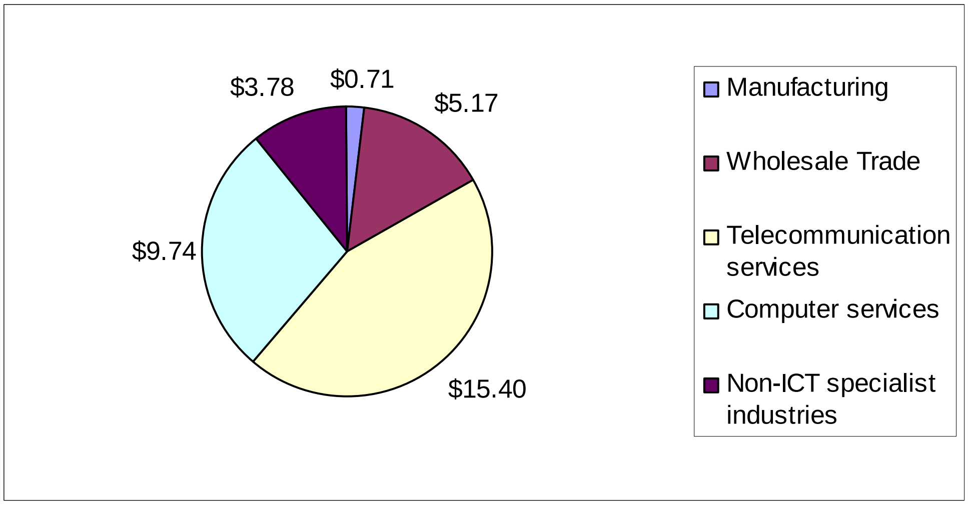
[31] ICT Industry = ANZSIC codes 2841, 2842, 2849, 2852, 4613, 4614, 4615, 7120, 7831, 7832, 7833 & 7834.
[32] ABS Cat 8126.0
[33] ABS Cat 5259.0
[34] *ICT Production in Australian SMEs*, 2006
[35] The development of major applications in user industries is a significant form of ICT production in its own right. These developments are blurring the distinction between ICT production and use, a distinction that is yet to be adequately reflected in standard statistical measures.

Gross Value Added of the ICT Sector 2002-03[36]



Nevertheless, the Australian specialist ICT industry (as measured through the ABS ICT industry survey) comprises about 24 000 specialist ICT firms which employ approximately 234 700 people. As shown in Table 3, most of the firms are micro-firms (0–4 employees) and the 188 largest firms (100 or more employees) account for 55 per cent of total employment in the industry.

Table 3: ICT firm size and employment (2002–03)

102. 103. **Firm size (number of employees)**	104. **Total number of ICT businesses (%)**	105. **Total ICT industry employment (%)**
106. 0–4	107. 79	108. 15
109. 5–99	110. 20	111. 30
112. 100 or more	113. 1	114. 55

Australia is developing strengths in computer services and software in niche high end applications and markets, reflecting the competitiveness of Australian skills and the demand from, and specific needs of, Australian users. McKinsey & Company identified two strands of major opportunities for Australian ICT producers:[37]

- providing specialised applications and services to global markets — for example, for the mining sector and computer games industry; and
- providing specialist skills and services for global multinational companies — for example, as regional hubs for high end research and development work.

A more detailed analysis of the Australian software specialist subsector examined the opportunities (mostly exporting) in the vertical markets: health, education, government,

36 *Australian ICT Production* ABS ICT Satellite Account 5259.2002-03
37 Australia: Winning in the Global ICT Industry, 2003

manufacturing, trade and commerce, minerals, energy and as suppliers to the ICT sector.[38]

The Australian ICT industry faces significant challenges under the influence of globalisation, the rise of China and India as significant ICT producers and the constant pressure of rapid technology development.

The Digital Content Industries Action Agenda (DCIAA) Report found that digital content is a high growth industry, growing faster worldwide than other economic sectors and its multipliers are higher than for many other categories of economic activity.

Accurate measurement of the industry is a complex matter although trends in the media and entertainment sector are the prevalent reference. The PriceWaterHouse Coopers Outlook[39] forecasts global growth for the media and entertainment sector at an average annual growth rate of 7.3 per cent, from $1.8 trillion in 2005 to more that $2.4 trillion by 2009. The DCIAA Report outlines strategies to lift activity above a forecast Australian growth rate of 3.8 per cent.

As the industry has emerged around the global adoption and rollout of new technology platforms, the health of the industry is closely linked to provision of a competitive infrastructure environment. The interdependence between content and infrastructure was initially recognised in the *Strategic Framework for the Information economy*[40] However Australia's digital content industry is also highly mobile and reliant on competitive skills, investment, research and intellectual property frameworks to grow. In this respect, the digital content industry provides additional insights to the opportunities and barriers faced by Australia's wider knowledge and service economy.

3. Communications Infrastructure

ICT is a network technology - its economic and social impact is dependent on how many people and firms are able to access and use the network. Appropriate investment in infrastructure and skills is important in maximising the economic and social benefits of ICT.

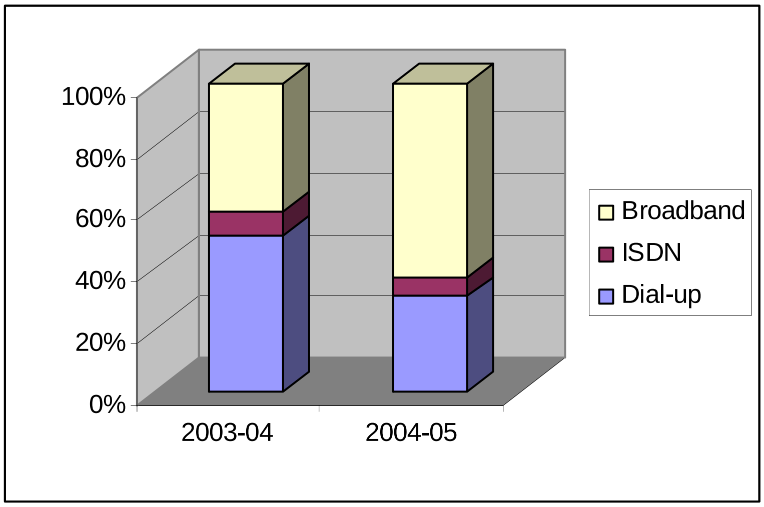
Developments and improvements in core ICT technologies such as processor speeds, miniaturisation and bandwidth are fuelling rapid changes in the capabilities of the communications platforms and the services they provide. For example, digitisation is blurring the boundaries between communications infrastructure and services such as television and telephony. Devices which attach to these platforms, such as 3G mobiles

[38] *The Australian Software Industry & Vertical Applications Markets: Globally Competitive, Domestically Undervalued*, CIIER
[39] PWC Global Media and Entertainment Outlook 2005-2009
http://www.pwcglobal.com/extweb/industry.nsf/docid/8CF0A9E084894A5A85256CE8006E19ED?opendocument&vendor=none#FE
[40] SFIE Strategy 1.3

and games platforms, are acquiring functionality which cuts across traditional industry distinctions.

Infrastructure technologies experiencing the highest growth are broadband networks and wireless systems, which form the communications backbone of business enterprises. Australian broadband connectivity is generally doubling every year[41]. However only nine% of Australian households have broadband connections at speeds that allow them to fully take advantage of current generation broadband features.[42]

Use of Broadband by Australian Businesses[43]



Past and current Australian Government programs such as the Higher Bandwidth Incentive Scheme (HiBIS), and Broadband Connect are designed to address broadband access and cost issues.

The education and research sector networks are serviced by Grangenet[44], CeNTIE[45] AREN and AARNet[46]. In particular, Grangenet and CeNTIE have provided the opportunity for research organisations and some businesses to explore the possibilities of developing and delivering new services based on very high broadband capacity. As well as infrastructure, broadband applications are key to improved broadband take up.

The National Broadband Strategy (NBS) was developed to coordinate activities across government and to provide a holistic approach to broadband development in Australia

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[41] **http://www.accc.gov.au/content/item.phtml?itemId=721272&nodeId=file43bb20329f183&fn=Snapshot%20of%20broadband%20deployment%20(30%20Sep%2005).pdf**

[42] http://www.ausstats.abs.gov.au/Ausstats/subscriber.nsf/0/E85DB7DE828A7B64CA25705A00762081/$File/81530_mar%202005.pdf (assuming 1.5mbps as a minimum for video conferencing, video on demand and a rich media broadband internet experience).

[43] Business Use of Information Technology, ABS 8129, June 2004

[44] Grid and Next Generation **Network** **http://www.grangenet.net/**

[45] **http://www.ict.csiro.au/page.php?cid=22**

[46] Australia's Academic and Research Network **http://www.aarnet.edu.au/**

with a view to achieving long-term strategic outcomes. One of its key objectives is to support the research community to participate effectively in collaborative national and international research activities. In addition, improving regional, rural and remote access to higher bandwidth services will ensure that rural industries, such as agriculture and mining, can participate in e-Research and benefit from the availability of research results online.

The Internet has proved scalable so far, but there are underlying infrastructure issues which continue to build up. With the current shift to IP-based networks, an inherently secure infrastructure – the Public Switched Telephone Network – will soon be replaced by an inherently insecure one. In addition to standards and engineering issues, there continue to be threats from spam and malware, cyberfraud and viruses which will require co-ordinated attention from business, government and civil society.

4. ICT R&D

Role of ICT in R&D

ICT is one of the most significant research fields for investment globally and consequently advances are rapid. ICT is also an increasingly important enabling infrastructure for most research and innovation.

For example, advances in computational techniques have radically altered R&D - computer modelling has increased R&D efficiencies and the biological sciences are undergoing a profound revolution, based largely on the use of genomics data and IT advances. Many viable research questions can be answered only through the use of new generations of powerful tools and ICT provides the foundation or support for their creation.

As ICT becomes more ubiquitous and a key part of innovation in many areas of the Australian economy, ICT R&D will increasingly cross traditional disciplinary boundaries.[47] Already some 50 per cent of the Australian Research Council's grants involving ICT are for cross disciplinary research projects involving non-ICT research from the humanities to medical sciences and the arts.[48]

Research teams and individuals with a mix of skills will increasingly be required to provide the knowledge of advanced ICT and other domains. More researchers, as individuals and in groups working in all research domains need to be connected to each other through email etc and also to a sophisticated array of facilities, instruments and databases through high capacity broadband links. This infrastructure also supports Australia's participation in R&D internationally, assists in leveraging our relatively small R&D effort and helps keep Australia part of leading edge technology development.

Science is increasingly addressing multifaceted problems in more complex systems. As a result, collaboration among disciplines is increasingly necessary and now requires, in some cases, hundreds of scientists working on a single project around the globe. Some

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[47] *Enabling our Future*, April 2003
[48] ARC, unpublished data

commercial laboratories and design centres are already exploring projects run on a 24 hour or 'follow-the-sun' basis.

A new and functionally different research infrastructure is evolving that delivers:

- greater computational power;
- increased access, distribution and shared-use; and
- new research tools.[49]

e-Research[50] involves a greatly enhanced capacity for large-scale, distributed, global collaboration in research, providing a new level of scope, scale and detail. It includes access to very large data collections, complex simulations, high performance visualisation, and virtual research organisations among geographically distributed researchers.

While relatively new as a structured concept, e-Research is starting to underpin all scientific disciplines including the social sciences and humanities. Because scientific and technological research underpins much innovation and our ability to absorb new technologies, this enhanced capacity for research has the potential to create a virtuous cycle of innovative activity. It is also emerging as a significant element in advancing the Information economy more broadly because of the strong symbiotic relationship between e-Research and the Information economy more generally. More detail is provided in Attachment G.

Statistical overview of ICT R&D performance in Australia

ICT is a significant part of Australia's R&D effort, accounting for $3 billion of the total $12.8 billion expenditure on R&D in 2003-04. About $2.6 billion was spent by business on ICT R&D[51], which was 36% of total business R&D expenditure. ICT R&D has been a major (and increasingly significant) component of total business investment in R&D for some time.

This proportion is comparable with international patterns of expenditure on ICT R&D in Europe (about 33% of total expenditure) but lower than the US where ICT R&D comprises almost half total R&D expenditure.[52] In contrast to other fields of research, expenditure by the Australian private sector significantly outweighs expenditure in the public sector and consequently the overall Australian research effort is weighted toward

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[49] National Science Board, *Science and Engineering Infrastructure for the 21st Century: the role of the National Science Foundation*, December 2002

[50] While the term is used interchangeably with "e-science", the use of "e-research" emphasises its broader application.

[51] For the purposes of this paper, ICT R&D is defined as the following research fields: 280000 (Information, Computing and Communications Sciences – 280100, 280200, 280300, 280400, 280500, 289900), 290900 (Electrical and Electronic Engineering), 291600 (Computer Hardware) and 291700 (Communications Technologies).

[52] *i2010 – Responding to the Challenge* UK Presidency of the EU 2005

experimental development. In 2002-03[53], business accounted for 85% of public and private expenditure on ICT R&D, the Australian Government 8% and the higher education sector 7%.

Business expenditure on ICT R&D

ABS data show that the expenditure on ICT R&D is almost evenly split between specialist ICT firms and businesses distributed across all other industries. Of the total ICT R&D expenditure in 2003-04 by businesses in Australia, ICT firms accounted for about $1.2 billion, about 46% of the total business expenditure.

Major ICT fields of business R&D expenditure in 2003-04 include computer software ($815m or 32%), communications technologies ($368m or 14%), electrical and electronic engineering ($289m or 11%), information systems ($707m or 27%) and computer hardware ($279million).[54] About 9% of all SMEs undertook software R&D[55].

Within the ICT industry in 2003-04:

- about 56% of expenditure on ICT R&D was undertaken by the computer consultancy service providers,
- the balance comprised 13% by telecommunication service providers, 9% by ICT wholesale traders, and 20% by ICT manufacturers.

In 2003-04, outside the ICT sector:

- Major ICT R&D fields were computer software, information systems and electrical and electronic engineering.
- The largest ICT R&D spenders included manufacturing, property and business services and finance and insurance sectors. However expenditure in the finance and insurance sector has declined since 2000-01.

It is well established that firms are more able to identify, access and use new technologies when they undertake R&D but according to economic theory, they will underinvest in it because of the risks and because they are unable to privatise all the benefits. Government support for business R&D reduces the risks for individual firms but given the role of ICT, the goods and services produced by these firms also have the potential to improve productivity in other industries and to provide benefits to the community.

ICT projects comprise a significant proportion of those receiving support from Australian Government innovation and R&D programs. For example, in 2004-05, the Industry R&D (IR&D) Board administered approximately $1.8 billion in programs and tax concessions for ICT projects out of $6.7 billion (total).

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[53] The ABS publishes data on business expenditure on R&D annually but every two years for the public sector. Data is collected on a calendar year basis from the universities. The most recent compilation for all the sectors is thus 2002-03 (approximately).

[54] DCITA calculations based on ABS data

[55] Sensis 2006 survey

There is some limited information available on the spread of these projects across the various industries.   Between 2000 and 2005 the IR&D Board contributed an estimated $22 million for 111 software related projects. These were in a wide variety of areas, from mining and engineering to textiles, mental health, sports administration, and a robotic device for turf marking.

