Creating Western Australia's Knowledge Infrastructure: Towards Global Competitiveness and High-Value Employment

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Foreword

The last half of the Century has seen massive changes in the global economy which have, in turn, driven transformations in the Western Australian economy. Some industries, like whaling, have disappeared. Others, like the wool industry, are shadows of their former glory. The resources boom and North West Shelf developments are among a range of new activities that have supported wealth creation over recent years, whilst the global information and communications technology revolution is enabling further change by transforming how business is conducted.

In 1999, TIAC commenced a series of reports under the title, *"Towards a Western Australian Knowledge Economy"*. The lead report of this series was entitled, *"Drivers and Shapers of Economic Development in Western Australia in the 21st Century"* (see Appendix 4).

In 2002, TIAC commenced work on a sub-section entitled, *"Creating the Knowledge Infrastructure"*. This is the second report debating the knowledge infrastructure development.

TIAC is mindful and supportive of the State's fiscal discipline with respect to the recommendations made in this document. The recommendations are made with the objective of assisting the Western Australian government to develop policy in order to optimise economic development in Western Australia over the next decade.

I would like to thank The Allen Consulting Group for their help in undertaking research and analysis and in supporting the TIAC Steering Committee in the development of this report.

Sharon Brown
Chair, Steering Committee

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Executive Summary

The Importance of the Knowledge Infrastructure to Western Australia's Future

Obtaining value from the creation, sharing and use of knowledge is becoming an increasingly dominant factor in determining which economies prosper and which do not.

A transition is underway in developed economies around the world that is changing the fundamentals of economic performance and prosperity. Put simply, obtaining value from the creation, sharing and use of knowledge is becoming an increasingly dominant factor in determining which economies prosper and which do not. This capacity for systemic "innovation" is set to be a differentiator of competitive performance of countries and of regions for the foreseeable future.

Western Australia is not immune. The need to create a strong and vibrant Western Australian knowledge economy with high quality "knowledge infrastructure" as its foundation should be seen as both a challenge that has to be met and an opportunity that should be grasped.

Western Australia is not immune from this. The need to create a strong and vibrant Western Australian knowledge economy with high quality "knowledge infrastructure" as its foundation should be seen as both a challenge that has to be met and an opportunity that should be grasped. Ultimately, the State's success or otherwise in this regard will have a marked bearing on the future quality of life experienced by all West Australians.

The challenge for Western Australia in terms of positioning itself in the global knowledge economy can be stated in terms of three propositions:

- using knowledge to add value to the State's traditional industries;
- using and sharing knowledge to create new businesses; and
- connecting the State to global knowledge networks.

What is the 'knowledge infrastructure' anyway?

Knowledge infrastructure is the people, institutions and processes, and the linkages between them, which combine to provide the essential building blocks for creating and transforming ideas into tangible economic performance.

Knowledge infrastructure is defined as the people, institutions and processes, and the linkages between them, which combine to provide the essential building blocks for creating and transforming ideas into tangible economic performance.

Creating, building and developing knowledge infrastructure (such as the education and training system, research institutions and facilities, information and communications technology (ICT) systems as well as more intangible infrastructure such as clusters of elite researchers, technologists, teachers and business entrepreneurs and national and international networks and linkages) is neither a quick nor easy process. Success requires a long term and ongoing commitment and investment by governments, business and the community more generally, and where the terms "partnership", "cooperation" and "collaboration" have to be given tangible expression. There are few, if any, shortcuts.

Adopting a Global Perspective

Western Australia needs to be aware of and measure itself against world's best practice, recognising it is the global market more so than the national market that will ultimately determine Western Australia's prospects.

The reality is that Western Australia must find its place within the global economic system and, in this context, a "draw globally, adjust and apply locally" approach is an appropriate way of thinking about knowledge infrastructure creation. There are many international "exemplars" for use as reference points. This report (in Section Two) identifies some of these exemplars as being of practical relevance to Western Australia.

There is an understandable inclination for Western Australia's performance in the development of the innovation system and creation of knowledge infrastructure to be modelled on or compared against other jurisdictions in Australia, particularly those with similar natural endowments and/or economic characteristics (and against the national average). While such comparisons are appropriate up to a point there is a bigger picture to consider. Western Australia needs to be aware of and measure itself against world's best practice, recognising it is the global market more so than the national market that will ultimately determine Western Australia's prospects.

There is no external "blueprint" that can be replicated directly in the Western Australian context. The imperative is to discern and distil the key characteristics from elsewhere that are applicable to the Western Australian situation and seek to apply them intelligently by taking account of cultural, institutional and resource endowment differences.

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The Current State of Western Australia's Knowledge Infrastructure and Innovation System

Western Australia has a reasonably sound infrastructure platform but there are also gaps and some weaknesses.

Western Australia has a reasonably sound infrastructure platform for developing a knowledge economy, but there are also gaps and some weaknesses.

Western Australia has a well developed education and training infrastructure with evident high literacy and numeracy standards and performance. There are, however, weaknesses in participation levels, in particular, participation in higher education. Western Australia's research and development base is diverse with internationally recognised excellence in a number of areas. However, the research system as a whole is fragmented and lacks critical mass when considered in global terms.

The major areas of concern are participation rates in the education system, fragmentation and lack of critical mass in the R&D system, immature state of commercialisation infrastructure and availability of higher bandwidth ICT infrastructure.

The commercialisation infrastructure is less well developed and, as evidenced by indicators such as royalties and patents, commercialisation performance is lacklustre. The ICT network infrastructure is also an area of particular concern in respect of the variable availability (and, in some instances, affordability) of infrastructure capable of carrying higher bandwidths.

Building Western Australia's Knowledge Infrastructure – Key Messages?

The Western Australian government has recognised the challenge to the State's future prosperity represented by the need to increase the State's innovative capability. There are a significant number of government initiatives in place or in progress relating to Western Australia's knowledge infrastructure, most notably the Innovation Fund announced by the Premier in 2002, involving a commitment of $50 million over five years.

Notwithstanding the range of initiatives being undertaken and the investments already made, there remains a major long-term challenge to achieve the goal of a globally competitive Western Australian knowledge economy characterised by a highly skilled, high value workforce.

Notwithstanding the range of initiatives being undertaken and the investments already made, there remains a major long-term challenge to achieve the goal of a globally competitive Western Australian knowledge economy characterised by a highly skilled, high value workforce. This report highlights key messages and proposes recommended actions considered to be priorities and, in some cases, requiring urgent attention.

Setting Clear Strategic Directions and Goals

It is difficult to understate the importance of the government communicating effectively to the Western Australian community the key concepts, strategies and specific plans of action being pursued in building the State's knowledge infrastructure, and the benefits of doing so.

Even some stakeholders directly involved with the government's innovation initiatives are unsure of many aspects of the government's agenda and strategy.

It is too easy for discussion and debate concerning innovation and knowledge infrastructure creation to take on the character of a technical treatise that sounds more concerned with means than ends and runs the risk of being impenetrable to many in the community and therefore misunderstood, ignored or rejected as irrelevant to their needs.

What has not yet been conveyed to intended audiences is a sense of a coherent strategic plan of action or "game plan" for the development of the State's innovation system and how this needs to be pursued in order to achieve the goals set (e.g. a high value workforce and global competitiveness) and the benefits this is expected to generate for the State.

Investigations conducted as part of this study have shown that even stakeholders directly involved with the government's innovation initiatives are unsure of many aspects of the government's agenda, even more so in respect of the overall strategy being pursued and its connection to business competitiveness and the State's economic prosperity.

In particular, what has not yet been conveyed to intended audiences is a sense of a coherent strategic plan of action or "game plan" for the development of the State's innovation system and how this needs to be pursued in order to achieve the objectives set (e.g. a high value workforce and global competitiveness) and the benefits this is expected to generate for the State.

Ensuring Effective Intra-Governmental Coordination Arrangements

The government needs to satisfy itself that its current inter-governmental arrangements are optimal.

The way the Western Australian government seeks to manage its own knowledge infrastructure affairs (and is perceived to do so by other stakeholders) will have a major bearing on the success or otherwise of actions designed to influence others outside government to contribute strongly to knowledge infrastructure creation. The government needs to satisfy itself that its current inter-governmental arrangements are optimal.

Some of the main messages to emerge include:

There is no clearly established Ministerial authority concerning knowledge infrastructure matters and, by implication, no visible "product champion".

- There is no clearly established Ministerial authority concerning knowledge infrastructure matters and, by implication, no visible "product champion", also leading to bureaucratic lines of responsibility/authority being unclear.
- Opaqueness concerning the makeup and functional arrangements of Cabinet sub-committees makes it difficult to discern how the government would deal with innovation and knowledge infrastructure matters that required Executive decision but were not the focus of an expenditure proposal (i.e. under the Expenditure Review Committee) or requiring full Cabinet consideration in the first instance.

It is not apparent to what extent, if at all, there is a functional whole-of-government coordination/networking system in place that links advisory bodies.

- It is not apparent to what extent, if at all, there is a functional whole-of-government coordination/networking system in place that links advisory bodies and/or integrates their advice.
- Existing structural arrangements are somewhat redolent of "ministry silos" with cross portfolio coordination, to the extent it does occur, being heavily focused at the decision making level (i.e. between Ministers and their respective Ministerial offices).

Establishing a more coherent and transparent "whole-of-government" set of coordination responsibilities and arrangements should be investigated.

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Improving Government Programs and Services

Not all programs and initiatives relating to knowledge infrastructure would "pass muster" according to effectiveness and efficiency criteria.

There is an array of existing Western Australian programs and initiatives relating to knowledge infrastructure. The results of this study suggest that not all programs would "pass muster" according to effectiveness and efficiency criteria.

Quite a number of programs are small and administratively costly while others have not been or are not currently subject to regular review (including in the context of current or prospective infrastructure priorities).

There is apparent fragmentation of effort, leading to concerns about whether sufficient critical mass exists in key areas for effective results to be produced (even if program objectives and mechanisms are appropriate).

Taken in aggregate, there is apparent fragmentation of effort, leading to concerns about whether sufficient critical mass exists in key areas for effective results to be produced (even if program objectives and mechanisms are appropriate).

Building and Retaining Skills

Good quality graduates are being produced but there is nevertheless a supply shortfall in key disciplines.

People are integral to the success of the knowledge economy. Skills acquisition, development and retention, creativity and entrepreneurship (the State's human capital) are the 'engine' which drives it. Education and training is thus an issue of fundamental importance.

There are a number of features and strengths of Western Australia's education and training system that are important in it potentially fulfilling a pivotal role in knowledge infrastructure creation (a track record of maintaining high standards in secondary student education, a TAFE system which is market oriented and has generated a number of innovative learning platform models, and universities strong in a number of disciplines). However, education and training is an area of differing perspectives and strong opinions. Some of the key messages are:

- While Western Australia is producing good quality graduates, particularly in areas where the State is strong (e.g. engineering and physical sciences) there is nevertheless a supply shortfall in these disciplines.

In secondary education there is a need to balance increasing retention rates with skills development, including the linkage to tertiary entry requirements and industry needs.

- In respect of secondary education, the need is to strike a balance between increasing retention rates and skills development, including the linkage to tertiary entry requirements and industry needs. This necessitates increased interaction between business and curriculum developers.
- A potential disjunction exists between education as an industry (i.e. students as a revenue stream in an educational export business model versus students as participants and partners in a life-long relationship with Western Australia and the universities they attend).

Enhanced production of high level skills in entrepreneurship and innovation management is required as a complement to science and technologies skills development.

- There is a demonstrable need for enhanced production of high level skills in entrepreneurship and innovation management as a complement to science and technologies skills development.

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Clearly, some serious issues need to be addressed if the contribution of Western Australia's education and training system to knowledge infrastructure creation (in terms of scale and quality required for global relevance) is to be realised.

Clearly, some serious issues need to be addressed if the positive features and strengths of Western Australia's education and training system are not to be compromised and its potential contribution to knowledge infrastructure creation (in terms of scale and quality required for global relevance) is to be realised. Foremost among these is breaking down a propensity to not think and act beyond the bounds of the corporate objectives of the individual entity (whether it be at the level of an individual university faculty or at the level of organisations/institutes as a whole).

It is difficult not to draw comparisons between the situation pertaining to international exemplars referred to in Section 2 and that of Western Australia. The apparent differences epitomise why Western Australia has some way to go to approach the level of world's best practice and be regarded as an exemplar for others.

Building Critical Mass and Linkages

Innovation system participants tend to seek their own diverse goals in isolation from one another - "silo thinking", a "linear" rather than an "ecosystem" approach and an inability/unwillingness to break out of sectoral bounds.

A consistent message to come out of this study is the need for greater attention to, and improvement in, building critical mass and strengthening linkages within the innovation system in Western Australia.

During public consultations, it was revealed that innovation system participants in Western Australia tended to seek their own diverse goals in isolation from one another. For example, prevalent "silo thinking", a "linear" rather than an "ecosystem" approach and an inability/unwillingness to break out of sectoral bounds were but a few of the descriptions proffered.

Coupled with Western Australia's research and development expenditure, an indicator of innovation, being low by national and international standards, this fragmentation of effort means the deck is stacked against Western Australia achieving critical mass and effective linkages unless there is a circuit breaker.

The prevailing view amongst stakeholders seems to be that the government needs to take steps to show it is serious about fostering a collaboration culture in the State without stifling beneficial competition.

The prevailing view amongst stakeholders seems to be that the government needs to take steps to show it is serious about fostering a collaboration culture in the State without stifling beneficial competition. It is also apparent that there is widespread support for the government taking a leadership role in bringing relevant stakeholders together (i.e. as convenor/facilitator) focused on developing a tangible initiative that would build on and extend from the State's acknowledged economic strengths and existing clusters and networks.

Attracting and Securing Investment

The ability to attract investment and to secure reinvestment from outside Western Australia (by ensuring that capability is strongly "embedded") is an important aspect of building Western Australia's knowledge infrastructure. In the same way, fostering strong growth in knowledge infrastructure investment from within the State (both public and private) is also fundamental.

A challenge for the government is getting to a position of being able to make informed decisions about what are worthwhile investments.

A challenge for the government in the context of securing high quality investments in knowledge infrastructure is getting to a position of being able to make informed decisions about what are worthwhile investments and how valuable they are in terms of the benefits they are likely to contribute to Western Australia. This becomes a particular area of concern and importance when the government is either approached by external parties or proposals arise from within the government system to financially support a particular knowledge infrastructure investment or proposition.

There is an absence of coherent decision criteria supported by a defined and rigorous evaluation process for dealing with investment proposals.

There is currently an absence of coherent decision criteria supported by a defined and rigorous evaluation process for dealing with such cases. The risk of not addressing this issue is that government consideration of investment proposals could become ad hoc and inconsistent (relatively and in the context of government policy frameworks/settings).

There needs to be an appropriately assigned body to represent the Western Australian government in external negotiations and in coordinating whole-of-government assessments of investment proposals.

There also needs to be an appropriately assigned body to represent the Western Australian government in external negotiations and in coordinating whole-of-government assessments of investment proposals, recognising that in most instances it is neither appropriate nor prudent for such dealings to involve Ministers.

Developing Clusters

There are relatively few well established and globally competitive clusters in Western Australia.

There are relatively few well established and globally competitive clusters in Western Australia. However, competitive clusters that are recognised and regarded as such do exist in mining and energy and in agri-food. There also appears to be some other 'emergent' clusters (such as in environmental services, biomedical services, and maritime and defence engineering).

To date there appears not to have been any focused attempt to 'map' Western Australia's existing or emergent clusters (e.g. against world's best examples) as a basis for validating assumptions about what they actually comprise and for guiding governmental action directed at facilitating their further development.

However, to date there appears not to have been any focused attempt to 'map' Western Australia's existing or emergent clusters (e.g. against world's best examples) as a basis for validating assumptions about what they actually comprise and for guiding governmental action directed at facilitating their further development. This is important for a number of reasons, including in determining what role technology parks or enterprise precincts can/should play in cluster formation and development (recognising the government's previous and possible future investments in this area).

Strengthening ICT Networks

ICT network infrastructure in Western Australia is currently not of sufficient quality and coverage to make it a key driver or enabler of innovation.

The existence of a functional and robust ICT network is an essential infrastructure component, not just from the perspective that ICT companies potentially represent important high skill, high wage employers, but also because they are the providers of products and services that are the enablers for other sections of the knowledge economy to communicate and operate.

ICT network infrastructure in Western Australia is currently not of sufficient quality and coverage to make it a key driver or enabler of innovation. It is suggested that there is not a lot of options for government in seeking to upgrade the State's ICT networks or to stimulate the industry to take similar action (i.e. encourage carriers to invest) that would not either involve major public expenditure and/or result in market distortions.

A forthcoming TIAC report (Broadband Bandwidth in Metropolitan WA) deals specifically with ICT network issues.

This is not to say the government should do nothing. Noting that another forthcoming TIAC report (*Broadband Bandwidth in Metropolitan Western Australia*) deals specifically with ICT network issues, there are actions that could be taken that would have a positive long-term effect without significant public expenditure or market intervention, such as in the area of urban and industrial planning.

Improving Leverage Potential with National Programs and Initiatives

Western Australia has not been particularly successful over recent years in securing what is considered to be a satisfactory proportion of national program resources

Western Australia has not been particularly successful over recent years in securing what is considered to be a satisfactory proportion of resources available from national programs, except in areas such as agriculture and resources.

A variable appreciation of joint venture and alliance building as a winning strategy in competitive bidding processes, coupled with variability in the skill sets of researchers concerning preparation and presentation of high quality bids, is hampering Western Australia's performance in securing Commonwealth funding.

There is a highly variable appreciation and regard for joint venture and alliance building as a winning strategy in competitive bidding processes, which tend to be the predominant character of Commonwealth programs relating to innovation. This, coupled with variability in the skill sets of researchers concerning preparation and presentation of high quality bids, is hampering Western Australia's performance in securing Commonwealth funding.

There is also, paradoxically, evidence of a tendency for many Western Australian research bodies to be overly preoccupied with securing Commonwealth funds. While perhaps understandable in the circumstances of Western Australia's relative underperformance in this respect, this does, however, have the potential to divert attention away from research which is integral to achieving the primary mission of research bodies.

Opportunities should only be pursued if they are consistent with strategic intent. Such opportunities are more likely to be of this character where the Western Australian research agency is able to develop a "partnership" with the Commonwealth agency.

Developing International Linkages

An "alumni" approach to creating and extending Western Australia's international networks has been suggested as one potentially highly effective, relatively low cost means of extending Western Australia's "sphere of influence".

The establishment and maintenance of effective networks lies at the centre of the most successful knowledge economies. While there are a number of ways of building international linkages, an "alumni" approach to creating and extending Western Australia's international networks has been suggested as one potentially highly effective, relatively low cost means of extending Western Australia's "sphere of influence". It also has relevance for attracting talent and investment.