Public Sector ICT R&D

Basic research and the pool of talent in science and technology have been identified by the US Competitiveness Council as two of the key contributors to a nation's innovation capability. Apart from its role in increasing the stock of fundamental knowledge, publicly funded research provides an increased capacity for scientific and technological problem-solving, the skilled graduates that are essential to firms seeking to adopt new technologies, instruments and methods for industrial research and some spin-out firms. Scientific institutions also play a role in the formation of the world's research and innovation networks which are increasingly crucial to technology diffusion and innovation.[56]

In 2002-03, the Australian Government accounted for 49% of expenditure on public ICT R&D, the higher education sector for 47% and State/Territory governments for the remaining 4%. In that year, expenditure on public ICT R&D was $426 million, about 7.1% of total expenditure on research in the public sector about the same proportion that it was in 1996-97 [57]. Closely allied disciplines to ICT accounted for 0.34% of total expenditure on public R&D in 2002-03. These allied disciplines include nanotechnology, robotics, mechatronics, CAD/CAM and control engineering.

Some limited international data available indicates that Australian R&D may have less focus on ICT R&D in the public sector than Japan, the USA, and the European Union where the proportion of public R&D funding for ICT was about 20% in 1999.[58] In the Australian public sector, the largest portion of R&D funding is on biological, agricultural and life science R&D, which is nearly nine times the level of public research expenditure on ICT.[59]

While ICT is often regarded as being close to the commercial interface, a significant proportion of the ICT R&D performed in Australia could be considered as having strong

[56] *Driving the New Economy* Report to PMSEIC 2000
[57] Calculated from ABS, Research and Experimental Development, Higher Education Organisations, Australia CAT 8111.0, & ABS, Research and Experimental Development, Government and Private Non-Profit Organisations, Australia , CAT 8109.0, Survey of Research and Experimental Development - General Government and Survey of Research and Development - Private Non Profit Sector and ABS data which was made available on request. In addition to the information and communications sciences, communications technologies, electrical and electronic engineering and computer hardware are included in ICT R&D expenditure calculations.
[58] *R&D Spending on ICT- Overall Evolution in the Major Industrial Countries and Close-up on Major Telecoms Operators' New Organisation* D Pouillot, A Puissochet Communications and Strategies, No. 48, 4th Quarter, 2002 (http://www.idate.fr/an/publi/revu/num/dern/pouillot.pdf)
[59] *Driving the New Economy op. cit*.

“social good” characteristics. This is illustrated in DCITA’s case studies of DSTO, BMRC, CIEAM for example.

The institutional backbone of public ICT R&D comprises National ICT Australia (NICTA), the Defence Science and Technology Organisation (DSTO) and CSIRO (in particular its ICT Centre) which jointly account for almost 70% of all public ICT R&D. There are, in addition, five Cooperative Research Centres, the Bureau of Meteorological Research Centre (BMRC - about $14 million) and several smaller centres.

Both DSTO and the BMRC have mission-oriented research. DSTO is the largest concentration of Australian ICT R&D (about $160 million in 2005-06), with R&D in several ICT-related areas, notably intelligence, surveillance, electronic warfare and communications.

DSTO’s mission is the expert, impartial and innovative application of science and technology to the defence of Australia. The organisation has one key customer, the Australian Defence Organisation (ADO). It spends 90% of its budget on projects defined and agreed with the ADO and the remaining 10% of the budget is spent on long range enabling research projects not defined by the ADO, in areas such as robotics, quantum computing and photonics.

Many of DSTO’s projects focus on working with international partners to apply technologies developed overseas. The ADO also requires solutions that are not available on the international defence market. In these circumstances the DSTO develops new technologies, using a combination of in-house expertise and collaboration with the Australian public research and private sector. In these instances the DSTO sometimes generates innovative intellectual property with commercial value in the international defence market and in other sectors.

CSIRO has established an ICT R&D Centre that provides a whole-of-CSIRO focal point for the organisation’s research. The Centre focuses on a few high impact areas of ICT research and facilitates the integration of CSIRO’s core ICT research with the research being undertaken in application domains.

NICTA was established in 2002 as a key measure to address the gap in long-term public sector ICT R&D identified in a report to the Prime Minister’s Science, Engineering and Innovation Council, *Driving the New Economy.* Although NICTA has only just reached full size, it is starting to play a key role in Australia’s ICT innovation infrastructure, building commercialization capabilities within itself and more broadly as well as encouraging more linkages and coordination among researchers and developing major research projects and new training for students. NICTA is described more fully in Attachment D.

Most of the remaining sources of funding sources are through external competitive grants and the outcomes of the process can fluctuate. For example, five of the ten ICT CRCs closed in June 2006 following their lack of success in the 2004 funding round. This could potentially reduce the amount of ICT R&D undertaken in the public sector significantly if the former CRC partners also reduce their support for ICT R&D[60]. Such outcomes dissipate the policy intention in establishing NICTA ie to significantly increase the level of public sector expenditure in this strategically vital and under-supported technology. It points to the difficulty in incorporating strategically important goals into competitive funding rounds that tend to reinforce existing research trajectories.

The relationship with the private sector is also important in determining the amount of ICT R&D performed in the public sector. For example, post the 2001 "Techwreck" a number of multinational ICT firms closed or scaled back their research laboratories in Australia, most notably Nortel Networks, Ericsson, and Motorola. This significantly reduced the amount of private sector research in communications,[61] and because these companies also supported and worked with public sector researchers, there is a flow on reduction in public communications research as well.

Following *Backing Australia's Ability*, new priorities have been introduced to public research that will, among other things, direct more public research funding to ICT. The first step in this process was the targeting of the ARC's 2003 round of grants, with 33 per cent of funding provided to priority areas and targeting was subsequently introduced more generally for public research in science. These latter priorities are:

- An Environmentally Sustainable Australia
- Promoting and Maintaining Good Health
- Frontier Technologies for Building and Transforming Australian Industries
- Safeguarding Australia.

The Frontier Technologies and Safeguarding Australia priorities have significant ICT elements - Frontier Technologies will support research in areas such as ICT, bio-and geo-informatics, nanotechnology and biotechnology while the Safeguarding Australia priority encompasses a range of research activities to counter threats from terrorism, crime, invasive diseases and pests and threats to critical infrastructure. All of the priorities however, are critically dependent on Australia having leading edge skills and infrastructure capabilities in ICT.

However, it should be noted that the research priorities are couched in very broad terms and may not achieve the degree of alignment desired between our industrial aspirations and the research effort. This would appear to be an area where the Productivity Commission study could make a useful contribution to policy development.

While it is not clear how the Research Quality Framework will impact on the ICT research capabilities, at least two policy levers have the potential to enhance the ICT research infrastructure and research capability:

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[60] Annual funding for the ICT CRCs will be at least $14m lower due to the cessation of the CRC program support for five CRCs. The total commitments of their partners were on average, about $64 million annually.

[61] Business ICT R&D declined from $2.7 to $2.6 billion over 2001-02 – 2002-03, and stabilised at $2.6 billion in 2003-04. The decline in 2002-03 was mostly caused by a drop in communications research expenditure, which continued to decline in 2003-04.

- The National Collaborative Research Infrastructure Strategy (NCRIS) roadmap that provides a strategic direction for investments in major research infrastructure. It proposes several ICT and ICT-related research infrastructures.

- e-Research. In April 2005, the e-Research Coordinating Committee was established jointly by the Minister for Communications, Information Technology and the Arts and the Minister for Education, Science and Training to provide expert advice to the Government about developing Australia's e-Research capacity. The Committee has now submitted its Final Report: *An Australian e-Research Strategy and Implementation Framework*, to the Government following extensive consultations in conjunction with the NCRIS Committee.

Various output measures are available in relation to the performance of public ICT R&D. Some indicate a quality performance overall, though not a particularly high publication rate[62]. For example, Australia accounted for 2.38% of the world's academic publications in computer science over the period 2000-2004 (compared with an Australian average of 2.89% for all sciences). The index of relative citation rate ranks computer science above the world average for that field (1.10 times the world average), indicating that Australian computer science papers were highly regarded.

Indicators relating to commercialisation such as patents, licenses and licensing revenues and spin-offs and their survival rate are particularly difficult to interpret. For example they do not capture some other important transfer activities such as the advisory services the public research organisations provide to business and it is difficult to assess the success or otherwise of institutional policies relating to spin-outs during business downturns. It also needs to be kept in mind that it can be difficult to evaluate the success of individual programs and policies in view of the complex process of innovation and the many actors involved in commercialisation.

Such indicators may be useful for identifying trends and the net result of significant changes in behaviour by the research organisations, individual firms and the various other organisations involved in the commercialisation process but they need to be complemented by additional work. For example, NICTA, DSTO, the CSIRO ICT Centre and ICT CRCs established a roundtable with a view to encouraging research collaboration. They found they needed to address a variety of institutional issues including differing priorities and timelines and IP ownership.

[62] For example, *Australian Science and Technology Indicators at a Glance* DEST 2006

ICT Skills

ICT skills are found across the economy, reflecting the general spread of ICT use and some development and production in all industry sectors. In February 2006, Australia had 356 600 ICT workers. While it is difficult to draw clear boundaries around the question of 'what are ICT occupations', DCITA estimates suggest that ICT represents about 3.6 per cent of the total workforce. This is a higher proportion than for Europe (about 2.5 per cent) and the United States (about 2.8 per cent).

The estimate is likely to be an under-representation of ICT occupations as some ICT occupations and specialisations are not explicitly recognised in the current occupation classifications.[63] In general the available data does not adequately reflect the ongoing development and uptake of ICT applications has brought growth in non-ICT occupations which are increasingly dependent on high level ICT skills.

Many features of the market for ICT skills are described in the report of the ICT Skills Foresighting Working Group, *Building Australian ICT Skills.* The following is a synopsis of key findings.

Employment

Indicators point to a continuing pick-up in the ICT labour market in Australia, although prospects vary for skill sets. Employment levels are projected to rise, albeit not as strongly as in the past decade, particularly at the peak of the "dot.com" boom, with the prospects for ICT more closely linked to Australia's overall economic and employment growth prospects.

However the dynamics of the market for ICT skills can result in many mismatches between the supply and demand for ICT skills. For example, demand for employees with skills in new technologies can outpace the supply if enterprises and governments suddenly adopt new technologies and their applications. Equally, businesses using older ICT technologies can sometime find the recruitment of practitioners difficult because the needed skill sets are becoming rare.

Furthermore, demand for ICT skills changes as ICT tools and enhancements change business models and firms grow and move up the value-chain. Many industries and areas of research are becoming increasingly dependent on the advances in ICT to support their leading edge research and applications.

Qualifications in the ICT workforce

According to data provided by members of the Information Technology Contract and Recruitment Association (ITCRA):

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[63] The new Australian and New Zealand Standard Classification of Occupations (ANZSCO) will significantly upgrade the quality and usefulness of data collected on ICT occupations. ANZSCO will also provide an 'alternative view' of ICT occupations that will reflect a more inclusive view of the ICT industry. The ANZSCO classification will be implemented in the August 2006 Census, and in the Labour Force Survey from August 2006. More information on the ICT nomenclature in ANZSCO is available in the Information Paper on the ABS website (*www.abs.gov.au*) — ABS Cat No. 1221.0.

- 9 per cent of IT professionals have no ICT qualifications;
- 13 per cent have TAFE qualifications;
- 13 per cent have an industry or vendor certificate; and
- 52 per cent have an ICT related degree.

There is also evidence of people from non-ICT backgrounds moving into ICT occupations. Although migration from non-ICT backgrounds is significant, university training remains the key source of new ICT professionals. TAFEs and private training organisations are also significant providers of specific professional ICT courses, but the relevant data tends to be fragmentary.

<u>ICT skills supply from Higher Education</u>

Only four universities now have IT Faculties (Monash, UTS, QUT and Wollongong). Of the remaining 39 universities ICT is often located in a department or school within the Faculty of Engineering or Business. In addition, many universities are making provision for more complex arrangements in cross-disciplinary degrees, such as combining ICT units with studies in commerce, languages and health sciences.

There has been more than a doubling in the number of ICT graduates, spurred in large measure by rises in the number of overseas students (by about one thousand% between 1994 and 2003). It is not clear how much these students will eventually contribute to Australia's ICT capability.

Of concern for the future, it is clear that enrolments of domestic students in ICT undergraduate degrees are declining sharply. They have declined by 31% between 2002 and 2004 and there are strong indications that this downward trend will continue.

According to the report of the ICT Skills Foresighting Working Group, *Building Australian ICT Skills*, the rapid rate of technological change creates challenges for universities to keep pace with the skills needed to build and maintain new technologies. Traditionally, the cycle for the introduction of new curricula takes five to eight years. This is severely misaligned with changing technology cycles which can be counted in months rather than years.

The capacity of most universities to respond to short-term specialisations is currently severely limited, given competition for funding with other disciplines and the constraints of the availability of teaching staff, resource allocations driven by (declining) undergraduate enrolments and increased reporting requirements.

The vocational education and training (VET) sector also plays a primary role in the provision of training for ICT workers. There has been a substantial fall in student numbers of 33 per cent between 2002 and 2004. This is set against the smaller overall fall in VET students of 5.5 per cent.

ATTACHMENT B

THE AUSTRALIAN GOVERNMENT'S POLICY FRAMEWORK

1. *The Strategic Framework for the information economy*

Following from Australia's Strategic framework for the information economy which was first articulated in 1998, the Strategic framework for the information economy 2004-2006 provides the policy platform to address new and ongoing challenges. This Framework identifies four priorities (with 16 supporting strategies) for a whole-of-government agend to:

1. Ensure that all Australians have the capabilities networks and tools to participate in the information economy.

2. Ensure the security and interoperability of Australia 's information infrastructure and support confidence in digital services.

3. Develop Australia 's innovation system as a platform for productivity growth and industry transformation.

4. Raise Australian public sector productivity, collaboration and accessibility through the effective use of information, knowledge and ICT.

The priority of developing Australia's innovation system, has four supporting strategies which involve building an ICT innovation culture that focuses on education, skills formation and ICT literacy, creating capabilities and coordination mechanisms to integrate ICT in national research activities, as well as connecting to the global research effort and developing ICT industry capability.

2. *Development of ICT capability*

The Government's strategy for the ICT industry builds on the 1997 *Investing for Growth* strategy which targets the environment for ICT industry growth, emphasising the importance of strong leadership, attending to fiscal and competition settings, getting Australia online, and addressing market failures through general programs (eg the Innovation Investment Fund and Commercial Ready programs administered by DITR and skills and education programs administered by DEST).

Operating within and building on this context, the 2003 Framework for the Future report, "Enabling our Future", was developed to provide a guide for the key elements which are necessary to support the longer term development of the ICT industry and national ICT capability [64].

[64] http://www.dcita.gov.au/__data/assets/word_doc/10229/Enabling_our_Future.doc

The Framework recommended maintaining, and in some cases strengthening, policy settings to provide a long-term consistency of approach to developing Australia ICT capability, improved coordination of ICT-related initiatives and better integration of ICT into the national research infrastructure. The Framework emphasized the need for sustained Government and industry leadership to build the profile of ICT in Australia by emphasizing its role in achieving national objectives such as productivity and economic growth. Building innovative firms was a key focus as well as skills development, and attracting and retaining foreign investment. The report also highlighted the need for priority attention to communications infrastructure and associated standards development to overcome impediments to both research and commercial use of advanced networks.

A summary of the recommendations of the report is at the end of this Attachment.

3. *Backing Australia's Ability*

ICT is a significant priority for the Australian Government's innovation action plans, *Backing Australia's Ability* (BAA) and *Backing Australia's Ability – Building our Future through Science and Innovation.* Several initiatives specifically focused on bolstering Australia's strategic capability in ICT (which was found to be low in the 2003 mapping exercise, and providing further confirmation of earlier reports, including to the Prime Minister's Science Engineering and Innovation Council[65]). The measures include:

- $380 million (to 2010-11) for the establishment of an ICT Centre of Excellence
- $21 million (to 2006-07) to extend the Advanced Networks Program
- $36 million (to 2007-08) to extend the Incubators Program.

In addition, $13m was provided to extend the IT Online Program (ITOL) in the first BAA package.

ICT firms benefit from many of the other innovation measures in the packages with a broader remit, such as the COMET (Commercial Emerging Technologies) and Commercial Ready Programs.

4. *Key Objectives of DCITA's Innovation Programs and other initiatives*

National ICT Centre of Excellence (National ICT Australia Ltd) – to build critical mass in Australia's ICT research effort through the creation of a world-class, world-scale ICT research organisation. (Joint with the Australian Research Council)

Advanced Networks Program creates advanced network testbeds for developing the next generation of applications, products and services for the ICT industry and others sectors, such as health and education.

[65] *Driving the New Economy*

ICT Incubators provide incubation services such as seed capital, business advice and assistance with raising follow-on capital to start-up ICT companies.

Digital Content Strategy – DCITA is supporting the development of a comprehensive digital content strategy taking account of the findings of the Digital Content Industry Action Agenda and wider social, economic and cultural policy issues associated with digital content. Some of the wider themes are outlined in the PMSEIC Report on *The Role of Creativity in the Innovation Economy*.

Research, analysis and benchmarking – in particular in relation to the Information economy, the relationship between ICT and productivity growth and innovation and the availability of private equity for innovative companies.

E-Research - DCITA is also supporting the development of an e-research strategy, in collaboration with DEST.

Porfolio agency programs and activities

Synapse Art & Science program (Australia Council) builds innovative links between arts and science by providing funding for artist residencies in scientific research institutions.

Maker to Manufacturer program (Australia Council) supports development of commercial practice models for the contemporary arts sector, particularly craft and design.

Regional Digital Screen Network (Australian Film Commission) facilitates mass distribution of content, expanded interactive and live educational, cultural and business services including access to a wide range of performances, events and activities.

Broadband Production Initiative (Australian Film Commission) supports the production of innovative, high technology, broadband content and interactive applications focusing on high quality content to deliver Australian cultural experiences into a global environment.

The Australian Institute of Sport (AIS) is developing technology to assist Australian elite athletes for competition (in collaboration with the CRC for Microtechnology). The **AIS Anti-doping research program** provides support for the development of new tests for drugs and doping methods used to enhance performance.

The **Australian Business Arts Foundation** (AbaF), through its role in bringing the business and cultural sectors together and in collaboration with its associates in business, government and the arts, could be well placed to assist with the process of capability to commercialisation.

The **National Library of Australia** is working with the research sector on the development of new models for scholarly publishing and dissemination of research output in the digital world.

FRAMEWORK FOR THE FUTURE REPORT - RECOMMENDATIONS

LEADERSHIP

Recommendation
115. Commonwealth, State and Territory governments should work together to articulate ICT goals, and develop and urgently implement strategies to harness ICT to achieve broad national objectives in areas such as health, education and security, and improve coordination of programs. • A meeting of the Online Council (OC) should be convened by the Commonwealth within the next three months to discuss the outcomes and recommendations of this Report, and take the Report's agenda forward, including addressing issues of coordination of ICT strategies and priorities between jurisdictions.
116. A forum of industry leaders should take place within the next three months to: • discuss practical ways in which industry can take forward the recommendations in this report and the Framework agenda; and • develop a plan setting out actions to be undertaken by industry in the Framework's implementation. Industry associations should convene the forum.
117. Governments and leaders in industry, education and the research community should: • recognise the critical enabling role of ICT in improving productivity, driving business efficiencies and supporting innovation, and the importance of a strategic information capability to achieving broad national economic and social goals; • explicitly reflect this role in the development of their organisational strategies and policies, and the implementation of programs to achieve those strategies; and • work together to ensure that Australia's business environment is conducive to fostering ICT innovation, including regularly reviewing and benchmarking innovation strategies against international best practice, and focusing on longer-term initiatives that are given time to make a difference.
118. A meeting should take place in early 2004 between representatives of government, industry, the research community and the education sector, to: • review progress in implementing this Report's recommendations; and • take stock of developments in the ICT sector. It should be convened and coordinated by DCITA and NOIE.

RESEARCH AND DEVELOPMENT

Recommendation
119. The amount and effectiveness of public sector support for ICT R&D should be increased. Governments, research funding bodies such as the ARC, and research performing bodies such as CSIRO, DSTO and universities should: • give ICT a prominent focus in research supported under priorities already identified; • coordinate processes for priority setting and the allocation of resources to ICT R&D, to minimise overlap and ensure consistency of areas identified; and

- build scale and critical mass in excellent research, focused on:
    - o areas where Australia has world-class ICT research strengths, or the clear potential to develop them;
    - o areas where there are existing commercial strengths in Australia, or clear potential to create such strengths; and
    - o areas of national interest such as solving problems of importance to Australia.

120.Cross and multidisciplinary research should be encouraged and funded, including in areas where ICT intersects with other technologies.

- Universities, public sector research organisations, and research funding bodies such as the ARC and the National Health and Medical Research Council (NHMRC) should take steps to facilitate such research including changing funding structures and guidelines if necessary.

7. NICTA, CSIRO and DSTO should provide national research leadership by developing themselves as hubs of ICT research activity, with close links to other ICT research teams, and strong links to industry.
    - These three organisations should coordinate the establishment of a regular round-table of major publicly-funded ICT research groups, including the ICT-related CRCs and appropriate larger groups in universities, to:
        - o develop an implementation plan setting out actions to respond to recommendations in this Report in a coordinated fashion;
        - o share information on ICT R&D, including international developments, and build relationships;
        - o explore ways of more effectively commercialising R&D and linking with industry;
        - o coordinate research efforts and priority setting activities; and
        - o assist in efforts to build and coordinate ICT R&D infrastructure.

    An annual report on round-table activities should be provided to the Minister for CITA.

8. Commercialisation of ICT research should be a major focus of all publicly funded research organisations, and research funding bodies, in their strategic research planning, and commercial goals should be built into all stages of their ICT research activities. Businesses and industry associations should take action to communicate their R&D needs effectively to public sector research organisations, and engage and partner with those organisations in the development of their commercialisation strategies and the conduct of their ICT R&D.

9. Industry and research organisations such as CSIRO, NICTA, DSTO, CRCs and universities should work together to more fully integrate and embed private sector R&D facilities and centres into the Australian ICT R&D community.

10. The Commonwealth Government should take the lead in exploring options to support joint R&D activities with businesses, as a way of developing the cutting-edge ICT products and services that agencies need to improve agency performance.

INFRASTRUCTURE – CONNECTIVITY

Recommendation
11. The Broadband Advisory Group recommendations—including the role for the Commonwealth Government in developing a National Broadband Strategy, supporting and coordinating e-health and e-education initiatives, and encouraging SMEs to take up broadband services—are broadly supported. The Government should give close consideration to the recommendations of the Regional Telecommunications Inquiry including those relating to access to high-speed data services in regional Australia.

12. Ongoing priority must be given to the continued and coordinated upgrading and spread of advanced research networks, by governments, public research institutions and universities, as a key infrastructure underpinning the development of next generation broadband activities. • The role of the Commonwealth in driving the development of e-science should be examined by the NOIE & DCITA. • The proposed National Broadband Strategy Implementation Group should consider developing a coordinated national framework for research broadband networks as part of the National Broadband Strategy.
13. Research and development needs and priorities related to the security of Australia's information infrastructure should be identified, and action taken to better coordinate and harness Australia's existing R&D effort related to that security. The Department of Communications, Information Technology and the Arts and the National Office for the Information Economy should work with the Department of Defence (including DSTO) and other relevant Commonwealth agencies on this issue.

INFRASTRUCTURE – STANDARDS

Recommendation
14. Industry-based forums should be established by industry and industry associations to progress practical issues needed to implement an environment of trust for online business and transactions.
15. A framework to guide Australia's involvement in international ICT standards setting should be developed and implemented by NOIE, DCITA and Standards Australia, in consultation with industry. • These organisations should also establish a strategic group with membership drawn from industry, researchers and government to determine which areas of ICT R&D have the potential to yield products for markets where international standards are still fluid, and determine the most appropriate means of shaping standards in those areas.

INFRASTRUCTURE – INTELLECTUAL PROPERTY

Recommendation
16. The Commonwealth Government's review of its Digital Agenda legislation should examine the balance of rights between creators and users in a digital environment, in the context of Australia's future as an information economy, and focus on ensuring that Australia's copyright regime does not hinder innovation and investment. • ICT business leaders and industry associations should ensure that the perspectives of the ICT industry are considered during that review.
17. In relation to government ownership and use of intellectual property (IP): • the Commonwealth should adopt and promulgate management practices for its IP which encourage and maximise industry development, consistent with the management of government IP as a public asset, and should regularly audit their IP to review opportunities for its commercial development; • DCITA, and AG's should ensure that the Commonwealth's information technology IP guidelines are up to date, encourage their widespread adoption and use, and disseminate best practice examples of IP management; • the Auditor-General should conduct an audit of practices adopted by Commonwealth agencies for the management of IP, and report on the extent to which the guidelines are being followed, and whether IP resources are being used efficiently and effectively to achieve government objectives including industry development; and • the Commonwealth should work with State and Territory governments to achieve uniform policies in the use of Crown IP.

Recommendation 16(c) of the Broadband Advisory Group, that the Commonwealth should ensure that its IP policies do not act as a barrier to the development of digital content industries, is supported.
18. Industry associations should continue to work with their members, particularly SMEs, to inform and educate them about IP rights and the processes required to protect them, and to provide appropriate assistance services.

SKILLS

Recommendation
19. University and other ICT course providers should: • develop courses and curricula to ensure that students studying in areas other than ICT develop the broader conceptual and practical skills to be ICT-fluent in their own profession; • link ICT and other science and engineering courses at both undergraduate and postgraduate level, so that ICT students are exposed to issues in other disciplines; and • give greater emphasis to the development of business, project management and entrepreneurial skills in ICT students and staff.
20. Tertiary education institutions, individual businesses, and industry associations should work together to: • develop and design more flexible, responsive and targeted courses in ICT to provide for specific industry needs; and • more closely involve industry in education programs, for example through sponsorship, direct involvement in teaching, support for staff exchanges and secondments between industry and education institutions, and the provision of work experience for students.
21. Universities should fully examine the significant structural issues relating to ICT teaching, including the substantial growth in the student-staff ratios and the difficulties in attracting and securing teaching staff in a competitive market, and take action to redress them.

PROMOTING *"TECHNOLOGY AUSTRALIA"*

Recommendation
22. The Commonwealth Government should provide additional investment support, targeted at ICT investments of strategic significance to Australia. There should be a particular focus on projects which would increase Australia's innovation capacity and build strong links into our R&D infrastructure.
23. Australian governments should work with each other and with peak industry bodies to: • adopt well-coordinated, aggressive investment attraction and embedding strategies, which focus on maximising the linkages of MNCs into the Australian economy, to obtain the greatest possible flow through into Australian firms in terms of skills, knowledge and access to global linkages and networks; and • undertake coordinated and sustained efforts to promote Australia's ICT strengths internationally.
24. Local branches of MNCs should expand and develop their role in investment attraction and retention including through: • close involvement with governments in the development and implementation of appropriate strategies; • providing leadership by pursuing those strategies through their overseas linkages; and • ensuring ongoing information flows to head offices.
25. Research organisations and individual researchers should make concerted and coordinated efforts

to develop and promote Australia's international profile as a nation with a growing, leading-edge ICT R&D capability. • Such promotion should be a key objective of NICTA, CSIRO, DSTO, the universities and other ICT research organisations, who should report annually on their activities in this area.
26. Better ways of accounting for the total national ICT capability (including ICT capabilities in other industries outside the traditional ICT industry) should be developed and implemented by governments, industry and the research community. • Benchmark data should be identified which demonstrate Australia's strengths and level of competitiveness in ICT, including ICT R&D.

BUILDING INNOVATIVE SMES

Recommendation
27. The Commonwealth Government should keep under review measures to encourage the provision of early stage capital, including recent changes to taxation laws, and the need for any further adjustments to these laws or to programs.
28. Proposals to improve the preparedness of SMEs to undertake their initial market entry should be identified and implemented by governments and industry, to: • facilitate access for SMEs to particular markets within Australia and overseas; and • expand overseas network support for SMEs.
29. Governments should continue to work with industry to make it easier for SMEs to sell to governments and big business by examining issues such as: • access by SMEs to information about opportunities to tender for business; • the structure and complexity of contract documents and other requirements of doing business, the associated costs of providing tenders, and the time taken to evaluate them; • approaches to risk management, and insurance and indemnity requirements; • the extended use of e-purchasing arrangements in order to improve access by SMEs to business opportunities; • consistency of approaches between jurisdictions; and • the use of government purchasing to create reference sites for SME products and services.

NETWORKS AND CLUSTERS

Recommendation
30. State and Territory governments should take the lead in bringing together major focal points of R&D activity and the innovation infrastructure (such as CSIRO, DSTO, NICTA, CRCs, the BITS incubators, and the GrangeNet, CeNTIE and mNet test networks) with potential industry partners, to drive cluster development. • These activities should be coordinated through the Online Council, to ensure that activities are linked and networked across jurisdictional boundaries.

THE INFORMATION BASE FOR THE ICT INDUSTRY

Recommendation
31. Commonwealth, State and Territory governments, working with industry associations, should: • develop comprehensive collections of data about the ICT industry which fully recognise its breadth and pervasive nature and move beyond traditional classification categories; • explore ways of improving the timeliness of ICT statistical collections; and • undertake further work to more comprehensively understand and measure the productivity benefits of ICT across the economy, and its contribution to exports in other sectors. Government involvement in this work should be coordinated through the Online Council.