It is apparent that there is quite an extensive informal, if fragmented, network of Western Australian expatriates, many in very senior research, business and other roles, spread around the globe. Taking steps to establish an encompassing and systematic approach to tracking, informing and interacting with expatriates who are associated with the knowledge economy and who are familiar with or have connections to Western Australia is regarded as worthy of investigation.

Measuring and Monitoring Performance

Integral to a strategic approach to building Western Australia's knowledge infrastructure has to be serious ongoing attention to measuring and monitoring performance. This has not been a feature of the Western Australian system to date.

Integral to an emphasis on adopting a strategic approach to building Western Australia's knowledge infrastructure has to be serious ongoing attention to measuring and monitoring performance. This has not been a feature of the Western Australian system to date.

Performance measurement and monitoring needs to operate effectively at two levels. At the "macro" level it involves measurement of progress in Western Australia's knowledge infrastructure creation and of outcomes that can be attributed to the "investments" made (such as in relation to high-value jobs created, discernible improvements in business performance and competitiveness and broader economic results in relevant industries or the economy as a whole). The Porter-Stern framework for measuring the innovation capacity and performance of an economy (as discussed in Section Two).

At the "macro" level this involves measurement of progress in Western Australia's knowledge infrastructure creation and of outcomes that can be attributed to the "investments" made (such as in relation to high-value jobs created, discernible improvements in business performance and competitiveness and broader economic results in relevant industries or the economy as a whole).

At the "micro" level (i.e. in respect of individual programs or initiatives) the imperative is to have performance measurement and monitoring integrated in their design and operation as the basis of a transparent and recurrent evaluation/review methodology. Performance measurement needs to focus on both effectiveness (i.e. measuring outcomes achieved against goals and objectives set) and efficiency (i.e. measuring program/initiative outputs relative to the administrative cost of delivering them).

Recommendations

The Technology and Industry Advisory Council (TIAC), being mindful and supportive of the government's fiscal policy, makes the following recommendations.

Setting Clear Strategic Directions and Goals

Recommendation 1

The West Australian government, as part of its innovation policy statement, set out clearly defined goals in respect of building Western Australia's knowledge infrastructure and the details (principal initiatives and mechanisms) of a strategic plan of action by which it will seek to achieve them.

Ensuring Effective Intra-Governmental Coordination Arrangements

Recommendation 2

The Western Australian government assign explicit Ministerial responsibility for knowledge infrastructure matters, carrying with it the responsibility for developing and implementing effective 'whole-of-government' (including inter-Ministerial and inter-agency) coordination/networking arrangements.

Improving Government Programs and Services

Recommendation 3

The Western Australian government consolidate available resources into an integrated set of key programs which have (i) clear objectives relating to agreed policy priorities (ii) appropriate scale (iii) low administrative overheads (iv) strong inter-program and external synergies and (v) clear evaluation and review arrangements.

Recommendation 4

The Minister for State Development recommend that the Department of Industry and Resources extend the online innovation portal known as the 'WA Centre for Innovation' into a full 'one stop' entry point for external stakeholders (i.e. a 'hub' for government information) to (i) consolidate, synthesize and disseminate information on Western Australia's innovation system (ii) act as a repository for relevant national/international developments and (iii) act as both a physical as well as virtual (i.e. online) 'portal' for stakeholders concerning innovation system and knowledge infrastructure issues.

Building and Retaining Skills

Recommendation 5

The Western Australian government take action to encourage the graduate business schools in the Western Australian universities to collaborate to establish an internationally recognised and regarded (i.e. a "WA brand") post graduate course with a curriculum focus on entrepreneurship and innovation management in a global knowledge economy and the outcomes achieved in this process be used as a basis for assessing other potential collaborative initiatives in the Western Australia education sector.

Recommendation 6

The Western Australian government investigate vocational training models (i.e. learning platforms) such as those being developed by some of the TAFE's (e.g. Central TAFE's 'The Design Centre' pilot program to provide real and virtual vocational training solutions for industry) for their relevance in the context of creating the research incubator/knowledge hub proposed in Recommendation 8.

Building Critical Mass and Linkages

Recommendation 7

The Western Australian government incorporate in the eligibility criteria for State funding of research programs and initiatives a requirement that all collaborative opportunities and pathways have been fully investigated by prospective recipients as a basis for awarding funds and that where funding is awarded on the basis of a collaborative initiative there be a mechanism to ensure collaboration continues after the funds are provided.

Recommendation 8

The Western Australian government develop a proposal, in collaboration with Western Australian universities, vocational training bodies, research institutes and potential business participants/sponsors, for establishment of a 'research incubator' modelled on successful international examples (such as Yamacraw in Georgia in the USA referred to in Section 2 of this report) that would (i) act as a 'knowledge hub' (ii) provide a focus for research collaboration and commercialization (iii) link research and training to business/market opportunities and (iv) assist growth in knowledge-intensive areas according to market determinants.

Attracting and Securing Investment

Recommendation 9

The Western Australian government, through the Departments of Premier and Cabinet, Treasury and Finance, Industry and Resources and Education and Training, develop decision criteria (for consideration by Cabinet) and which, once agreed, will be made public and used by the Western Australian government to guide its decisions in respect of major investments in the knowledge infrastructure (i.e. those requiring an explicit government decision at Cabinet or Ministerial level).

Recommendation 10

The Western Australian government give consideration to appointing/assigning a person or body to represent the Western Australian government in non-Ministerial liaison/negotiation with the Commonwealth government in relation to major knowledge infrastructure investment/development proposals and in this context, to be a coordinator of inputs and advice to the Western Australian government decision making process on such matters.

Developing Clusters

Recommendation 11

The Minister for State Development recommend that the Department of Industry and Resources undertakes work to 'map' Western Australia's existing and emergent clusters so that their substantive makeup and characteristics can be described in sufficient detail to assist policy making and public communication concerning their relevance and potential contribution to a Western Australian knowledge economy.

Strengthening ICT Networks

Recommendation 12

The Western Australian government through the Department of Planning and Infrastructure, in consultation with Landcorp, Western Power (incorporating Bright Communications) and other relevant agencies collaboratively review the arrangements governing the development of industrial and residential land with a view to determining the extent of any impediments (such as legislative, planning or financial) to installing 'broadband ready' infrastructure (e.g. conduit fibre optic cables) as part of the development process, in order to ensure that all government sponsored and funded developments are 'broadband ready'.

Improving Leverage Potential with National Programs and Initiatives

Recommendation 13

That the Minister for State Development recommend that the Department of Industry and Resources develop and maintain a "tool kit" for prospective applicants for Commonwealth programs and establish a dedicated advisory service (potentially in association with the proposed establishment of the "one stop entry point" initiative at recommendation 4), with a view to improving the capacity of Western Australian applications achieving success in competitive bidding processes.

Developing International Linkages

Recommendation 14

The Western Australian government support the establishment and maintenance of a Western Australian alumni database and network (focusing on expatriate graduates and postgraduates from Western Australian universities and elite researchers/technologists, teachers and business leaders/executives with experience of Western Australia), with a view to developing a global network of contacts with connections to/appreciation of Western Australia, supported by an online information service.

Measuring and Monitoring Performance

Recommendation 15

The Minister for State Development recommend an annual "State of Knowledge Infrastructure in Western Australia" report, be prepared and publicly released by the Department of Industry and Resources, either as a stand alone volume or as part of a broader compendium, such as "The State of Western Australia's Innovation System". The report should be set against the best practice principles set out in Section 5.1 and should incorporate chapters on (i) high-value jobs created (ii) a description and, where appropriate, measurement of, the cost of and benefits derived from programs and initiatives taken by the government during the period and (iii) a performance assessment of Western Australia's knowledge infrastructure and innovation system, based on the Porter-Stern or other appropriate methodology, against relevant international benchmarks.

Section One

The Importance of the Knowledge Infrastructure to Western Australia's Future

1.1 The Knowledge Economy

The starting point for considering knowledge infrastructure and its importance to Western Australia's future is to understand the forces now at work in OECD countries and elsewhere in driving and characterising economic development. Three fundamentally important drivers are:

- the globalisation of the world's economies which increases competition and places a premium on knowledge as a source of competitiveness;
- the increasing importance of research, science, innovation and technology in knowledge creation; and
- the use of computers and the Internet to generate, share and apply knowledge.

Knowledge is the key to the emerging economy.

During the 1990s an important body of literature emerged dealing with the transition of OECD economies to knowledge economies. Increasingly, the OECD economies are making the transition from a situation in which physical capital and raw materials were the major determinants of industrial development and living standards to one in which knowledge and intangible capital are increasingly recognised as being the dominant factors for economic development within the emerging knowledge economy.[1]

There have been two major lines of thought which have led to this conclusion. The first being new growth theories particularly associated with the American economist, Paul Romer.[2] The starting point for his analysis was the fact that instead of convergence taking place between the growth rates of nations — with high income countries tending to have a slowing rate of growth and low income countries tending to have an increasing rate of growth — the reality was that the high income countries tended to experience continuing strong growth, while most lower income countries continued to experience comparatively slow rates of growth. Only a relatively small number of countries were able to make the transition from the low income to high income group of countries.

The essential conclusion reached by Romer and others was that the lack of convergence observed in reality was due to the fact that economic growth was internally generated and as such, a country's basic capabilities in education and research and development set up a virtuous cycle reinforced by positive spillovers associated with the generation, sharing and use of knowledge.