ATTACHMENT C

KEY AUSTRALIAN GOVERNMENT INDUSTRY DEVELOPMENT MEASURES RELEVANT TO THE ICT INDUSTRY

Key measures include:

a. *Leadership* - The Minister established an ICT Advisory Board to provide ongoing advice on a broad range of strategic issues. An Australian/State/Territory ICT Working Group of the Online and Communications Council is progressing initiatives to build Australia's ICT capability, including trade and investment promotion, skills, ICT statistics and digital inclusion.

b. *Skills* - the Government is supporting the development of skills in ICT through a range of activities, including a 10-year commitment to support additional HECS places in ICT, maths and science; a report from a joint government/industry/education ICT Skills Foresighting Working Group on how to improve the supply of ICT professionals to meet the future skills needs of industry and a partICipaTion summit to identify and propose ways to address barriers to women, as well as men and young people, participating in the ICT sector.

c. *Trade* - The Government has entered free trade agreements with the USA, with emerging ICT centres such as Singapore and Thailand and is in the process of negotiating FTAs with China, Malaysia, the ASEAN economies and New Zealand and the United Arab Emirates. The government is providing $25m to help Australian exporters benefit from the free trade agreements.

d. *Infrastructure and R&D* - funding programs to promote innovation under the $5.3 billion science and innovation strategy *Backing Australia's Ability* to 2010-11 (building on the previous $3 billion strategy) include extension of the ICT Centre of Excellence, NICTA, ($251m to 2010-11) and the Advanced Networks Program ($21m to 2006-07) and $542m (to 2010-11) for a National Collaborative Research Infrastructure Strategy (through the Education portfolio).

e. *SME support* - the ICT Incubators program (which was provided an additional $36m to 2007-08 in BAA2) helps ICT start-up firms. The Information Technology Online program supports innovative collaborative e-business projects. AusIndustry innovation programs provide support at various stages in the innovation process, including R&D, venture capital investment, business advice and technology transfer. Programs include the Commercial Ready (BAA2 provided $1 billion to 2010-11), Innovation Investment Fund, COMET (Commercialising Emerging Technologies) and Innovation Access Programs.

f. *ICT procurement* – while value for money is the core principle for government procurement, SME participation is supported through requiring agencies to give appropriate consideration of SMEs, by setting SME participation levels in contracts over $20m, and through provision of guides and advice.

g. Other strategies which support current ICT initiatives include the Electronics Industry Action Agenda (September 2003 and currently being reviewed), the March 2006 Digital Content Industry Action Agenda and the July 2004 *Strategic Framework for the Information Economy*.

ATTACHMENT D

PORTFOLIO PROGRAMS AND OTHER INITIATIVES

The following section discusses CITA programs, their objectives and some of the outcomes from the Government intervention that have been identified.

1. NICTA

The ICT Centre of Excellence was established in October 2002 with the signing of a Funding Deed between the Australian Government and NICTA following a competitive selection process for the Centre's operator. National ICT Australia Limited (NICTA) is an independent, not-for-profit company with its four founding partners – the University of NSW, the Australian National University (ANU) and ACT and NSW governments.

The Government's objective for NICTA is that it will be a world-class, world-scale ICT research and research training institute that takes Australia's ability to create and exploit information and communications technology to a new level. Four core objectives have been set in the Australian Government's Funding Agreement with NICTA, namely:

- develop within Australia ICT research capabilities in existing and emerging fields;
- increase the availability within Australia of ICT research skills by providing postgraduate training and attracting ICT researchers from overseas;
- exploit for the benefit of Australia the commercialisation of research outputs; and
- become a catalyst for the development of ICT industry networks and clusters.

Resource Support for Program
The Australian Government has allocated $380.5m over ten years to 30 June 2011 ($129.5m over the first 5 years to 30 June 2006 and $251m over the next five years). $6.3 million of the total funds has been allocated for the Australian Government's administration costs of the ICT Centre of Excellence program. Annual Australian Government contributions to NICTA are now around $48 million.

Australian Government administered funding is provided through DCITA and the ARC in equal shares, who jointly administer the Funding Agreement. ARC funds are subject to the provisions of the ARC Act and must be applied to research.

The four founding members of NICTA have committed around $80 million cash and in-kind to the Centre over five years to end 2006. The precise level and nature of these contributions are nominated in the Partner Agreements between NICTA and each of the four members.

In 2003 the University of Sydney became an Alliance Partner and committed a minimum of $1 million cash and up to $5 million in-kind over 5 years. The in-kind contributions include staff, background intellectual property and access to infrastructure.

An agreement for the establishment of a new research node in Melbourne was announced on 21 April 2004. The laboratory, based at the University of Melbourne, involves a

Victorian Government contribution of $8m and contributions by the University in cash and kind of $20m over 5 years. Three of NICTA's research programs are now based in Melbourne.

On 29 July 2004 NICTA announced its agreement to establish a research node in Brisbane involving three universities, each contributing $2m and the Queensland Government contributing $4m over 4 years. NICTA's partners in the Brisbane Laboratory are the University of Queensland, Queensland University of Technology and Griffith University. The Laboratory was launched on 18 February 2005 by the Queensland Premier and focuses on the national research priority of "Safeguarding Australia".

NICTA is also generating in-kind contributions through various collaborations with both the private sector and public sector research organisations. In addition NICTA is expected to generate income from the commercialisations of its IP. This funding source is not expected to be of a sufficient level for NICTA to become self-sustaining.

It is expected that during the currency of the new 5 year Funding Agreement to 30 June 2011, NICTA will generate about 40% of its resource requirements from its members, alliance partners, collaborations and commercial activities (cash and in-kind).

Evaluation of Program

A review of NICTA's progress in establishing, managing and operating the ICT Centre of Excellence was undertaken during 2005. The review was conducted jointly by the Department and the ARC through an independent Review Panel of experts.

The review concluded that NICTA has made major progress in its establishment phase and has met its agreed milestones with the Australian Government.

- The review concluded that NICTA has attracted leading Australian and international researchers and established an outstanding research training program.
- The review was highly supportive of NICTA's 'use-inspired, basic research model' and considers this has the greatest potential for national economic benefit.
- The review found that NICTA was well on track in developing the basic infrastructure in order to achieve successful transfer of its research results to commercial outcomes.

A further review of NICTA is planned to be undertaken in 2008.

Program's Outputs and Outcomes

NICTA's research facilities and education program have grown rapidly since its establishment in October 2002. At 1 January 2006 NICTA had 196 researchers (many recruited from overseas) and a further 77 research support staff (engineers, programmers and assistants) working on 56 projects across its 16 research programs at its five laboratories. NICTA had 209 endorsed PhD students who were supported through

NICTA funded scholarships at 1 January 2006 and a further 59 PhD students receiving NICTA supervision.

The Centre's objectives include that it commercialise its outputs and assist the development of the Australian ICT sector, particularly SMEs. NICTA has to date lodged 23 provisional patent applications and NICTA has plans to spin off four companies stemming from its IP rights, with *Open Kernel Laboratories* to be the first such venture based on its research into embedded computing systems.

NICTA has established the basic infrastructure for its prospective commercialisation and linkages with the local ICT industry. These activities include:

- the development of an Intellectual Property framework for its research;
- the appointment of a commercialisation and IP manager;
- the systematic scanning for commercialisation opportunities for its research outputs;
- development and delivery of a program of IP commercialisation training and awareness across NICTA for its researchers and students;
- an Entrepreneur-in-Residence program involving the appointment of two individuals who have a history of successful venture capital backed, start-up company development, together with extensive experience and connections with investors and potential industry partners;
- an industry leaders program, which provides experienced business developers with a short-term opportunity to work with the NICTA commercialisation team on a variety of projects, including evaluating spin-out opportunities, participating in commercialisation activities (such as market research or writing a first-cut business plan), and exploring opportunities for NICTA's technologies;
- recruitment of liaison officers to engage with SMEs on NICTA's research activities and capabilities and to seek commercial opportunities;
- establishment of a website subscription service to allow firms to register an interest in NICTA's programs and activities and receive relevant online updates;
- regular interactions with business through a variety of forums to improve mutual understanding of activities and needs of NICTA's work and SMEs' requirements; and
- the establishment of a Roundtable process, in conjunction with CSIRO, DSTO and ICT CRCs, providing a platform for improved coordination of research and linkages with industry.

Other key NICTA outcomes and outputs include:

- establishment of key research infrastructure at five ICT research laboratories (two in Sydney and one in Canberra, Melbourne and Brisbane) involving collaborative funding agreements with state and territory governments and with major Australian universities;
- development of linkages and collaboration with other ICT research organisations and major multinational companies, including IBM, Intel, Qualcomm, Ericsson, Max Planck Institute (Germany), Stanford University (USA), Kyoto University (Japan);
- establishing research and remuneration conditions within Australia that are attracting high quality researchers from overseas and have led to the recruitment of expatriate Australians from overseas research institutions; and

- the launch of two larger scale and longer-term research projects in key areas of national economic benefit (focussed on the areas of water management and road traffic management), with a third one planned to cover e-government.

Measurement of Outputs and Outcomes
During its establishment phase to date, NICTA has been primarily focussed on outputs rather than outcomes. Outputs were agreed by the Australian Government in the first Funding Deed and in the context of the milestones set in the annual activity plans. In 2003 the Australian Government and NICTA agreed to a set of growth performance indicators and benchmarks to 31 December 2007. NICTA has performed well in meeting the Funding Deed milestones and growth performance indicators, as well as in relation to the annual milestones. NICTA reports against the agreed milestones in its half yearly and annual reports to the Australian Government, with the reports being publicly released on NICTA's website.

Under the new Funding Agreement NICTA is required to develop revised performance indicators that are agreed by the Australian Government and to develop benchmarks to rank NICTA as a world-class ICT centre of excellence.

2. Advanced Networks Program (ANP)

In 1999 the Australian Government announced a $158 million commitment to establish the Building on IT Strengths (BITS) Program funded from the proceeds of the partial sale of Telstra. A key element of this program was the provision of $40 million to support the development, trialling and demonstration of advanced networks, experimental networks and test beds. This element is now referred to as the Advanced Networks Program (ANP). The ANP was based on the objectives and some of the features of the Canadian CANARIE program and advanced network programs in the US and other countries. The ANP subsequently received additional support of $21m in BAA2.

Cash and in-kind support from other sources (project consortia) for the same periods was approximately $90m and $30m (expected). The requirement for government funding for the project to proceed was a selection criterion for the assessment of funding applications.

Two networks with gigabit capacity (CENTIE, GrangeNET) and one advanced wireless network (m-Net) were established under the program (see Section X for a more extensive description). These projects have promoted the development of advanced network and test bed infrastructure in Australia which has, in turn, enabled researchers to develop, trial and test leading edge applications, network technologies, web services and communication services. The ANP also progressed the establishment of a national high capacity backbone network to encourage e-research (collaborative very high bandwidth-based research) between universities and research institutions which was not possible at the time under AARNET.

The achievement of program objectives for the first phase of funding was examined in the mid-term review (November 2003). The review found that at that stage the program was on track to meet its objective, but without a further period of funding support, the ANP projects could not maintain the projects in their current form beyond mid-2004, their research and development activities would be severely curtailed and the benefits from the significant investments made would not be fully realised.

Policy Lessons
DCITA suggests that some of the key policy lessons from the program include:

- The benefits from research, innovation and commercialisation can take a significant period of time to be captured, beyond the scope of a one-off three year funding program; and

- Government support is still required to give industry, research and education, and other sectors (a) access to leading edge high capacity networks for experimental and research purposes and (b) assistance to develop new ways of doing business and new applications to support the new business methods.

Outputs and outcomes
It has proven very difficult to generate any quantitative estimates of overall economic impact or of more specific impacts. Impacts have generally been monitored through examples/case studies of project outcomes, for example innovations and successful commercialisations (see case studies below).

Impacts were spread over a number of diverse sectors including research and education, health, film post-production, sport, regional development and mobile telephone services, with unexpected learning from R&D in one domain being relevant to many (with further work).

Case study
The Centre for Networking Technologies for the Information Economy (CeNTIE), one of three projects funded under the Advanced Networks Program (ANP), was funded $14 million for three years from 2001 under the first phase of ANP to build an optical fibre network (the 'Foundation Network') for research into advanced networking technologies and applications that would enable next generation information economy business systems. The Foundation Network, with 10 gigabits per second capacity, comprises two Metropolitan Area Networks (MANs) in Sydney and Perth and a dense wavelength division multiplexing (DWDM) link between Perth and Melbourne. A further backbone link between Melbourne and Sydney is provided to CeNTIE by GrangeNet, another ANP funded project. CeNTIE also established and maintains the Post-Production Industry Network for the post-production film industry and media organisations.

CeNTIE was allocated $10.1 million for the extension of the project over the three years 2004-05 to 2006-07 to continue to provide an advanced network resource linking research to economic outcomes and develop new applications, services and business processes not addressed by private sector initiatives.

CeNTIE works with five sectoral Focus Groups to establish the needs for new business applications and to ensure that the business applications develop according to market needs. The Focus Groups include e-Health, Digital Media, Enterprise Systems, Regional Australians and the First Mile Forum.

Significant applications from the CeNTIE project to date include the following (both now being commercialised):

- The Virtual Critical Care Unit which allows a specialist to guide and interact with a team at a remote hospital via a high capacity broadband link that transmits very high quality video, sound and digital images; and
- The Haptic Workbench, a virtual surgical training system which realistically simulates the surgical environment by incorporating interactive modelling, stereo vision, realistic sound, haptic (force) feedback and the ability of a teacher and trainee to interact in the same virtual space over a network.

Innovation: Development of a Generic Technologies Suite to enable the easy deployment of tailored business applications

To underpin the development of business applications, CeNTIE developed technologies in Networked Media, Networked Environments (Telepresence and Virtual Environments), Virtual Network Operators and Trusted Systems. CeNTIE initially developed the business applications independently for each business area (Focus Group), drawing on these underpinning technologies as and when necessary.

Following from the initial R&D work, it has emerged that it should be possible to develop the underlying technologies as a generic suite for building tailored business systems, for potential application across a range of industries, not limited to those covered by the CeNTIE Focus Groups.

To ensure successful adoption, the innovation relies on three important components, technology, human factors and skills training:

- CeNTIE is continuing its research into developing the generic suite of interworking technologies which are able to be integrated in different configurations into business applications with different functionality suited to specific sectoral needs, in a ‘mix and match’ fashion;
- the application of social sciences, to optimise the technology for end users and the tasks they carry out using it by incorporating into the technology design an understanding of human factors in telepresence. To better design telepresence technologies – technologies that are ‘as good as being physically there’ – , CeNTIE is working to understand the factors that influence the way people interact and behave with telepresence technologies. The aim is to create in users a strong sense of ‘telepresence’ by quantifying this sense and relating it media, sensory and social factors.
- a skills training component for end users. A strong element of CeNTIE’s work deals with multiple multimedia formats as well as the underlying hardware required to

process such content. This requires detailed knowledge of all aspects of end-to-end audio and video and skills training for end users is often essential

3. BITS / ICT Incubators Program

Program objectives
The BITS/ICTIP addresses a market failure in the venture capital market, as early stage ICT companies often found it difficult to raise seed capital and business advice during start-up and initial business development. The BITS/ICTIP was designed to include a range of business models and be a demonstration program to help instil confidence in private capital markets in early stage ICT firms. The program was not designed as a permanent subsidy for ICT start-ups, but as a short to medium term measure to complement other Australian Government initiatives encouraging innovation. Accordingly, the BITS/ICTIP has aimed to:

- strengthen the competitiveness of Australia's ICT sector;
- improve the rate of commercialisation of ICT ideas and research and development (R&D);
- increase the success rate of newly formed ICT businesses; and
- develop linkages with R&D bodies, universities and other capital providers.

Total resources provided.
Since 2000 the Government has invested $122 million in these programs, which includes $36 million of extension funding until 2007-08 as part of *Backing Australia's Ability*. By 2004–05, incubators had attracted $34.8 million of other contributions for the operation of the incubators since the start of both programs.

When the program was announced no significant technology-based incubators were operating in Australia. The program was based on successful technology-based incubator programs operating in the USA and Israel. The program commenced following the "dot-com" crash of 2000 when private equity capital investments in technology-based start-ups practically dried up. There is still reluctance by private equity investors to take risks in early stage technology companies. Many ICT companies that were supported under the BITS/ICTIP would not have survived without the programs' support.

The program guidelines have required incubators to outline strategies towards financial self-reliance under both BITS and ICTIP. Three incubators have committed to raise an investment fund as part of their strategy, but are aiming to exceed this commitment. Other incubators have also decided to investigate raising a fund as a platform towards financial self-reliance to complement their existing business strategies. Raising co-investment for incubatees is a key KPI for the program and all incubators have committed to raising matching co-investment for incubatees. However, as the incubators wish to build and enhance their reputation in the private equity industry, all have exceeded this commitment and consequently established sound networks from which to source private capital.

Policy lessons

- Continuing market failure

At the time the program was launched, it was thought that private equity capital growth could return to early stage technology companies with the return of the economic cycle which would assist with the sustainability of incubators. This has not turned out to be the case. Although the overall economic cycle has returned to sustained growth and total private equity investment has increased substantially, it has mostly been directed towards later stage companies. Incubators provide a tailored package of seed capital and business support for early stage ICT companies which private equity providers are generally unable or unwilling to provide. There are Government innovation programs addressing this market failure but those providing seed capital have been delivered to more later stage companies.

- Sustainability of incubators

One of the program's aims was to have incubators financially self-reliant by the end of the program and establish a revolving fund that can re-invest in further technology companies. This aim has been difficult because of the longer lead time incubatees generally take to grow to a point that becomes profitable for the incubator to exit their investment without jeopardizing the incubatees' future or causing a crisis in confidence in co-investors. The fall-out from the 2000 dot-com crash meant that finding co-investors became difficult and some incubatees and consequently some incubators have not survived.

Outputs and outcomes

- In 2004–05, the eight incubators reported a significant program outputs that included:
  - 640 applications, bringing the total applications under the BITS Incubator Program and ICTIP to 4865;
  - 32 ICT companies being accepted into the ICTIP as 'incubatees' for a total of 376 over both programs;
  - 35 incubatees completing agreed business milestones to become 'graduate' incubatees for a total of 223 over both programs;
  - raising over $42 million in private co-investment for their incubatee companies, which brought the five year total over both programs to more than $169 million; and
  - assisting incubatees to win more than $14 million in government grants, which brought the five year total over both programs to more than $38 million.
- In 2004–05, $26 million in exports were reported by incubatees, bringing the total over both programs to over $42 million.
- In 2004–05, incubators reported that the annual revenue of incubatees had increased by $43.2 million to $72.2 million.

- ICTIP incubators reported that as of 30 June 2005, over 280 full-time or equivalent additional jobs had been created in incubatees, with a further 30 part-time positions also created.

- A number of incubatees were recognised for their achievements in numerous local and international industry award competitions during 2004–05.

Issues in measurement
An evaluation of the BITS incubator program was conducted in 2003 which suggested and measured performance indicators Incubators are also required to submit progress reports and an annual report. The outcomes and outputs outlined above were taken from the incubators' annual reports.

The major externality benefit from this program is that a level of confidence has returned to investing in early stage ICT companies, particularly where incubators have done groundwork to enhance their prospects of success. In addition, a network of skilled incubator managers have been developed with a vested interest in the success of their portfolio companies and a reputation in the ICT and private equity industries for providing a quality service at the early stage end of the market.

A number of case studies have been produced for the Annual Incubator reports and the Department's DATA magazine which are available from the Department's incubators web page that illustrate impacts of the program.

4. The Information Technology Online (ITOL) Program

ITOL is an Australian Government funding program administered by the Department of Communications, Information Technology and the Arts (DCITA). Since 1996, the Government has allocated more than $15.4 million to 131 innovative ITOL projects across a range of industry sectors and geographic regions.

The ITOL program is designed to accelerate the national adoption of e-business solutions, especially by small to medium enterprises (SMEs). It encourages industry groups and small business to identify and adopt commercial uses of the internet to support productivity and profitability. The program is a catalyst for industry groups to work collaboratively to solve common problems on an industry wide basis, rather than working individually and developing multiple solutions and in some cases unnecessarily duplicating efforts. The preferred e-business solutions are open and inclusive for all participants.

Most of the projects funded under the ITOL Program exhibit a high level of broad industry collaboration, with identified long-term strategies to ensure their solutions are sustainable. They have the potential to result in large scale B2B uptake and to demonstrate benefits for the wider community. The outcomes of these projects reflect promoting an innovation culture and economy – maximizing Australia's creative and technological capability by understanding the factors conducive to innovation and its acceptance.

The ITOL program has funded a large number of projects to non-profit organisations. These fund recipients have indicated to the ITOL team at the interview or provided feedback when the project was completed that without government funding their particular project would not go ahead because they had limited resources to kick start an innovative project or they were unable to secure private sector investment for their project.

Evaluation of the ITOL Program
1st Evaluation - In February 2001, the then National Office for the Information Economy (NOIE) commissioned Macquarie Graduate School of Management to undertake a study on the 67 projects funded under the first five rounds of the ITOL program. The study was completed in February 2002. Its research showed that the majority of ITOL projects have been successful in raising e-business knowledge across diverse geographic regions, in businesses and in the broader community. Further, the report showed that constructive collaboration enabled the growth of e-commerce capabilities.

2nd Evaluation - In November 2004 DCITA commissioned a further review of the ITOL Program (covering funding round s 6-11). The review showed that the ITOL Program has achieved its overall objectives in three key areas. They are: appropriateness, effectiveness, and efficiency.

Appropriateness - the objectives of the ITOL Program is consistent with the Government's priorities – this was expressed in the Government's 2001 Innovation Action Plan for the Future, *Backing Australia's Ability* was the source of the second tranche of funding ($13 million) made available from fiscal year 2001/02 onwards.

Effectiveness - In general the ITOL Program has made a positive contribution to the development of e-business. Its main contribution has been in drawing a wide range of diverse industry sectors into considering the potential of e-business to lift productivity and competitiveness.

ITOL has facilitated a substantial amount of learning and experience-gathering by industries and especially those industries comprising mainly SMEs. A number of new e-business systems have been developed and are now being used as intended in their targeted industry sectors. In addition, a range of prototype systems have been demonstrated in many other industry sectors and some of these have generated intellectual property with commercial potential. Some SMEs involved in the projects have generated intellectual property which is capable of being commercially developed. The program has also stimulated information sharing and technology diffusion from funded projects across to other projects and industry sectors.

Efficiency – the ITOL Program has been measured favourably against management of funds, selection and administration, targeting applicants and feedback from funding recipients. For example, in the area of management funds, ITOL has exercised economy with the funds allocated – for both program and administrative purposes. The ratio of direct administrative expenses to program funds averages about 20%. In the area of selection and administration, since 2001, ITOL has produced a procedures manual documented set of processes for selection, assessment and the monitoring of funding agreements. In the area of feedback from funding recipients - most project managers interviewed in the fieldwork were very positive about the ITOL processes and the 'customer service' they received.

Conclusion of the ITOL Program

The ITOL Program concludes in June 2007. Round 14 advertised in September 2005 is the last competitive round of the Program.

Case Studies

The ITOL Program, in the past few years, has produced a number of case studies to demonstrate the impact and success of the Program. Two recent case studies are provided below.

Collaborative B2B for SMEs in the Mining Industry

The project Collaborative B2B for SMEs in the Mining Industry was to address the need for SMEs to be able to trade electronically with both their larger trading partners who were enabled for e-Business already, as well as their trading partners who had no present e-Business capability. The project delivered two (2) products, namely TradeRoute™ a B2B "middleware" solution appropriate for SMEs, and TradeForms™ an advanced Web services based solution for electronic trading with partners who previously used manual methods such as fax, email and post.

Overall, the desired outcome was to enable the SME to trade more effectively with a much higher%age of their trading partners, both large and small. The e-Business solutions - TradeRoute and TradeForms - have delivered tangible, measurable benefits.

The project was developed by, XML Yes Pty Ltd, in collaboration with MSA (Australia) Limited, PT Newmont Mines, Quadrem International, IBM Australia and Mincom.

Global Electronic Invoice Presentment and Payment

The project Global Electronic Invoice Presentment and Payment was to develop an export e-commerce service trusted by both exporters and importers that can be secured simply and cost-effectively over the Internet without paperwork or time delays. The secure service provides reliable cross-border, multi-currency invoicing and payment capabilities designed for small business exporters and importers.

Only 31,000 of 1.1 million Australian SMEs are exporters. To effectively buy and sell goods worldwide, importers and exporters must have an effective, efficient way to send and receive payments. They need cost-effective logistics services to ship goods and track shipments globally. They need to meet cross-border regulatory and compliance requirements and make their businesses scalable for global trading without large upfront investments.

The MyExports portal is a platform to enable businesses to ramp up their global trading without increasing staffing or any technology investment. Allowing overseas buyers to pay from their bank accounts in their local currency at no cost can increase sales by making it simple and convenient. Australian sellers can avoid the high costs and risks of credit card payments with a flat AUD$5.50 per payment received.

The project was developed by Payment Pty Ltd, in partnership with Australian Trade Commission and Danzas Pty Ltd.

5. Australian Institute of Sport

The Australian Institute of Sport(AIS) supports innovation and science through the Anti-Doping Research Program and through its participation in the CRC for Microtechnology.

Anti-Doping Research Program
The Anti-Doping Research Program (ADRP) provides funding for research to improve the analytical capability of detecting banned substances and doping agents in sport; and social science research into motivations, attitudes, values and behaviours that may lead to the development and implementation of practical deterrence strategies.

AIS/Cooperative Research Centre for Microtechnology
Since 2001 the AIS has worked closely with the Cooperative Research Centre for MicroTechnology to develop a number of prototype athlete monitoring devices.

The innovative research and development work is made possible by drawing on the knowledge and core competencies of the CRC for MicroTechnology with AIS know-how focusing on the interpretation and meaningful presentation of information to both coaches and athletes. This combination enables elite athlete monitoring in the field, including during competition, in addition to traditional laboratory techniques – a huge competitive advantage for some of AIS sports programs.

Case Study: Sport and Recreation (Anti-Doping) Program – Anti-Doping Research Program

Australia has been at the forefront in the fight against drugs in sport, having one of the most rigorous anti-doping regimes in the world and being committed to supporting anti-doping measures internationally. The Australian Government will invest over $125 million in 2006-07 in support of our elite athletes. There is a community expectation that athletes representing Australia or receiving Australian Government support compete without the use of drugs or doping methods. This is demonstrated, for example, by the adverse public reaction to athletes who are banned because they were found guilty of using banned substances or who are suspected of using banned substances.

Drug use by athletes is damaging to the image of sport because it is perceived as being unfair and because of the stigma of drug use in wider society. At the same time, investors and sponsors only wish to contribute to "clean" sports. There are also potentially serious health effects from the sustained use of banned substances and the "flow-on" risk for communities in that the proliferation of drug use at an elite level may be seen to legitimise use by individuals at the "grass roots" level. This could have serious health consequences for those participating in sport at the community level.

The difficulty for sport is that the substances used by athletes to gain an unfair advantage are generally becoming harder to detect or the types of banned substances available to athletes vary over time. Keeping up with and, where possible, getting ahead of the latest doping practices is essential to the development of an effective testing program.

Accordingly, the Australian Government provides funding for anti-doping research in Australia to improve the analytical capability of detecting banned substances and doping agents. Since 2001-02, nearly $5 million has been provided for anti-doping research. These projects cover research into gene doping, blood doping, detection of new steroids as well as the first social science project funded under the program, designed to develop an anti-doping research agenda for Australia.

Under the Program, an Anti-Doping Research Panel, comprising four government members and three independent scientific experts, identifies research priorities, seek and consider applications for research funding, select projects for funding and monitor the progress of individual projects. The ADRP Panel has the expertise to ensure that the funds are allocated to projects addressing anti-doping research priorities and the scientific expertise to ensure project methodologies are scientifically rigorous.

Funding under the program is advertised and is open to any applicant with a demonstrated capacity to meet the selection criteria specified by the Panel.

There are currently no barriers to private interests undertaking research outside of this initiative, however, this is not prevalent because anti-doping research is highly specialised, has high resource costs and there is unlikely to be a large market for the results of the research. Like most forms of research, there are also significant time lags and high resource costs associated with anti-doping research. For example, officials became aware of the possible use of erythropoietin (EPO) by athletes in the late 1980s. However, it was not until research led to the development of a blood test for EPO in 1999 that athletes were tested for EPO immediately prior to and during an Olympic Games. Unless governments take a forward role, this research is unlikely to happen.

Failure to undertake anti-doping research would make it more difficult for testing systems to keep pace with the changes in drug use. This would undermine the credibility and effectiveness of the entire drug testing process. Athletes who develop new ways of concealing the use of banned substances would have a greater prospect of not being caught and this, in turn, would encourage greater drug use. Athletes must believe that any doping activity is likely to be detected if they are to be effectively deterred from breaching the rules of their sport.

While Australia has its own anti-doping research program, there is a broader international effort to improve the analytical capability of detecting banned substances and doping methods. Since 2001, the World Anti-Doping Agency (WADA) has committed more than US$28 million to research into the development of new and improved detection methods for performance-enhancing substances and methods.

The key priorities for WADA include: factors enhancing the oxygen carrying capacity of blood; factors regulating and enhancing growth; exogenous and endogenous anabolic steroids; and projects relating to the prohibited substances list. WADA also monitors emerging threats. This includes monitoring the latest advances in the field of gene therapy and methods for detecting gene doping.

6. The Australia Council for the Arts

The Australia Council for the Arts is the Australian Government's principal arts funding and advisory body, with a history of success in supporting artists working at the intersections of science and technology. The Australia Council considers that there is a the need for a more comprehensive national innovation policy that offers greater recognition of, and support for, the role of creativity and the arts to Australia's innovation economy.

As noted in its submission to the Prime Minister's Science Technology and Innovation Council (PMSEIC) Working Group *Inquiry into the Role of Creativity in an Innovation Economy* (September 2005)[66] the Australia Council for the Arts considers that a whole-of-government strategy is needed to 'facilitate a co-ordinated approach to government investment in creativity and innovation, and accelerate the production of creative content across the cultural and creative industries'.