A second and reinforcing line of thought which places the spotlight on the role of innovation has emerged from the consideration of the relative performance of high income countries and regions in raising their per capita incomes in the last decade or so. An important finding has been that in general, those countries and regions that have performed better have invested strongly in strengthening the capability of their innovation systems.

[1] See for example, OECD, 1996, *The Knowledge-Based Economy*, OECD Paris.
[2] See Romer, P,1990, "Endogenous Technological Change" , *Journal of Political Economy*, 98:71-102.

At the outset of this study, it is useful to provide a definition of what is meant by the knowledge economy. Our preferred definition is that a knowledge economy is one where creating, sharing and using knowledge are key factors in the creation of high value jobs, wealth and the improvement in the quality of life. Knowledge increases the value of equipment, workers, firms and public bodies.

The definition of the knowledge economy rests upon the conception of knowledge itself. A useful definition of knowledge is *familiarity gained by research and experience*.[3]

Within the context of this study, four aspects of knowledge are important. These may be described as *knowing what* (knowing facts), *knowing why* (understanding fundamental phenomena and cause and effect), *knowing how* (knowing how to do things) and *knowing who* (knowing who knows what and how to do things). Knowledge may also be thought of as being codified (in which case its use and transfer can be separated from individuals) and tacit (which is carried by individuals and is the sum of their experiences).

A challenge for nations and regions is to obtain the most value from knowledge in terms of:

- knowledge creation;
- knowledge sharing; and
- knowledge use.

Essential conditions for maximising knowledge and value are the presence of "hard" infrastructure such as schools, universities, TAFE colleges, research facilities and modern information and communication technology systems as well as "soft" or intangible infrastructure such as human capital, high quality researchers, and national and international linkages.[4]

Together, these elements comprise an economy's "knowledge infrastructure" which in the 21st Century will be at least as important, and probably more so, than the economy's physical infrastructure such as roads, railways, ports, etc.

1.2 Knowledge Infrastructure and the Innovation System

In the knowledge-based economy, the main driver of growth is seen to be innovation. While there are a number of possible definitions of innovation[5], an attractive definition in the context of this study is the one proposed by the Business Council of Australia:[6]

> "In business, innovation is something that is new or significantly improved, done by an enterprise, to create added value either directly or indirectly for its customers."

[3] Alan Burton-Jones (1999) defines knowledge as "the cumulative stock of information and skills derived from use of information by the recipient". Knowledge is distinguished from data (signals which can be sent by an originator to a recipient) and information (data which are intelligible to the recipient). See: Alan Burton-Jones ,1999, *Knowledge Capitalism: Business, Work and Learning in the New Economy* (Oxford University Press 1999).

[4] In measuring the investment in knowledge, the OECD constructed an investment index which includes expenditures on research and development, software and public spending on education. These forms of investment are essentially intangibles rather than investments in physical capital. According to the OECD, investment in knowledge on this measure represents 8 per cent of OECD-wide GDP, a share similar to investment in physical equipment and is increasing. It exceeds 10 per cent when private spending in education and training is included. See OECD, 2001, *Towards a Knowledge Based Economy*.

[5] For example, see Rogers, M., 1998, "The Definition and Measurement of Innovation", Melbourne Institute of Applied Economic and Social Research, University of Melbourne, Melbourne Institute Working Paper 10/98.

[6] Business Council of Australia , 1993, *Managing the Innovating Enterprise* p3.

In the knowledge-based economy, science, technology and research are seen as important and direct influences on innovation, especially but not only, in the fast-growing new industries. The focus on these elements has led many governments in the OECD to redirect public investment towards infrastructure such as universities, which predominately carry out basic research leading directly to new knowledge and which are increasingly seen not just in their traditional roles of education and research, but also as sources for ideas, new business, jobs, wealth creation and growth.

The focus on innovation has lead to a large body of literature (a good deal of which has been generated by the OECD) devoted to an examination of "innovation systems". Innovation systems include not only "hard" investments, in terms of learning institutions, research agencies and businesses, but also intangibles such as human capital, incentives, connections and linkages, and the performance of these features.

For example, the Chairperson of the CSIRO regards the innovation system as:[7]

> "…a system that recognises the complex linkages that underpin successful innovation, while providing a common purpose. These linkages extend through our education, research, business, government and regulatory institutions. Their complexity means that we cannot pursue one in isolation from the others: a change in one will ripple through the entire fabric of our modern economy and society."

The idea of an innovation system is based on a rejection of the linear model of innovation that says there is a unidirectional movement from basic research and the creation of ideas which takes place mainly in the universities and national research laboratories and are subsequently commercialised by the business sector. In practice there is in general a much richer set of relationships between researchers, producers and end customers. Feedback effects including knowledge and insights are generated at different parts of the system and then subsequently diffused and further developed by other elements of the system. In reality, there is a rich mixture of collaboration and competition in the innovation system and the economy itself.

As well as leading to a focus on linkages and inter-relationships, the concept of an innovation system is also associated with notions of critical mass and clustering of activities.

For the purposes of this study the knowledge infrastructure is regarded as being:[8]

> "…the people, institutions, processes and the linkages between them that combine to provide the essential building blocks for creating and transforming ideas into tangible economic performance – as manifested in a State economy characterized by high wage, high skill employment."

Furthermore, the knowledge infrastructure (both hard and soft) can be distinguished by whether elements contribute to the creation, sharing and use of knowledge:

- infrastructure to *create* knowledge - this includes elements such as the education system and the research and development system;
- infrastructure to *share* knowledge - this includes elements which facilitate research collaboration and the technologies which enable collaboration such as the development of information and communications technology systems (e.g., broadband); and
- infrastructure to *use* knowledge - this includes elements which enhance research commercialisation, provide investment capital and skills to support new business development, cluster development and international linkages.

[7] Catherine Livingstone, Chairperson CSIRO Board, Brodie-Hall Public Lecture, 20 November 2002.
[8] The Allen Consulting Group ,2002, Presentation to the TIAC Knowledge Infrastructure Steering Committee, November 2002.

1.3 The Development Challenge Facing Western Australia

The ability for developed economies to transform into knowledge-based economies is becoming increasingly important in the presence of globalisation. In a global market, businesses must become internationally competitive or customers will select alternative products and services from suppliers in other countries or regions. This means that, for developed countries, competitive advantage must be sought in innovation and adding value rather than through reliance on lowering labour costs.

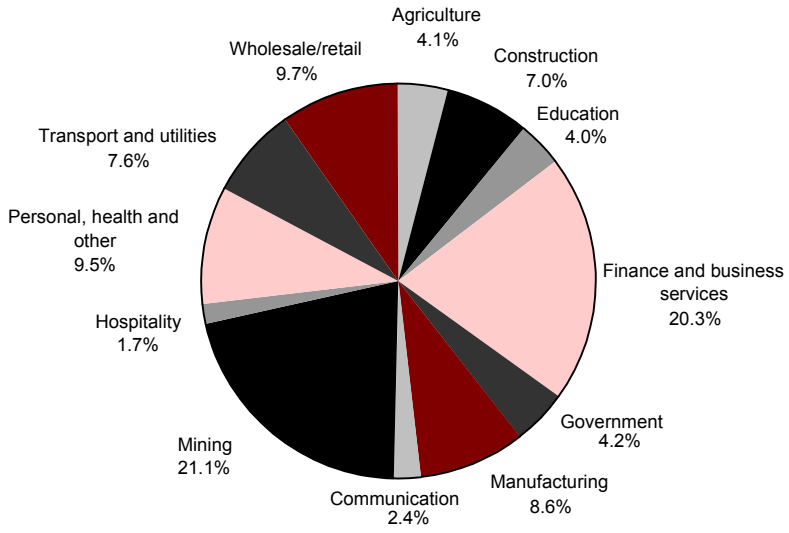
The Western Australia economy faces the challenge of developing into an internationally competitive knowledge economy. Particular challenges Western Australia faces, if this goal is to be achieved, relate to the fact that the State is a small economy (1.9 million people with a Gross State Product of $77 billion, which is some 11 per cent of Australia's aggregate product and therefore represents approximately 0.1 per cent of global output). By world standards (in terms of both perception and in many practical aspects of global commerce) Western Australia is also remote, notwithstanding its proximity to a number of important markets for existing economic outputs.

As is well known, Western Australia's economy is dominated by the resources sector which generates a quarter of the State's output (up from around 18 per cent a decade ago).[9]

The State's manufacturing base is significant at around 10 per cent of the economy but its links to and reliance on the resource extraction industries is significant (nearly 50 per cent of manufacturing is comprised of downstream processing of mineral and energy).

Figure 1.1

WESTERN AUSTRALIAN GSP BY INDUSTRY, 2001/2002



Source: Australian Bureau of Statistics, 2002, *State Accounts 5220.0*

The State has traditionally had a strong agricultural base but the contribution of this sector to Gross State Product has fallen gradually over the years (to around 4 per cent currently).

[9] WA Department of Treasury and Finance, 2002, *Structure of the Western Australian Economy.*

The Western Australian services sector, far and away the most important sector of the economy in terms of employment, is quite diverse with property and business services (19 per cent) and health and community services (11 per cent) the two largest industries by output.[10] In terms of services sector growth, property and business services, together with health and community services, tourism and government administration/defence are the standout industries.[11]

The Western Australian economy has generated strong economic growth over the past decade. In this time, growth in Gross State Product has averaged 4.1 per cent per annum compared to Australia's GDP growth rate of 3.9 per cent.[12]

The positive 'takeaway' from this snapshot of the State's economy is that it appears structurally sound, has and is continuing to grow at or around the national average and has been diversifying, albeit gradually and concentrated in particular industries.