The Council is currently pursuing a number of new pilots and initiatives in the context of a *Creative Innovation Strategy* (CIS), which aims to strengthen the links between the arts and science, technology and innovation sectors. To date, four art/science collaborative research projects (known as the 'Synapse' program) supported by the Australia Council have obtained ARC Linkage grants, in areas that include robotics, distributed and decentralised systems and human/machine interaction, digital/audio technology and immersive cinema. The feedback from these projects has been excellent, with participants across arts and science backgrounds reporting significant unanticipated knowledge gains and expanded opportunities for developing new applications and services.

The transfer of specialist knowledge and skills across disciplines is vital for generating new ideas, products and services. In the sciences, the adoption of cross-disciplinary approaches to discovery and innovation has given rise to important new fields such as

[66] http://www.ozco.gov.au/news%5Fand%5Fhot%5Ftopics/news/creative%5Finnovation/

bioengineering and nanobiotechnology. The role of cross-disciplinary approaches to practice and discovery is no less important in the creative arts.

Artists have been practising at the edges of their artforms for centuries, and it is this ability to work across specialist fields, to address complexity and to find new answers to old questions, that is generating interest in the role of creativity in innovation. The same spirit of critical enquiry now sees a growing number of artists investigating and translating their creative practice using research-based methodologies—what is now termed ‘practice-based research’.

In our universities and colleges, however, the value and impact of research in the arts remains poorly understood. In particular, applications for Australian Research Council (ARC) competitive grants in the area of Creative Arts suffer from very low success rates compared to other disciplines, partly because measures of value and output do not adequately capture creative works, and instead favour text-based mediums, such as journal citations.

A memorandum of understanding with the ARC enables the two agencies to work together to support innovation in areas where Australia can be globally competitive and deliver benefits to the community. Through its relationship with the ARC and other key organisations, such as the Council for Humanities Arts and Social Sciences (CHASS), the Australia Council will build research capability in the arts and grow recognition and investment in emerging, cross-disciplinary areas of creative practice.

An outline of Australia Council support for R&D, science or innovation is set out below.

Creative Innovation Strategy
The Australia Council’s Creative Innovation Strategy (CIS) was released in December 2005 and presents a coordinated approach to supporting creativity as one of Australia’s most valuable assets. The Strategy identifies and clarifies the many initiatives supported by the Council that enhance Australian creativity and build pathways to successful innovation, spanning creative skills, enterprise and leadership. These initiatives are a solid basis from which to build future partnerships across government portfolios, industry and research sectors.

The Strategy comprises four key components built on an ‘innovation value chain’ that begins with supporting pathways for creators and leads to commercialisation and innovation in new works:

1. *Creative Schools:* Promoting arts education in schools
2. *Synapse Research:* A cross-disciplinary research framework
3. *Creative Leadership:* Developing creative leaders and international exchange
4. *Create + Accelerate:* Support for creative enterprise and innovation

The following program – and the artworks they support – provides examples of existing initiatives supported by the Australia Council in the area of science and innovation.

Synapse – Art and Science Strategy

In 2003 the New Media Arts Board of the Australia Council launched *the Synapse Art and Science Strategy*. Synapse aims to encourage creative and experimental collaborations between scientists and new media artists and further enhance public engagement with both science and art. It consists of three components:

1. Australia Council and Australian Research Council (ARC) Industry Partnerships
2. Development of a Synapse database (launched in May 2003)
3. ANAT Synapse Art and Science Residency program (launched May 04)

Additional three-year funding for *Synapse* from 2006 to 2008 was announced in May 2006.

1. *Australia Council and Australian Research Council (ARC) Industry partnerships*

Synapse industry partnerships is a funding program that aims to:

- foster new collaborations and creative partnerships between artists and scientists;
- develop partnerships with key players in the arts, science and technology sectors, nationally and internationally; and
- develop sustainable support for long-term collaboration between the arts and sciences.

The Australia Council for the Arts has allocated funds to provide industry partnership support for collaborative arts/science research applications submitted to the Australian Research Council's (ARC) Linkage program. This partnership provides the opportunity for the Council to lever additional ARC funding in support of cross-disciplinary research and practice. To date, four Synapse art/science collaborative research projects have been supported by the ARC in areas that include robotics, distributed and decentralised systems and human/machine interaction, digital/audio technology and immersive cinema. Total financial commitment (to date) under Synapse has been around $350,000, leveraging over $1 million in ARC funding.

2. ***Synapse Database***

The Synapse Database has been developed by ANAT as a resource for artists, scientists, researchers, curators and industry to develop innovative and dynamic collaborations and connections. The database can be searched by artist, project or science organisation. It contains information on exhibitions, collaborative projects and areas of science interest and includes a showcase of artworks in the online gallery.

3. ***ANAT Synapse Art and Science Residency Program***

Through the Australian Network for Art and Technology (ANAT), the Australia Council provides support to artists seeking to undertake a residency at a scientific institution. Total support of $60 000 per annum has been offered over two years (2003 and 2004). In collaboration with the Australian Network for Art & Technology (ANAT), the Australia Council offered four Synapse Residencies to artists in 2004.

1. Examples of outcomes from Synapse Art/Science Projects

Australian National Botanic Gardens and the Centre for Plant Biodiversity Research (CPBR) Canberra
Julie Ryder is working closely with the scientists at the CPBR on the little understood world of cryptogams-spore-bearing plants without flowers or seeds, which include the mosses, hornworts, liverworts and ferns. With a background in textile design, Julie is increasingly working with new media technologies to enable the development of new techniques and designs. With access to electron microscopy, the residency will explore the visualisation and display of small-scale objects and applying web-based technology to exchange visual information about these fascinating organisms and their role in modern ecology.

*"The **Synapse** residency will give the Gardens the chance to link scientific and artistic creativity in a way we hope will be of mutual benefit to the artist and scientists involved."* - *(*Rod Harvey, former Public Art Program Coordinator, Australian National Botanic Gardens)

South East Sustainable Marine Ecosystems, CSIRO Marine Research, Hobart, Tasmania
South East Sustainable Marine Ecosystems is the research group within CSIRO Marine Research that is hosting the *Synapse Artist in Residency* program. This multidisciplinary group comprises teams of ecologists, taxonomists, chemists, geneticists and ecological modellers. Together they are exploring and documenting the unique biodiversity of sea mounts, assessing the impact and developing management strategies for marine pests, analysing the impact of human development on our coastal ecosystems, modelling ecosystems, mapping ocean floor habitats and assessing fish stocks. This means their scientists look at diverse aspects of marine life; from the chemistry of the water and sediments, to tiny microscopic algae, to the amazing creatures from the deep sea.

Peter Charuk's interest is to extend and enhance an understanding of the diverse aspects of marine life in a current exploration of the ocean and its creatures. This interest extends to how ecosystems could be mapped visually and transcribed using particle system software, a project that he is currently developing. This mapping could lead to a new poetic interpretation and visualisation of gathered data for public display in both static and moving forms.

7. Australian Film Commission

The Australian Film Commission (AFC) is the primary agency for supporting development of film, television and interactive media projects and their creators. It supports a range of projects to encourage the uptake of new technologies in the film sector and many of these activities encourage innovation activities more broadly. Some examples of completed and new projects are provided below:

AFC's Documentary Online Initiative
The AFC partnered with ABC New Media as part of the Documentary Online Initiative. The initiative was established to encourage projects that exploited the possibilities of the internet and challenge conventional documentary forms. ABC Online housed the four projects that were produced.

Guerilla Documentaries
Completed in 1996, this initiative aimed to encourage ideas to be captured using alternative production methods and new technologies such as Digital Vision or Hi-8 formats.

Regional Digital Screen Network
The AFC is piloting a Regional Digital Screen Network (RDSN) across 10 regional centres in NSW, QLD, WA, VIC, TAS, SA and the NT. The RDSN will enable mass distribution unachievable with traditional film formats and will broaden the range of films available to audiences throughout Australia as well as increasing access to Australian screen content. Scheduled for launch in October 2006, the pilot will assist market and audience development for Australian feature films, documentaries and other Australian screen content by utilising the cost savings afforded by digital technology.

The RDSN will also assist to address market impediments that currently disadvantage regional communities by:

- contributing to regional renewal;
- acting as a catalyst for take-up of interactive broadband services around Australia; and
- providing a tool for increased participation and communication between regional communities locally, nationally and internationally.

AFC Broadband Production Initiative (BPI)
The BPI was funded by the Australian Government to facilitate the production of innovative, high technology broadband content and interactive applications. The initial allocation for the BPI was $2.1 million over three years. The aim is to emphasise high-technology content, including interactive applications. The local development of high-quality content is crucial in ensuring that Australia's cultural experiences and character is maintained and reflected in the global digital environment. Working closely with other funding partners including ABC New Media, the Tasmanian Electronic Commerce Centre, the Telstra Broadband Fund, South Australian Film Commission, Adelaide Film

Festival and the Learning Federation, the AFC almost doubled this allocation to a total of around $4 million and funded seven projects.

Ongoing Funding of Digital and Interactive Digital Media
In addition to the AFC's discreet projects to fund digital and interactive content and industry development, the AFC supports the development of interactive digital media, as an integral part of its Film Development funding strands. Through these strands, the AFC funds games concepts, innovative websites, interactive DVDs, mobile phone content, online documentaries, interactive television applications and multi-platform interactive content.

Through Strand V, the AFC provides funding of up to $15,000 per project for the early development of Interactive Digital Media Projects that have the potential to attract third-party financial support.

Through Strand W, the AFC provides up to $50,000 for Digital Media Projects that have been able to attract matched marketplace funding.

And through Strand X, the AFC provides grants of up to $20,000 to experimental digital media projects that are innovative in form and content.

ATTACHMENT E

DCITA RESEARCH PUBLICATIONS AND SPONSORED CONSULTANCIES

Achieving value from ICT: key management strategies, 2005.

Australia's National Broadband Strategy, 2004.

Australia's strategic framework for the information economy 2004-2006: opportunities and challenges for the information age, 2004.

Community ICT transformations: next steps, 2005.

Digital factories: the hidden revolution in Australian manufacturing, 2005.

Estimating aggregate productivity growth for Australia: the role of information and communications technology, March 2006.

Exploration of future electronic payments markets, June 2006.

Forecasting productivity growth 2004 to 2024, March 2006.

ICT and Australian productivity: methodologies and measurement, March 2006.

ICT production in Australian SMEs, 2004, 2005 and 2006.

Information economy Index 2006.

National Broadband Strategy Implementation Group (NBSIG) government action plan 2005.

National Broadband Strategy Implementation Group yearly update 2005

Productivity growth in Australian manufacturing, 2004.

Productivity growth in service industries, 2005.

The Australian software industry and vertical applications markets: globally competitive, domestically undervalued, 2005.

The current state of play: Australia and the information economy, November 2005.

Trust and growth in the online environment, November 2005.

ATTACHMENT F

SYNOPSIS OF SOME DCITA CASE STUDIES

DCITA case studies provided an indication of the range of social, environmental and economic impacts from public ICT R&D. Key findings are summarized below.

NEW BUSINESS MODELS OF PUBLIC ICT R&D ORGANISATIONS

Leaders of ICT R&D organisations are developing new business models, which complement rather than duplicate private sector approaches. These business models seek to deliver 'public good' and commercial outcomes by focusing on the development of innovative ICT services and solutions for complex sectors where the market has failed or is unable to deliver (eg. health, emergency services, meteorological data).

Income is generated through contract research and consultancy, and the development of new technologies is user-driven through collaborative research. These business models are relatively new and are focused on increasing the returns from ICT R&D to the Australian public and economy.

- **DSTC –** The board and management of this CRC observed that it was difficult for public ICT R&D to secure funding on the basis of its ability to deliver incremental improvements in technology, particularly in light of the dotcom crash. It used this knowledge to develop a new business model focused on achieving "innovation" in targeted industries, such as electronic records for the health industry. As DSTC wound-up in June 2006, it spun off one more company, Extensia Solutions Pty Ltd, to act as a vehicle for DSTC's electronic health records, services and technology.

- **NICTA –** A user-centric, collaborative approach is apparent in several of NICTA's project. The Disaster Prediction Response and Recovery Project (discussed above) is focused on delivering solutions for targeted users in the emergency services sector. A collaborative R&D initiative with DSTO in human system integration programs, known as HxI, is expected to offer significant benefits to DSTO and Defence by bringing together a critical mass of new technologies and researchers to develop advanced human-machine interfaces for evaluation as potential ADF applications.

- **BlueLINK –** This $15 million Australian Government project has developed ocean forecasting systems and services for use by marine industries. The project utilized the Bureau of Meteorology's expertise in forecasting service delivery, CSIRO's expertise in marine research and the Royal Australian Navy's experience as a user to deliver a product which meets the needs of the immediate stakeholders and the broader public.

- **CSIRO's National Research Flagships** bring together expertise across all divisions to achieve specified goals. CSIRO's ICT Centre is developing technologies for monitoring and management of water resources through a Water Resources Observation Network (WRON) under the "Water for a Healthy Country" Flagship.

- **QUT**'s multidisciplinary Information Security Institute (ISI) brings together expertise in ICT R&D with researchers in law, policy, social and behavioural issues to address complex e-security and e-health issues.

- **Smart Internet CRC** seeks to improve the relevance and uptake of its research outcomes by including social science perspectives in all aspects of their research, including commercialisation. For instance, usage studies have shown that many people utilise Peer-to-Peer (P2P) file-sharing networks to explore music and other content, and in most cases are still willing to purchase media that they like. These findings have influenced a preliminary design for a P2P file distribution system that enables users to share lower quality files and purchase higher quality ones through the same system.

IMPACTS OF PUBLIC ICT R&D

1. Governments are one of the primary users of public sector ICT R&D and they use it in a variety of ways.

Guiding ICT procurement decisions
Public sector ICT R&D organizations combine a high level of technical expertise and knowledge with vendor independent advice. Government agencies with highly specific needs develop this capability in-house (eg. the Defence Science and Technology Organisation (DSTO), the Bureau of Meteorology (BOM) and on a smaller scale, the Centre for Accident Safety Research (CASR)). Other agencies secure it on an ad hoc fee-for-service basis. The benefit of using ICT R&D in this way is that it enables agencies to procure the most appropriate ICTs (in terms of functionality and price) for their needs.

- DSTO's ICT research is essential to Australia's defence. The technical expertise built up through its research enables it to assess and advise the Australian Defence Forces (ADF) on weapons and other ICT-rich technologies and to build ICT solutions to meet the ADF's specific requirements. DSTO has a range of projects focussing on the development of technology in the immediate future and in the long-term. This balance of projects enables DSTO to identify its ICT procurement needs now and into the future.

- The Queensland Government's *Access Queensland* project was conceived to deliver a consistent user experience for the general public while also providing the flexibility for all state agencies to develop their own e-services. The Distributed Systems Technology Centre (DSTC) provided expert consultancy services to the Queensland Government. This involved delivery of an innovative system architecture design and specifications for the required technology. SMEs were then introduced to the solution, one of which won a significant tender to deliver. DSTC continued to provide expert advice to the project throughout implementation, via a consultancy agreement.