Despite its strengths, however, there are also weaknesses in the Western Australian economy that have to be addressed if erosion of the State's competitiveness is to be avoided and a sustainable, competitive knowledge economy is to make a growing contribution to economic outcomes.

As identified in the report *Drivers and Shapers of Economic Development in the 21st Century*,[13] Western Australia's industry base is narrowly focused and dominated by the export of primary and resource products with only a small proportion of trade in elaborately transformed manufactures (ETMs). Consequently, the prosperity of the economy continues to be vulnerable to fluctuations in world commodity prices as a result of the long-run decline in terms of trade (i.e. the things Western Australia is exporting are earning less and less on world markets relative to the things being imported – a decline which reduces the standard of living over time). The report considered that the challenge for Western Australia is as follows:[14]

> "The issues facing Western Australia are indeed serious, as is the need for a profound change in economic structure. Failure to act quickly and on an adequate scale may have very adverse consequences. But every nation and region has to find its own way of adjusting to the 'brave new world' of knowledge intensity, globalisation and environmental sustainability. Given the State's assets, its rich human and physical resources, vitality and openness to change, Western Australia remains a privileged place from which to address that common challenge."

The State government is cognisant of the implications of a continuation of heavy emphasis on the resources industries for economic growth without recourse to leveraging off the inherent strengths in this sector and building additional knowledge infrastructure and industries. As stated by the Minister for State Development:[15]

> "… economic prosperity can no longer rely solely on the existence of abundant natural resources, a good climate and a stable political environment. The world today is not the same place as the one in which Western Australia achieved its initial economic growth. The changes in the global marketplace, such as the uptake of new technologies and the increasing reliance on knowledge-based resources, have entirely shifted the goal posts of traditional economic activity."

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[10] Australian Bureau of Statistics, 2002, *AusStats* Catalogue Number 5220020.

[11] Australian Bureau of Statistics, 2002, *AusStats* Catalogue Number LABEJ5I.

[12] Australian Bureau of Statistics, 2002, *State Accounts* 5220.0.

[13] Technology and Industry Advisory Council, 2000, *Drivers and Shapers of Economic Development in the 21st Century.*

[14] Houghton, J.W, 2002, "The Global Knowledge Economy", Supporting Paper No 1 for *Directions for Industry Policy in Western Australia Within the Global Knowledge Economy* .

[15] Minister for State Development, Building WA: A Strategic Partnership, 4 September 2001.

This is *not* to suggest that the State should embark on a path aimed at altering the structure of the economy in a particular direction independent of market forces, or to suggest that the State should turn its back on its rich resource base. Rather, the objective should be, inter alia, to strengthen and expand these foundations of the State's future competitiveness. The challenge for Western Australia in terms of positioning itself in the knowledge economy can be stated in terms of three propositions:

- using knowledge to add value to the State's traditional industries;
- using and sharing knowledge to create new businesses; and
- connecting the State to global knowledge networks.

In this context, an imperative for government should be to set a strategic direction and take action that facilitates development of the knowledge infrastructure component of these foundations, including, existing and emerging networks and clusters of intellectual capital and expertise.

Section Two

The Knowledge Infrastructure in Western Australia: Adopting a Global Perspective

2.1 The Knowledge Infrastructure in WA: A Systemic Approach to Building, Assessing and Benchmarking the Innovation System

International developments have been influential in shaping thinking and actions concerning Australia's and, indeed, Western Australia's, approach to development of the innovation system and the knowledge infrastructure which supports it. The international realities are that nations and regions must find their place within the global economic system and a "draw globally, adjust and apply locally" approach is appropriate.

As part of this study, investigations were undertaken to identify appropriate means of demonstrating the nature and characteristics of Western Australia's innovation system (including the knowledge infrastructure) and for mechanisms that could be useful in assessing its development and relative performance. Techniques developed by Porter and Stern ("the Innovation Index") are considered to have relevance in these regards.[16]

The Porter-Stern framework postulates that an economy's innovative capacity is determined by three broad factors:

- the common innovation infrastructure (that supports innovation in the economy as a whole);
- 'cluster' specific conditions (that support innovation in particular groups of interconnected industries); and
- the strength of the linkages between the common innovation infrastructure and clusters and among clusters themselves.

Methodological application of the index involves the creation of a quantitative benchmark of innovative capacity which highlights the resource commitments and policy choices that most affect long-run innovative output, measured in the Porter-Stern framework by an index of performance in terms of registering US patents.

A schematic representation of the Porter-Stern framework, incorporating some indicative features in a Western Australian innovation system, is set out in Figure 2.1 (page 8).

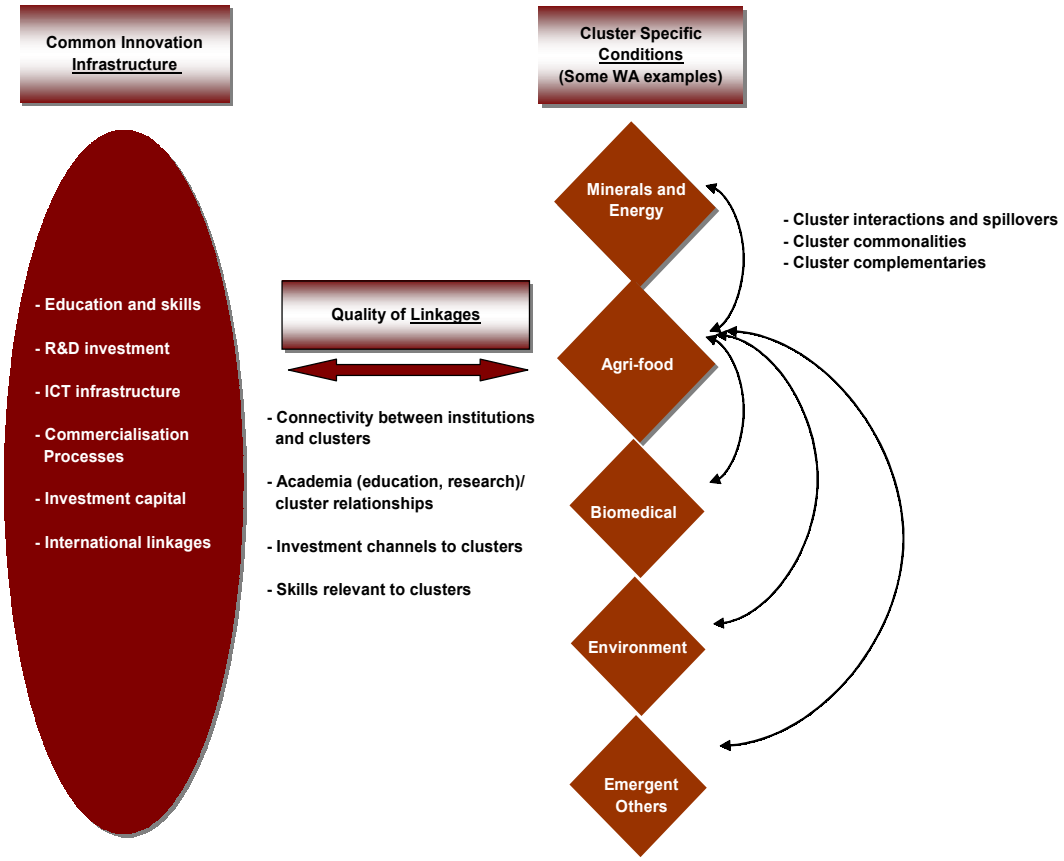
The main characteristic of the Porter-Stern approach is that it provides a schematic overview of the various core components of the innovation system to be described and monitored and is designed to measure innovative capacity – the ability of an economy to produce and benefit from a stream of commercially relevant innovations. While developed for application at the national economy level, it is adaptable for use at a regional level.

While a structured measurement/benchmarking exercise using the Porter-Stern methodology has not been undertaken as part of this study, it is considered an initiative worthy of further investigation to gauge its practical application as a tool of policy analysis in the Western Australian context.

[16] Porter, M and Stern, S, 1999, *The New Challenge to America's Prosperity: Findings from the Innovation Index*, Council on Competitiveness Washington D.C.

Figure 2.1

THE PORTER-STERN INNOVATIVE CAPACITY FRAMEWORK APPLIED TO WESTERN AUSTRALIA



Source: Porter, M and Stern, S, 1999, *The New Challenge to America's Prosperity: Findings from the Innovation Index*, Council on Competitiveness, Washington D.C.

2.2 Models Relevant to Western Australia: Where to Look for Reference Points

There is an understandable inclination for Western Australia's performance in matters such as the development of the innovation system and creation of knowledge infrastructure to be modelled on or compared against other jurisdictions in Australia. Questions such as how Western Australia is performing compared to other States, particularly those with similar natural endowments and/or economic characteristics (and the national average) have been a feature of broader debate and suggested policy prescriptions.

While such comparisons are appropriate up to a point and, indeed necessary, in some contexts (e.g. Commonwealth/State and Territory fiscal negotiations) there is also a "bigger picture" to consider. Put simply, Western Australia needs to be aware of world's best practice in these areas, recognising it is the global market, more so than the national market that will ultimately determine Western Australia's prospects.

In looking to which models or cases might serve as relevant reference points for Western Australia there is an understandable tendency to look for a "blueprint" that can be replicated directly in the Western Australian context. Practice shows that such approaches rarely work. Rather, the imperative is to discern and distil the key characteristics that are applicable to the Western Australian situation and seek to apply them intelligently by taking account of cultural, institutional and resource endowment differences.

Two case studies (the province of Alberta in Canada and the Georgia Institute of Technology, Atlanta, USA) are outlined and discussed below. Both have been the subject of attention in an earlier report prepared for the Technology and Industry Advisory Council, dealing with optimising the role of universities.[17] However, given their respective parallels with Western Australia's circumstances and, inter alia, the fact that they represent best practice as a research cluster, a strong case can be made that they provide highly relevant points of reference.

Box 2.1

THE ALBERTA EXPERIENCE

Alberta is a province of Canada with a population of 3 million (twice Western Australia's population) and a Gross State Product of approximately three times that of WA. Like Western Australia, Alberta is a resource rich province (90 per cent of Canada's natural gas, 50 per cent of its oil reserves and 100 per cent of its oil sands deposits) and with a major agricultural industry. Also like Western Australia, it is an export economy – with oil and agricultural products predominant.

In the 1990s, the government of Alberta foresaw the increased importance that science and technology would play in the future prosperity of the province. While Alberta was home to some of the world's leading researchers, the majority were working independently. The government also recognised that the province was falling behind the other Canadian provinces in terms of innovation capacity. This assessment was based on indicators that showed low levels of investment in research and development, human capital capacity, patents, research commercialisation and investment in knowledge based firms. In short, Alberta's knowledge-based economy was performing poorly.

In response, the Alberta government developed a strategic plan to establish the province as a leading knowledge-based economy. The strategy employed involved coordinating all research and development throughout the province (to maximise research and development synergies). *The plan also recognised Alberta's natural and existing advantages and was therefore built around its value-added resource-based industries and non-resource-based knowledge-intensive manufacturing industries.*

The strategy also involved the government increasing the level of targeted R&D investments (to promote world-class industry research in strategic areas and to develop critical mass). These investments were complemented by other policies by:

- expanding the network of public and private institutions that support industry requirements for applied R&D, technology transfer, knowledge prospecting and acquisition;
- building joint industry/university R&D consortia; and
- recruiting key companies to create critical mass in R&D intensive clusters.

The Alberta Science and Research Authority (a government body with an independent board) was formed to work with stakeholders to advise government on priorities and policies for science and research. The Authority also recommends investments and facilitates strategic initiatives directed at how best to promote science and research across its three clusters of strategic importance:

- Information and Communications Technology.
- Energy.
- Life Sciences.

The key elements in Alberta's industry policy therefore appear to be:

- strategic investments in research and development and education; and
- strong reliance on partnerships and consortia.

It should be noted, however, that the fiscal policy setting (which Western Australia is unable to replicate) has also had a major bearing on the innovation system's development. These include no provincial sales tax and a flat 10 per cent income tax rate.

Source: Technology and Industry Advisory Council, 2002, *The Organisation of Knowledge: Optimising the Role of Universities in a Western Australian 'Knowledge Hub'* and the Alberta and Science Research Authority (1997) *Sustaining the Alberta Advantage*.

[17] Technology and Industry Advisory Council, 2002, *The Organisation of Knowledge: Optimising the Role of Universities in a 'Knowledge Hub'.*

The strategy being pursued by Alberta is consistent with the policy directions being pursued at the national level. The Canadian government has committed to strengthen the national innovative performance by investing in the science and technology base with a goal of lifting Canada's research and development performance into the top five OECD countries by 2010.

The capacity for taking a more "shaped" role (e.g. coordination of the Province's research and development effort and in tax and fiscal policy) is clearly a differentiating factor between the two jurisdictions, with Alberta having demonstrably more policy flexibility.

However, in other respects (e.g. focusing research and development effort in areas of acknowledged strength, seeking to foster the development of a limited number of clusters of strategic importance, and building collaborative networks and consortia) the commonalities are strong – both in terms of stated goals and in relation to strategic direction.

Box 2.2

THE GEORGIA INSTITUTE OF TECHNOLOGY

The Georgia Institute of Technology (Georgia Tech) in Atlanta is one of the United State's top research institutions (currently enrolling around 14,000 students). It is widely regarded as one of, if not the, best research institutions in the US (in a recent study carried out to identify US universities that maintained what were considered to be outstanding examples in technology transfer Georgia Tech was rated the most exemplary research institution of 164 major US research institutions studied). Its genesis was as a trade school (in the late 19th century), subsequently offering a range of engineering programs (first half of this century) and becoming a pre-eminent research institution (post WWII).

The success of Georgia Tech as a research institution was attributable to a number of characteristics.

- *High investments in research and development.* In 1999 Georgia Tech's research expenditures was US$263 million (more than twice Western Australia's total higher education R&D expenditure).
- *High quality students.* Student entry scores are one of the highest in the US.
- *External partnering with industry and government.* For example, the school is an operating partner with the Georgia State government in the implementation and management of a variety of technology-focused initiatives.
- *Supporting alliances with other surrounding universities.* The Georgia Research Alliance involves six Georgia universities and makes strategic investments in building centres of research excellence, primarily in the sciences where there are obvious linkages to current or expected economic growth.
- *Focus on hard sciences.* The university has continued to maintain its institutional emphasis on engineering and science. It has not cultivated a growth in the liberal arts disciplines that characterise many other institutions, except where they relate to science and technology issues.

An example of successful partnership and collaboration in Georgia for the purposes of commercialising research is the Yamacraw ICT incubator. Yamacraw provides funding and services in research and commercialisation, seed capital as well as providing links between education, research and the ICT cluster. The partnership involves collaboration between businesses, eight universities in Georgia and a State government financial contribution of US$100 million in funding. Member companies contribute financially by having the choice of either committing US$1.25 million over a five year period or (and preferably) paying a $25,000 annual membership fee and committing to hire 100 high-tech employees in Georgia. In return, companies have access to graduates and university researchers.

Source: Technology and Industry Advisory Council, 2002, *The Organisation of Knowledge: Optimising the Role of Universities in a Western Australian 'Knowledge Hub'*.

The case of Georgia Institute of Technology, particularly the 'five factors of success' (high investment in research and development; high quality students; external partnering with industry and government; supporting alliances with surrounding universities and focusing on hard sciences) would seem to almost parallel the needs and/or stated intentions or aspirations of most stakeholders in the Western Australian innovation system.

The role of the government of Georgia, as a pro-active partner in a number of the initiatives in which the Georgia Institute of Technology is a participant, is a notable feature, as is the fact that notwithstanding its size and national/international standing, the Georgia Institute of Technology is a prominent participant in and supporter of alliances with other universities in the State.

Yamacraw, as the corporate vehicle for research incubation and commercialisation, combines and integrates all the features associated with a systemic approach to simultaneously developing research capability, nurturing and developing talent, building a highly skilled, high value workforce and generating tangible commercial outcomes. While its focus, having regard to Georgia's assessed strengths and priorities, is on ICT developments, it nevertheless stands as a relevant model for any similar initiatives in Western Australia, whatever the scale and industry focus.

Section Three

The Current Knowledge Infrastructure Base in Western Australia

3.1 Introduction

This chapter describes Western Australia's current knowledge infrastructure. As outlined in Section One, the knowledge infrastructure comprises elements which support the creation, sharing and use of knowledge. The elements discussed in this section are:

- Knowledge creation:
  - education and skills; and
  - research and development.
- Knowledge sharing:
  - research collaboration; and
  - information and communication technology networks.
- Knowledge use:
  - research commercialisation;
  - investment capital;
  - clusters; and
  - international linkages.

3.2 Knowledge Creation

3.2.1 Education and Skills

The State's education system comprises three key components:

- the school system (public and private schools);
- the higher education system; and
- the vocational education system.

In 2002, there were 1,123 schools in Western Australia servicing 365,571 students. Of these, 775 were government schools (255,461 students, representing 70 per cent of all enrolments) and 292 non-government schools (108,130 students, or 30 per cent). In 2002, the Department of Education spent approximately $1,274 million on education related employees (teachers and administration) and $293 million on other school expenses.[18]

The higher education system in Western Australia is comprised of five universities: The University of Western Australia, Curtin University, Murdoch University, Edith Cowan University and the University of Notre Dame.

[18] Western Australian Department of Education ,2002, *Annual Report 2001/02*.

In 2001, there were 66,633 full-time and part-time students in higher education, of which 33.9 per cent were from Curtin University, 28.6 per cent from Edith Cowan University, 20.6 per cent from The University of Western Australia, 16.1 per cent from Murdoch University and 0.5 per cent from the University of Notre Dame. University education is largely funded through Commonwealth distributions under the Higher Education Contribution Scheme (HECS) pursuant to the *Higher Education Funding Act*. In 2001, total HECS and student funding received by Western Australian higher education institutions from HECS and student contributions was $170.1 million. Furthermore higher education institutions in Western Australia received an additional $333.9 million from Commonwealth government Grants pursuant to the *Higher Education Funding Act*.[19]

The State's vocational education system sector comprises 11 TAFE colleges across Western Australia. A total of 105,356 students were enrolled in VET courses in 2001. The cost of services performed by the Department of Training in 2001 was $344.0 million.

Indicators for participation in education in Western Australia compared to other jurisdictions in Australia are presented in Table 3.1.