- The Australian Government Attorney-General's Critical Infrastructure Advisory Council (CIAC) agreed to the establishment of two expert advisory groups (EAG) in 2003. The IT Security EAG provides advice on technical solutions to problems identified by the key infrastructure groups participating in the Attorney-General's Trusted Information Sharing Network (eg. emergency services, medical networks etc.) The Futures EAG examines emerging trends and issues affecting Australia's Critical Infrastructure. Professor Caelli, at the Queensland University of Technology's (QUT) Information Security Institute, provides expert counsel to the Australian Attorney-General's Critical Infrastructure Advisory Council by participating on both of its expert advisory groups.

Developing ICT intellectual property in-house

Proprietary products and overseas ICT R&D do not always address Australian needs and priorities. In these circumstances Government agencies conduct in-house R&D activities to develop new technologies that meet their needs.

- The Sydney Coordinated Automated Traffic System (SCATS), developed by the NSW Roads and Transport Authority, is installed in most large Australian cities. It improves traffic flows and thus it saves workers time and reduces fuel consumption, air pollution and government expenditure on roads. It was also an important positive factor in Australia's success in winning the 2000 Olympics.

- BOM focuses on major areas of long-term significance to Australia where research is not likely to be conducted effectively by other organisations, national or international. BOM has niche expertise in computer modelling across all the R&D programs (weather, climate, ocean and hydrology). It produced the Predictive Ocean Atmosphere Model for Australia, which analysed the relationship between the El Nino, the Southern Oscillation Index (SOI) and Australian rainfall, with the aim of developing a better understanding of the key influences on drought. This model is now used as the basis for the Bureau's National Climate Centre El Nino outlook. The El Nino outlook is an important tool for Australian wheat farmers, particularly in Queensland and New South Wales, where rural productivity is linked to the SOI.

Informing policy development and priority-setting by Government

Members of Australia's public sector ICT R&D community balance commercial opportunities with a commitment to achieving 'public good' outcomes. This 'public good' focus leads researchers to work together on long-term strategic issues of national interest, such as security, climate change and accident safety. Senior researchers play an important role in providing expert advice to all levels of government on Australia's future ICT needs at both the national and state levels (in areas such as e-security and e-health).

Researchers from other domains also use public ICT R&D to guide policy development in other areas.

- NICTA aims to deliver commercial and public good benefits by developing a business model which successfully exploits this collaborative and strategic capacity. For instance, the NICTA Queensland node for Disaster Prediction Response and Recovery Project aims to better enable public sector transport and emergency services around critical incidents, whilst also developing new technologies for commercialisation. NICTA (Queensland) works closely with end-users in the public sector to produce prototypes that meet their needs. The group will collaborate with industry to commercialise the product once a prototype has been developed. Leading senior researchers from other Queensland institutions with expertise in e-security are collaborating with NICTA on this project, with additional financial support provided by the Queensland Government.

- The ARC's National Network program currently provides funding to facilitate collaboration on 'public good' goals. Examples of the ICT R&D supported are the ARC Research Network for a Secure Australia and the ARC Earth System Science Research Network.

- CASR's ICT R&D enabled it to formulate innovative new accident safety policy, leading to reductions in speed limits in all states and demonstrated savings in human and economic costs.

***2.* Over the past 10-15 years Australian public sector ICT R&D has successfully developed new, internationally competitive and commercially successful ICT products. However, this commercial income has not been sufficient to support financially-independent R&D organizations within that timeframe.**

The DSTC was one of several ICT CRCs funded by the Australian Government. It wound-up at the end of the 2006/07 financial year after receiving two rounds of CRC funding. The DSTC generated commercial income through a variety of means, including licensing, spin-off companies, training and contract research. It produced internationally competitive and commercially successful ICT products, notably:

- **Wedgetail Communications** - Founded in 2000 and headquartered in Brisbane, Australia. The company was established as a direct result of IT security breakthroughs in DSTC's R&D program, which created a suite of cryptographic and authentication security software products for the Java and embedded device markets. In July 2004 Wedgetail announced a merger with US enterprise solutions company, Vintela, Inc, a leading provider of innovative platform integration solutions for UNIX and Microsoft Windows.

- **Mantara Software** - A universal network messaging technology capable of delivering millions of discrete messages at high speed to any number of information consumers. Elvin is used by securities trading firms in the US to distribute market quote feeds and transaction data. It has also been licensed to customers for telecommunications and military simulation applications.

3. Economic benefits outside the ICT sector can be quantified on a case-by-case basis and some data is available.

Current sources for this data are the non-ICT industries in which the ICT R&D has had the impact. Available data suggests that ICT R&D is increasingly important in delivering benefits to industries outside the ICT sector.

The Capital Markets CRC was established in 2001 to build-upon the success of Australia's SMARTS technology. SMARTS was initiated developed in 1993 by a finance researcher at the University of Sydney to enable gathering and assembly of electronic market data for research purposes. In 2006 the SMARTS application suite has the functionality to combat insider training, securities and health fraud by analyzing the electronic data.

The CRC developed ***Detecht*** software to track health insurance fraud. Availability of electronic real-time data in this area has allowed SMARTS to apply their data mining, surveillance and visualisation software to the problem. The resulting venture is called Detecht, and in beta testing has identified fraud levels of 4%. This indicates a possible saving of $720m per year.

There is a similar issue with securities fraud in Australia, which has increased with the increasing availability of the internet. The CMCRC product ScamSeek trawls the internet and examines advertising material to detect potential scams. Recovering assets from securities fraud is a resource intensive and time consuming undertaking. The impact of the ***ScamSeek*** software has been described as:

> "*The estimate of savings in human effort in its monitoring role is the order of 100 to 1, as previously ASIC had to read 80 documents to find one of interest they now read 5 documents to find 4 of interest. The estimate in savings to the community by bringing speedier detection and intervention of scams cannot be estimated readily but is likely to be of the order of tens of millions of dollars.*"

The **NSW Road and Traffic Authority's (RTA)** R&D program has developed an internationally recognised electronic system for the management of traffic, now in operation in Australia and around the world, called SCATS.

Investigations by Tyco (private sector producer of traffic systems) states that SCATS has been found to save 20% in travel time, give 40% reduction in stops resulting in 12% less fuel usage". This is a significant saving as the latest update to Austroads figures for the cost of road travel (2002), put the value per occupant per hour at $9.23 for private cars, $29.52 for business cars and $19-$21 for most trucks found in urban areas. Freight costs per vehicle hour ranged from $1.00 to $27.57 for 6-axle articulated trucks and $39.91 for B-double trucks.

Research at Adelaide's **Centre for Accident Safety Research** has lead to road policy innovations and savings.

Case control studies on the relationship between speed and crashing, conducted in the US in the 1960s, have influenced the regulation of vehicle speed by government authorities for nearly forty years. These studies suggested that the safest strategy for a driver was to drive just over the average speed. Research conducted at CASR provides compelling evidence to the contrary.

Approximately 10 years ago CASR commenced a case control study of its own, collecting field data on crash events, of which 150 were found to be relevant to the study. Through collaborations with US developers, CASR gained expertise in leading edge computer simulation technology[67], which enabled it to accurately estimate the speed of cars in crash events using the field data. By employing other standard research methodologies, CASR used the speed data to develop a risk framework that would estimate the relative likelihood of a crash event on a metropolitan road for a range of speeds.

Using this risk model CASR predicted that a 10 km/h reduction in metropolitan car speed would yield a significant reduction in casualties (greater than 25%). State road authorities around Australia subsequently reduced the default urban speed limit by 10 km/h and CASR has been advised that its risk analysis was pivotal to the decision.

In 2005 the South Australian Department of Transport, Energy and Infrastructure commissioned CASR to evaluate the effects of the change in speed limit. CASR used South Australian data, comparing the incidence of crashes in the year before and the year after the introduction of the reduced speed limit. On roads where the limit had been reduced, the average vehicle speeds had declined by 2.3 km/h and casualties by 24 per cent. The effect also appears to have spread to roads where the speed limit remained at 60km/h: on such roads, average vehicle speeds dropped by 0.9km/h and casualties by 7 per cent. CASR suggests that this latter effect may be temporary, possibly due to driver uncertainty about the speed limit on certain roads and a heightened awareness of the importance of travelling speed. Conservative estimates of the monetary savings to South Australia alone from the lowering of the speed limit to 50km/h are in the order of $30 million.

Gravity Thickener -The Australian Mineral Industry Research Association (AMIRA) has an ongoing project through the Parker Cooperative Research Centre (CRC) for Integrated Hydrometallurgy Solutions (Perth). Researchers from two CSIRO divisions and several universities were involved in a multi-disciplinary team of chemists, computer modellers, engineers and fluid dynamics researchers that have successfully produced new gravity thickening technology for minerals processing, which improves the efficiency of the extraction process.

An evaluation study by Strategic Technology Evaluation and Management has found that for an investment of approximately $10 million over the 6 years since 2000, the project has generated at least $295m to the minerals processing industry, with a potential for a further $250m.

Other examples of ICT R&D with quantifiable benefits were also identified, but specific data is not available:

The **Darwin Volcanic Ash Advisory Centre** uses satellite information, ground reports from vulcanological agencies, pilot reports, meteorological knowledge and numerical models to track and forecast ash movements so that aircraft can fly around the airborne ash safely. The Centre operates 24 hours a day.

Most estimates cite costs to aviation of over $250 million since 1982. International airlines are willing to undergo extensive and very expensive re-routing if there is any possibility of ash contact on their regular routes.

Prior to 2003 the Bureau of Meteorology used a time and labour intensive process to provide advice on eruptions and ash cloud and identified threat areas. This manual approach was risky in terms of potential delays due to lack of staff and operator error. In 2002 the Bureau developed an interactive user interface to simplify and streamline the preparation of warnings. The new Volcanic Ash Warning preparation System has been received positively by the aviation industry and has been used to deliver more than 200 warnings.

The **Tasmanian Aquaculture and Fisheries Institute (TAFI)** was established in 1998 as a centre of excellence in marine science to support the development and sustainable management of Tasmania's living marine resources. TAFI's scientists are mostly fish biologists and modellers. However, working in combination with Tasmanian ICT companies, SciElex and Verdant, they initiated and shaped the development of ICT tools and associated measuring practices that are turning around the quality of the data available on fish stocks so that it reflects the true impact of fishing activities on the ecosystem.

The idea for the approach was conceived about 18 months ago and TAFI anticipates being in a position to provide robust advice regarding the status of abalone and some other fish populations (scallops, clams, urchins, banded morwong) to the Tasmanian Fisheries Department in another 3-5 years.

In 2003-04, Australia produced abalone worth $189 million, about half the total global abalone harvest. Tasmania, which started producing significant amounts of abalone in the 1960s, now accounts for 25% of the global abalone harvest. Australia's stake in the global market has significantly increased following the decline or disappearance of abalone populations in other parts of the world, including Japan, Mexico, Canada, South Africa and the US.

BlueLINK, developed by collaboration between CSIRO, the Royal Australian Navy and BOM will provide forecasts of what is happening at or near the ocean surface and in the upper two kilometers of the ocean.

The project outcomes will benefit the Navy by providing greatly enhanced support of onboard tactical response systems and potential cost savings for industries such as commercial shipping. For instance, The East Australian Current can reach up to four knots in spots which can significantly help or hinder a shipping vessel traveling between 10-20 knots either with or against the current. These vessels typically cost $50,000 or more per day to run so significant savings can be made with a better understanding of present and future ocean currents.

4. Many projects deliver social and environmental outcomes.

The beneficiaries of public ICT R&D are spread across the community and the value of these outcomes can only be measured in subjective terms. Whilst, in theory, it is possible to assess the value of this ICT R&D the process of evaluation is costly. Consequently little data is available. The anecodotal evidence available suggests that the social and environmental outcomes flowing from ICT R&D are significant.

The cases studied hinted at significant outcomes in the following areas. This list is not comprehensive. For instance, governments have also invested in the development of educational software for use in schools. This was not case studied due to time limitations.

Weather – The Bureau of Meteorology uses its ICT R&D capability to improve the accuracy and accessibility of its services. Recent innovations have included the production of an automated thunderstorm alerting service, available to the general public via the internet. The use of the Bureau’s website has approximately doubled every year between 2001 and 2005. The availability of this data will have social impacts in the community, enabling people to make decisions about social activities, driving etc. in a way that improves safety and general well-being.

Traffic Management – The case studies on CASR and SCATS demonstrated clear impacts on effective time-management of traffic and reduction of accidents. Social outcomes, in terms of stress reduction and improved health and well-being can be inferred.

Environment – Organisations such as BOM, CSIRO and others apply a variety of ICT R&D to address resource management (eg. Gravity Thickener in mining, TAFI in aquaculture) and to understand the impact of climate change. The Australian community places intrinsic value on the environment and this has been instrumental in this issue becoming a key government responsibility over the last 10-15 years.

Sport – The Australian Institute of Sport has invested in ICT infrastructure and ICT R&D as part of its strategy to be internationally competitive. The ICT R&D is delivering advantages in leading sports such as swimming (where it is used as a coaching tool in performance analysis). Sport is an important cultural and social priority for many Australian. Improved competitiveness in this area delivers social outcomes in self-esteem and well-being.

5. Public ICT R&D builds Australia's ability to work more efficiently and productively by transferring ICT skills, technology and research data.

The impacts of public sector ICT R&D projects are often diffused across many sectors and over many years. It is impossible to accurately quantify these impacts. This should be recognized so as not to grossly underestimate the current and future value of public ICT R&D already conducted. These indirect impacts occurs both within and outside of the ICT sector.

Outside the ICT sector – Generating and sharing research data
ICT R&D can be used to develop databases and other research tools to investigate a vast range of new or existing problems. These projects also build the ICT skills of people outside the ICT sector, which is likely to deliver productivity and efficiency gains.

- **ACCESS** - In a recent agreement between the Bureau of Meteorology and CSIRO, the two organisations have undertaken to develop the Australian Community Climate and Earth System Simulator (ACCESS), a state-of-the-science tool for examining climate change that models the physical interactions between the earth's terrestrial, oceanic and atmospheric systems, including a dynamic vegetation module. This tool is likely to yield long-term benefits in diverse sectors such as agriculture, ecotourism and health.

- **AADC -** The Australian Antarctic Data Centre (AADC) was established in 1996 to fulfil Australia's obligations under the Antarctic Treaty to make scientific observations and results from Antarctica accessible and freely available. AADC collects and manages Antarctic land, sea and atmospheric scientific data from Australian government agencies and makes it available on the web to researchers Intangible effects of this organisation's ICT activities have been:
    - More efficient use of research resources in science related to the Antarctica and marine environments
    - Expansion of public research capability through better availability of data for multi-disciplinary research
    - More extensive linking of Australian public marine researchers into international research
    - Better knowledge of Antarctic to underpin environment management, policy development and underpin Australia's claims to its Antarctic territory

    - Better knowledge of the seas to underpin the management of the marine environment, particular fish stocks, policy development and underpin Australia's claims to its EEZ, continental shelf and its resources
    - Enhancing the marine information relevant to Australia's defence.

- The **Capital Markets CRC** has made electronic markets data available to economics and finance through the *Research Application Service Provider* (RASP), and further enhanced Australia's reputation as a centre of excellence in securities market microstructure research.

Within the ICT sector - Skills and technology transfer
Virtually all research organizations case studied were involved in skills transfer through primarily postgraduate education, but also through undergraduate education in some instances. Some institutions, such as QUT's Information Security Institute tracked the placement of their students in employment, demonstrating that more than half of their PhD students took up jobs in Australia, evenly split between the public and private sectors. The commercial focus of QUT's postgraduate program also enabled some students to start-up their own businesses providing specialized e-security auditing services on completion of their degree.

Some organizations, such as DSTC and NICTA, transferred knowledge and skills by organizing summits and conferences on international technology developments and key national policy issues
.
Another avenue for technology transfer was collaboration with the SME sector through ICT procurement contracts. The Bureau of Meteorology and DSTO both had activity in this area. For instance, the Bureau worked with the Australian company Almos Systems to develop and roll-out Automatic Weather Stations. This procurement project built on BOM's ICT R&D in Automatic Weather Stations which demonstrated that current market offerings often lacked key software. Presumably Almos Systems could use this information to seek competitive advantage in international markets.

DSTO supports technology transfer between organisations by facilitating and funding collaborative projects that deliver ICT solutions to the Australian military. This project structure enables Australian SMEs and institutions such as CSIRO to exchange and extend their knowledge. DSTO's approach to satellite communications is a good example.

Satellite Communications in DSTO. DSTO and CSIRO have developed an antenna technology that enables simultaneous access to different frequency bands of satellite transmissions, greatly expanding the information transfer and situational awareness capabilities available to military users.

Multi-band feeds have already been in use for some time on large antennas, like those applied to radio astronomy and deep space mission tasks. The capability being developed for Defence was aimed at providing the same functionality in much smaller antennas, enabling the rapid deployment of such units to remote areas in support of operations.

CSIRO, which has been involved in building many of the larger systems, was included on the project to assist with the development of a compact, high-performance, low-cost, radio frequency (RF) technology suitable for military satellite communications applications.

DSTO developed the satellite earth terminal in partnership with several communications technology vendors, including EM Solutions in Brisbane which provided custom X-band and Ka-band equipment. CISCO (Adelaide) supported the final phase of the project, supplying much of the internet protocol (IP) telephony and router infrastructure used to demonstrate the terminal technology.

6. Public sector ICT R&D attracts international investment and collaboration. This has economic benefits and also builds Australia's ICT capability by acting as a conduit for leading edge skills and technologies from overseas.

International investment and collaboration can come in many forms. For instance, it can occur through co-investment in spin-offs, collaborative research or contract and consultancy. Many case studies demonstrated elements of this type of collaboration.

Investment by private sector ICT organizations in Australia is a particularly valuable form of collaboration. It has direct economic benefits and many intangible benefits (particularly in terms of skill and technology transfer). A key investor in Australia is SAP.

SAP is the world's leading provider of business software solutions. SAP Research is the research department of SAP and has research centres throughout Germany and in France, South Africa, Canada, UK, Switzerland, USA and in Brisbane, Australia. SAP employs 50 staff equivalent in its Brisbane office. The CEC Brisbane was established in 2001 and maintains an external network of approx 30 people including Small and Medium-sized Enterprise (SME) contractors, university academics and students.

One of the five research programs SAP has around the world is led by a Brisbane-based researcher. The SAP Research CEC Brisbane contains about 10-15% of SAP's global research infrastructure of IT engineering researchers. The centre provides approximately 20-40% of total SAP output such as patents and transfers of research results into SAP products. This is partly due to the strong relationship they have with the local universities. SAP Research, through the Australian Research Council (ARC) linkage program, undertakes collaborative research projects with Australian universities. SAP Research Brisbane sponsors scholarships at the University of Queensland (UQ) and the Queensland University of Technology (QUT).

SAP supports SAP Research Brisbane despite the Australian centre not receiving the same funding flows when investing in Europe. The SAP Research centres in Europe can apply for European Union funding whereby up to 50% of SAP's Research investment in projects is reimbursed. In Australia, only universities qualify for funding grants in linkage projects under Australian Research Council's framework - the industry partners are not eligible. Despite not being able to external government funding comparable to Europe or to qualify for R&D tax concessions, SAP Research is attracted to doing ICT R&D in Australia for many reasons. The available infrastructure and broadband capacity is considered good, while the Australian research landscape provides an excellent opportunity to establish and maintain sound working relationships with researchers.

7. Australia's ability to collaborate on international ICT projects is dependent on the country maintaining leading edge ICT R&D capabilities.

As a small country, Australia competes on the basis of strengths in niche areas. Public sector ICT R&D generates new niche capabilities and enriches existing ones. Niche capabilities are generated in a number of ways. Many institutions and generate new technologies by mining the skills, expertise and interests of their ICT researchers.

Codha Wireless - Cohda Wireless has headquarters in Adelaide, Australia and has US operations in Orlando, Florida. The company was founded in 2002 based on technology originally developed by researchers within the Institute for Telecommunications Research (ITR) at the University of South Australia. Cohda Wireless has developed a unique mobile broadband solution that provides high bandwidth communications to moving vehicles. This technology has a range of applications including emergency services whereby users can reliably send and receive broadband data, video and voice, even while driving in high speed emergency situations.

EpiTactix - EpiTactix was formed in 2004 as a spin-off company from CSIRO's ICT Centre. EpiTactix is developing new semiconductor technologies which enable new classes of advanced radio frequency and communications systems to be made. EpiTactix's technologies are based on compound semiconductor materials which have higher performance that common silicon based chips. The CSIRO had a history of working with semiconductors spaning at least 17 years but in 2001 the facility was closed as part of a refocusing of CSIRO research.

In addition to research funding, since it was established, EpiTactix has received $2.3 million funding from private investors to continue the support the first phase its business plan. This funding has been used to provide capital and staff and to facilitate the development and commercialisation of the EpiTactix technologies. Investors included Epicorp, an ICT Incubator under the Australian Government's **ICT Incubator Program;** SciVentures Investments; Seaspin and the Entrepreneurs in Residence (EiR). In-kind support has also been provided from CSIRO. EpiTactix visited the the United States in May 2006 to market the company's technology and ensure its adoption by major ICT companies. EpiTactix's intention is to raise $AUD 10-20 million to support the production of its new compound semiconductor technologies.

Governments have developed niche capabilities by investing strategically in projects that address specific government needs. Significant niche capabilities have developed in areas such as defence technology and environmental management. A defence example is provided below. (CSIRO and BOM's R&D in environmental modeling and management have been discussed earlier.)

Agent Oriented Software Pty Ltd - DSTO is a world leader in the use of artificial intelligence in the form of intelligent agents to represent human decision-making in combat simulation software. This technology enables DSTO to assess the effectiveness of ADF capabilities under simulated combat conditions. These assessments are then used to make informed decisions about current ADF capabilities and priorities for future development.

Agent Oriented Software Pty Ltd was established in 1997 with the objective of developing and marketing JACK Intelligent Agents™. Now in its fourth version, JACK is a proven, fully supported agent platform that includes JACK Teams – believed to be the only commercial team-modelling framework available in the world. DSTO was one of AOS' first customers and the strong relationship continues. AOS has close links with Australian public ICT R&D researchers, drawing much of its expertise from Australian research institutions. It continues a close relationship with RMIT in Melbourne.

AOS' close and successful collaboration with DSTO has been instrumental in the development of its core product, 'JACK Intelligent Agents™'and in its success in international defence markets. This is illustrated by the adoption of JACK by QinetiQ Limited in the UK, based on DSTO's experience with the product. QinetiQ's application is novel – building a mission management system for the UK Ministry of Defence to explore the use of autonomous teams of Unmanned Air Vehicles, a whole new market for agent-based software.

New niche capabilities will also arise from the multidisciplinary, user-focused business models gaining currency in the public ICT R&D sector. Some of these niche capabilities may result in the development of new internationally-competitive technologies. The Nimrod example provided below demonstrates how user-focused business models can generate new technologies with much greater impacts than originally envisaged.

NIMROD

Professor David Abramson joined the CRC DSTC in the mid-1990s, bringing expertise in computer architecture and high performance computing research. Whilst at DSTC Professor Abramson and his colleague, Mr Rok Sosic, were tasked with assisting the Victorian Environment Protection Authority to predict pollution patterns using computer modelling. Abramson and Sosic developed a parametric modelling tool for the task, which they called Nimrod. They recognised that complex parametric modelling experiments would require access to a considerable level of computing power that was not readily available to the majority of research organisations and businesses, and came up with the solution of clustering PCs.

Nimrod facilitates clustering by incorporating a distributed scheduling component that can manage the scheduling of individual experiments to idle computers in a local area network. The flexibility of the Nimrod system was demonstrated by the successful linking of PCs to model the growth of cattle tick infestations across Australia.

The commercial potential of the Nimrod system was realised with the development of commercial grade software, Clustor™, which became the basis for DSTC's first spin-off company, Active Tools, in 1997. International users of this technology include J.P. Morgan, Procter and Gamble and CBS News.

Following the development of Clustor™ Sosic and Abramson proceeded with the commericalisation of debugging software, entitled Guardsoft. (This was not a DSTC project).

Professor Abramson, now based at Monash University, has continued developing the Nimrod technology and the project is an affiliate of the Globus alliance (a leading international organisation facilitating collaboration in grid computing research). Grid computing is a developing area for international research with huge potential for delivering economic benefits through better utilisation of resources. Professor Abramson's involvement in grid computing is a useful channel for transferring international developments in this technology to Australia. He continues to develop new technologies for grid computing with commercial potential, such as GriddLes (a tool that facilitates the construction of complex Grid application using legacy software components, thereby making use of the billions of lines of existing source code in new grid applications).

E-RESEARCH

e-Research[68] involves an evolving new capacity for large-scale, distributed, global collaboration in research, providing a new level of scope, scale and detail. It entails harnessing the capacity of ICT systems, particularly the power of high-capacity distributed computing, and the vast distributed storage capacity fuelled by the constant dropping cost of memory, to study complex systems across the research landscape. It has a number of components:

- access to very large data collections,
- complex simulations,
- high performance visualisation , and
- virtual research organisations involving researchers distributed geographically.

This new methodology, which combines the potential of ICT systems, with multi-disciplinary collaborative research among researchers distributed geographically, is a powerful new paradigm of research endeavour. Such new paradigm intends on breaking down traditional barriers among researchers across a number of disciplines, and allow them to work on challenging and interesting problems hitherto not possible because of limitations on the bringing the ICT infrastructure together.

While e-Research is relatively new as a structured concept, it is starting to underpin all scientific disciplines including the social sciences and humanities. It is also emerging as a significant element in advancing the Information Economy more broadly because of the strong symbiotic relationship between e-Research and e-transformation more generally. Consequently, it is hard to exaggerate the long-term importance of these developments for research and for economic development. For example, the Blue-Ribbon Advisory Panel on Cyberinfrastructure of the US National Science Foundation (NSF)[69] recently reported on these trends in the following terms:

> "*Recently, multiple accelerating trends are converging and crossing the threshold in ways that show extraordinary promise for an even more profound and rapid transformation – indeed a further revolution – in how we create, disseminate and preserve scientific and engineering knowledge. . . . In numerous fields new distributed-knowledge environments are becoming essential, not optional, for moving to the next frontier of research. Science and engineering researchers are again at the forefront in both creating and exploiting what many see as a nascent revolution and a forerunner of new capabilities for broad adoption in our*

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[68] While the term is used interchangeably with "e-science", the use of "e-research" emphasises its broader application.

[69] The US National Science Foundation is an independent agency of the U.S. Government, established by the National Science Foundation Act of 1950 to promote the progress of science; to advance the national health, prosperity, and welfare; and to secure the national defence. The National Science Board is its governing body. It is responsible for US national science policy and also performs a role similar to ARC.

knowledge-driven society. The opportunity is enormous, but also enormously complex, and must be approached in a long-term, comprehensive way. . . .

In the future we might expect researchers to

- *Combine raw data and new models from many sources, and utilize the most up-to-date tools to analyze, visualize, and simulate complex interactions.*
- *Collect and make available far more information . . . leading to a qualitative change in the way research is done and the type of science that results.*
- *Work across disciplinary boundaries. . .*
- *Simulate more complex and exciting systems . . .*
- *Access the entire published record of science online.*
- *Make publications incorporating rich media (hypertext, video, photographic images).*
- *Visualise the results of complex data sets in new and exciting ways, and create techniques for understanding and acting on these observations.*
- *Work routinely with colleagues in distant institutions, even ones that are not traditionally considered research universities, and with junior scientists and students as genuine peers, despite differences in age, experience, race, or physical limitations."*[70]

The report believed that the time was ripe for NSF to accelerate this revolution for the benefit of society. The report warned, however, that there are significant risks and costs involved in a failure to effectively coordinate e-Research activity:

e-Research has the potential to produce significant economic benefits in such areas as agriculture, environment, health, finance, mining and manufacturing. The skills and know-how created, and knowledge captured, will all contribute to Australia's capacity to exploit advances in leading technologies and will determine our competitiveness. Given the internationally distributed nature of research that these technologies are promoting, an active and receptive e-research programme is essential if Australia is to participate on a serious and equal basis in science and research more generally. Importantly, appropriate investment in e-Research has the potential to promote a virtuous cycle of innovation.

Consequently, the Government has very strong reasons to ensure that Australia participates effectively in e-Research. This will require not only the provision of the necessary physical infrastructure but equally important, the necessary coordinating and governance mechanisms. As *Revolutionizing Science and Engineering Through Cyberinfrastructure* reported "a program in this area should be interagency and international. It must address very complex interactions between scientific, technological, and sociological challenges and opportunities."

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[70] Revolutionizing Science and Engineering Through Cyberinfrastructure: Report of the National Science Foundation Blue-Ribbon Advisory Panel on Cyberinfrastructure, January 2003. The Report goes on to explain that simulations have begun to match the complexity of the real world, with fully three dimensional, time-dependent modelling with realistic physical models, opening up a vast range of problems to qualitative attacks.

The development of this capability has much wider implications beyond the science community. e-Research is providing the advanced platforms, the experience and the organisational structures that will be essential in the longer term in such areas as e-government, e-health, e-information and e-security.

In this regard it is important to recognise that Australia had already provided the investment funds for most of the physical infrastructure required. Thus the issues for Australia are how to exploit that installed physical infrastructure most effectively by establishing the appropriate institutional and governance frameworks, incentives for rapid adoption of this new research paradigm by researchers, and how to leverage overseas experience and facilities.

The e-Research Coordinating Committee

In April 2005, the e-Research Coordinating Committee was established jointly by the Minister for Communications, Information technology and the Arts and the Minister for Education, Science and Training to provide expert advice to the Government about developing Australia's e-Research capacity. The objectives of the Committee were to:

- provide the Australian Government with a strategic framework to establish an informed e-Research agenda;
- engage the interest, knowledge and enthusiasm of stakeholder groups in the development of an e-Research agenda; and
- establish an overarching strategic policy framework, and an implementation process to achieve optimum investments.

The Committee has now submitted its Final Report: *An Australian e-Research Strategy and Implementation Framework*, to the Government following extensive consultations in conjunction with the National Collaborative Research Infrastructure Strategy (NCRIS) Committee.