Table 3.1

EDUCATION INDICATORS, 2002

	NSW	VIC	QLD	SA	*WA*	TAS	NT	ACT	AUS
Participation rate of 15-19 year olds in education	80.1	83.5	70.4	73.7	*70.0*	73.9	73.2	82.4	77.4
Participation rate of 20-24 year olds in education	38.2	37.9	30.0	28.2	*30.6*	28.1	16.6	39.8	34.8
Participation rate of 15-24 year olds in VET studies	13.8	11.0	9.4	11.7	*12.7*	12.3	5.6	11.1	11.8
Participation rate of 15-24 year olds in Higher Education	17.7	21.8	18.3	13.4	*17.8*	11.3	11.6	20.4	18.4
Proportion of population aged 25-64 with Bachelor degree of above.	20.6	22.1	16.4	15.7	*18.9*	13.9	18.5	35.1	19.7

Source: Australian Bureau of Statistics, *Australian Social Trends 2002: Education – State Summary Tables*

Participation levels in Western Australian were found to be lower relative to the national average. The proportion of Western Australians aged between 15 and 64 holding a Bachelor degree was also found to be approximately one percentage point lower than the national average. Participation rates in education for 15-19 years olds and 20-24 years olds are also low compared to the national average.

Areas where Western Australia has performed better is the level of participation in vocational education and training (VET) studies. The State is ranked second behind New South Wales in VET participation.

In terms of science and numeracy literacy levels however, Western Australian students were found to be amongst the best in Australia and internationally. The mean performance in science literacy as assessed under the Programme for International Student Assessment (PISA) indicators is illustrated in Figure 3.1. To place Australia's States and Territories results in perspective, the means and distributions for the highest-achieving country (Korea) are included in the figure.

[19] Commonwealth Department of Education, Science ant Training, 2002, *Higher Education Statistics*.

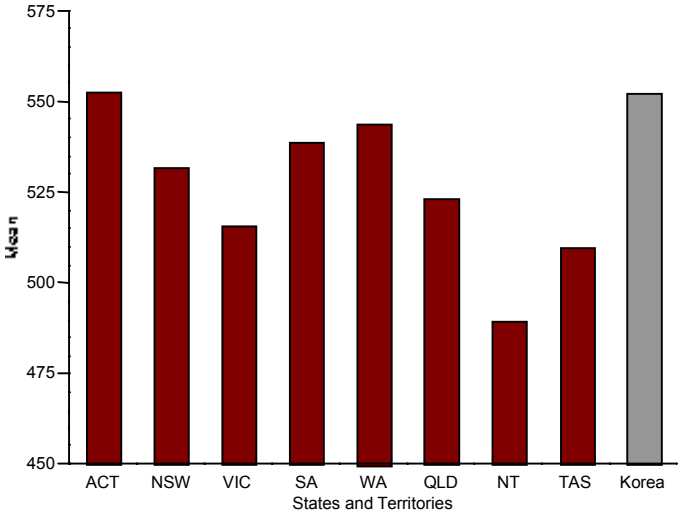
The figure shows that, in science literacy, Western Australian students perform on par with the highest-achieving country in the OECD.

The proportion of the workforce in science and technology occupations, such as scientists and engineers, is also considered as a strong indicator of a society's capacity to generate ideas that can add value to the economic system.

From Table 3.2, Western Australia generally has a good skill base as indicated by the proportion of the population employed in science and technology occupations. This outcome is likely to be attributable to the State's minerals and resources sector, which is a large employer of engineers.

Figure 3.1

STUDENT ACHIEVEMENT BY STATE AND TERRITORY (PISA INDICATOR)



Source: OECD PISA, *15-Up and Counting, Reading, Writing, Reasoning: How Literate are Australia's Students?*, 2001, p.120.

Table 3.2

CORE HUMAN CAPITAL CAPACITY IN SCIENCE AND TECHNOLOGY OCCUPATIONS (HRTSC), 1996

State	Number ('000)	Percentage of Population (%)
New South Wales	359	7.6
Victoria	274	7.8
Queensland	160	6.3
South Australia	75	6.5
Western Australia	97	7.3
Tasmania	22	6.1
Northern Territory	10	6.1
Australian Capital Territory	35	15.0
Australia	1033	7.4

Note: The Australian Bureau of Statistics regards the "core" human capital capacity of an economy as those employed as "Professionals" and "Specialist managers" with tertiary qualifications. The classification includes all persons with tertiary qualifications (regardless of their field of study, including fields such as social sciences and humanities). The definition is inclusive of persons employed as scientists and engineers as well as other professionals with tertiary qualifications (eg. school teachers and other professionals).

Source: Australian Bureau of Statistics, 1999, *Human Resources in Science and Technology, 1996* Catalogue No. 8149.0

3.2.2 Research and Development

Research and development is performed directly by higher education institutions, Commonwealth and State government agencies and businesses. In addition to direct research, the Commonwealth and State governments assist higher education and business researchers through the provision of research grants and incentives.

Box 3.1

TYPES OF RESEARCH AND DEVELOPMENT

The Australian Bureau of Statistics classifies research into four different types.

- Pure basic research. This research is curiosity driven research which may or may not have an application. Pure basic research is performed largely by higher education institutions.
- Strategic research. This research is mission oriented research with a medium to longer-term focus. Strategic research is performed mainly by the universities, government agencies such as the CSIRO and the CRCs.
- Applied research. This form of research involves taking well-known principles and applying them in a concrete situation but with some novelty involved and some risk. Applied research is undertaken by businesses, government research agencies and higher education institutions.
- Experimental development. This form of research is almost always performed by industry and includes developments such as process and product modifications.

Source: Australian Bureau of Statistics, 2002, Research *and Experimental Development, Higher Education Organisations, Australia Explanatory Notes*. 8111.0.

Measures of research and development activity in the State can be assessed by examining research expenditure levels. In 2002, the Premier's Science Council undertook a review of research expenditure in Western Australia.[20] Research expenditure in Western Australia comprised:

- approximately $225.5 million sourced from higher education institutions;[21]
- approximately $64 million sourced from Commonwealth government agencies;
- approximately $92.4 million sourced from State government agencies; and
- approximately $342 million sourced from businesses and industry.

Per capita expenditure on research and development in Western Australia has grown substantially over the past decade. In 1991, per capita expenditure was $226 per person, increasing to $439 per person in 1999 (or approximately 7.5 per cent per annum).

However, gross research and development expenditure (in terms of size relative to Gross State Product) is still low compared to national levels.

Table 3.3

GROSS EXPENDITURE ON R&D (GERD) AS A PERCENTATAGE OF GDP/GSP

		1991	1993	1995	1997	1999
Gross R&D	Western Australia	0.81	1.2	1.24	1.62	1.3
	National	1.16	1.35	1.44	1.60	1.51
Higher Education R&D	Western Australia	0.28	0.32	0.34	0.40	0.37
	National	0.30	0.38	0.37	0.44	0.46
Government R&D	Western Australia	n.a.	0.26	0.27	0.27	0.25
	National	n.a.	0.37	0.39	0.38	0.35
Business R&D	Western Australia	0.29	0.63	0.64	0.94	0.68
	National	0.45	0.60	0.69	0.75	0.68

Source: Department of Commerce and Trade, 2001, *Trends in Research and Development Expenditure in Western Australia*, prepared by Economic Consulting Services

[20] Premier's Science Council ,2002, *Report on Research in Western Australian State Government Agencies.*

[21] A more recent figure provided the Australian Bureau of Statistics is $240 million see (Table 3.3).

University Research and Development

Universities are the main source of pure basic research, as well as a good proportion of applied research. In 2000, 30 per cent of research at higher education institutions was of the form of pure basic research, 37 per cent of research was strategic research, and 24 per cent was applied research while 8 per cent was experimental research.[22]

Western Australia has five universities: The University of Western Australia, Curtin University, Edith Cowan University; Murdoch University and the University of Notre Dame. Of these, the University of Western Australia is recognised as the State's leading university for research and is a member of the "Group of Eight" universities. Group of Eight universities undertake 70 per cent of all research conducted by Australian universities and over half of all pure basic research conducted throughout Australia.[23]

Table 3.4

R&D EXPENDITURE BY HIGHER EDUCATION INSITUTIONS, 2000

State	Research Expenditure	Percentage of GSP
New South Wales	$810 million	0.36
Victoria	$630 million	0.39
Queensland	$463 million	0.43
Western Australia	$245 million	0.33
South Australia	$223 million	0.52
Tasmania	$74 million	0.63
NT	$18 million	0.21
ACT	$308 million	2.39
Total	$2774 million	0.42

Source: Australian Bureau of Statistics, 2002, Research *and Experimental Development: Higher Education Organisations* 8111.0

Research continues to grow in Western Australian universities. However, the share of research expenditure as a proportion of GSP is consistently below national levels over the past five years. Moreover, Western Australia is currently ranked sixth out of all States and Territories in terms of higher education research expenditure as a proportion of Gross State Product (Table 3.4).

The key research fields (in terms of dollars spent) were medical and health sciences (23.1 per cent of research expenditure), agricultural sciences (12.9 per cent), biological sciences (12.0 per cent) and general engineering (8 per cent). A substantial proportion of research (23.0 per cent) was also sourced to social and humanities sciences or "soft" sciences.[24]

Government Research and Development

Government organisations undertake both strategic research (through the CSIRO) and applied research (through State government agencies and CSIRO). In addition to direct research, governments also provide funds in the form of grants to higher education institutions and businesses and to the Cooperative Research Centres (CRCs).

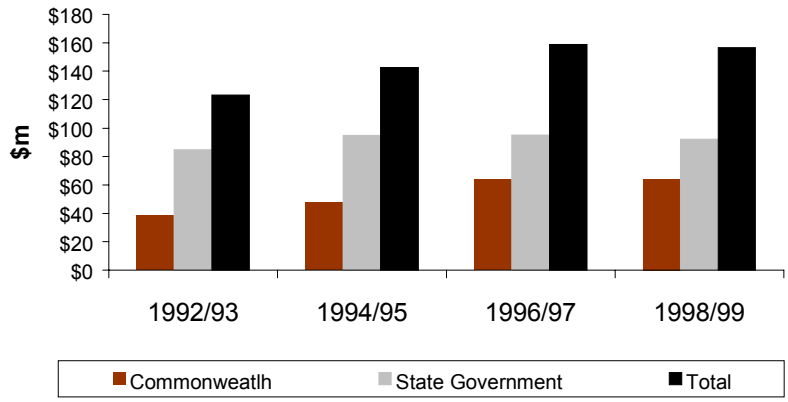
[22] Australian Bureau of Statistics ,2002, *Research and Experimental Development: Higher Education Organisations 8111.0* .
[23] Source: http://www.go8.edu.au/about.html
[24] Premier's Science Council, 2002, *Report on Research in Western Australian State Government Agencies.*

The State government is the largest contributor of government performed research in the State with approximately 58 per cent of total government research expenditures in 1998/99. However, State government research expenditures have fallen over the years: declining from $94.9 million in 1994/95 to $92.1 million in 1998/99. Concerns over declining State government research was also highlighted in a report by the Premier's Science Council.[25]

The agencies within the State government that perform the majority of State government research are the Department of Agriculture ($48 million per annum); Department of Conservation and Land Management ($10 million per annum); Fisheries WA ($8 million per annum); Forest Products Commission ($3.5 million); and the Chemistry Centre ($2 million per annum).[26]

Figure 3.2

GOVERNMENT AGENCY R&D EXPENDITURES IN WA



Note: Government expenditures refer to expenditures from government research agencies rather than government grants.

Source: Department of Commerce and Trade, 2001, *Trends in Research and Development Expenditure in Western Australia*, prepared by Economic Consulting Services.

On the other hand, Commonwealth government research expenditures have been growing in Western Australia: $38.3 million in 1992/93 to $64.2 million in 1998/99.

The increase in Commonwealth government research expenditures is attributable to the increase in presence of three Commonwealth research bodies in Western Australia: the CSIRO, the Defence Science Technology Organisation (DSTO) and the Australian Institute of Marine Science.

- Eight of the CSIRO's Research Business Units have a presence in Western Australia with two Research Business Units having their head offices in Western Australia (Mediterranean Agricultural Research and the Petroleum Resources at the Australian Resources Research Centre).
- The Western Australian (Fremantle) office of the Australian Institute of Marine Science (AIMS) is one of three AIMS bases in Australia. Other AIMS offices are based in Townsville (head office) and Darwin.
- The Defence Science and Technology Organisation (DSTO) operate an office at the HMAS Stirling facility (located near Perth) as part of the DSTO's Maritime Operations Division.

[25] Premier's Science Council, 2002, *Report on Research in Western Australian State Government Agencies.*
[26] Premier's Science Council, 2002, *Report on Research in Western Australian State Government Agencies.*

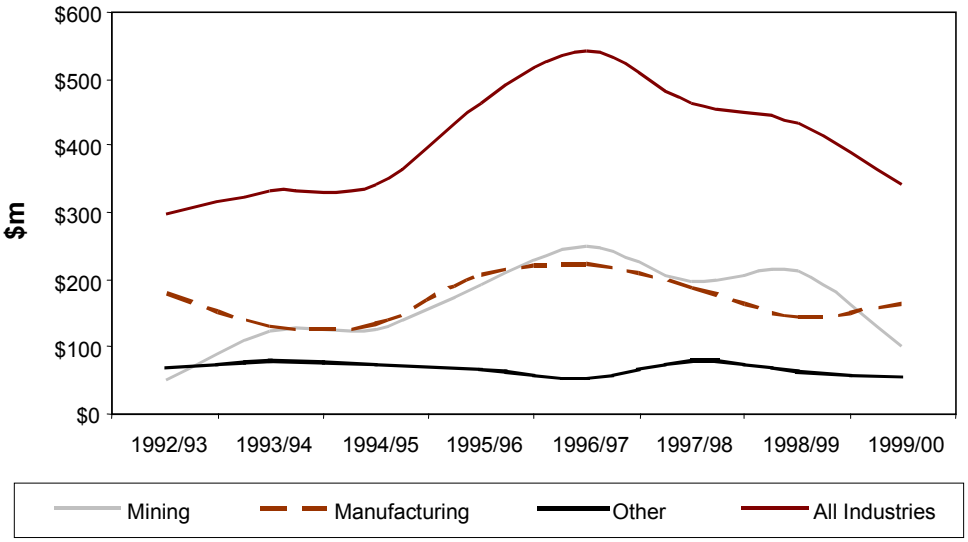
Business Research and Development

A large proportion of applied research and especially experimental development (such as product and process enhancements) is carried out by businesses.

The level of business research and development in Western Australia has generally performed well relative to the national average. From Figure 3.3, business research expenditures are largely sourced from the mining industry and manufacturing industries in the State.

Figure 3.3

BUSINESS R&D BY SECTOR



Source: Department of Commerce and Trade, 2001, Trends in Research and Development Expenditure in Western Australia, prepared by Economic Consulting Services

The levels of business research and development expenditure in Western Australia tend to correlate strongly with the research and development expenditures in the mining sector. As a consequence, there have been fluctuations in business research and development over the years, depending on the sentiment and developments of the mining industry.

Although Figure 3.3 displays a downward trend in business research up to 1999/00, recent statistics from the Australian Bureau of Statistics indicate that business expenditure of research and development has improved markedly in 2000/01, increasing by 18 per cent to the highest expenditure levels ever recorded.[27]

3.3 Knowledge Sharing

3.3.1 Research Collaboration

There are several research collaborations evident between business, universities and government. Most notably, universities operate Co-operative Research Centres (CRCs) that are funded by the Commonwealth and the State government. These research centres are partnerships between one or more organisations.

[27] See: Australian Bureau of Statistics, 2002, "Media Release: 8104.0 Business R&D bounces back".

Nationally, there are currently 64 CRCs, with five of these CRCs being hosted by a Western Australian university. The CRCs hosted in Western Australia have a focus on the following research fields:

- Mining and Energy (three CRCs).
- Information Technology and Communications (one CRC).
- Environment (one CRC).

Western Australian organisations are also core or supporting partners of 20 other CRCs hosted in other States. Western Australia's four key research universities (University of Western Australia, Curtin University, Murdoch University and Edith Cowan University) are all core partners of a least one CRC.

Box 3.2

CO-OPERATIVE RESEARCH CENTRES (CRC) IN WESTERN AUSTRALIA

Western Australian Institution as Host Partner

- CRC for AJ Parker CRC for Hydrometallurgy
- CRC for Australian CRC for Renewable Energy[28]
- CRC for Landscape Environments and Mineral Exploration
- Australian Telecommunications CRC
- CRC for Plant-based Management of Dryland Salinity

Western Australian Institution as Core/Supporting Partner

- CRC for Australian Sheep Industry
- CRC for Cattle and Beef Quality
- CRC for Molecular Plant Breeding
- CRC for Sustainable Aquaculture of FinFish
- CRC for Sustainable Production of Forestry
- CRC for Value Added Wheat
- CRC for Predictive Mineral Discovery
- CRC for Mining Technology and Equipment
- Australian Petroleum CRC
- CRC for Coal in Sustainable Development
- CRC for Innovative Wood Manufacturing
- CRC for Welded Structures
- CRC for Australian Weed Management
- CRC for Biological Control of Pest Animals
- CRC for Conservation and Management of Marsupials
- CRC for Greenhouse Accounting
- CRC for Sustainable Tourism
- CRC for Waste Management and Pollution Control
- CRC for Water Quality and Treatment
- CRC for Asthma

Source: Commonwealth Department of Education, Science and Training, 2002, 2002 CRC Compendium, May 2002.

[28] The Commonwealth will no longer fund this CRC in 2003.

Other major research centres in Western Australia involving collaborative efforts include as follows.

- The Australian Resources Research Centre (ARRC) is the CSIRO's national research facility for petroleum and mineral resources. The ARRC houses CSIRO's Petroleum and Exploration and Mining Divisions, along with Curtin's Departments of Exploration Geophysics and Petroleum Engineering and State Centres of Excellence for Petroleum Research, Petroleum Geology and Exploration and Production Geophysics.
- The National Networked Tele-Test Facility for Integrated Systems at Edith Cowan University. The facility was one of the 15 major research facility projects as part of the Commonwealth's Major National Research Facilities Program. The facility has nodes in universities from four other States.
- The IBM Australian Programming Centre located in Perth was established in 1986 with the core activities of developing and supporting software which runs on IBM mainframe computers. The Centre has contracts with IBM laboratories in Germany, UK, US, Canada and Japan. The Western Australian government has pledged $1.9 million in financial assistance to expand this centre.
- The UWA-Motorola Software Centre of Excellence, involving collaboration between the University of Western Australia, Motorola and the Western Australian government will establish a facility with focus on research into third generation wireless technology. It is envisaged that the facility would provide accommodation for a workforce of 200, increasing to 400 scientists.

3.3.2 Information and Communications Technology Infrastructure

The information and communications technology (ICT) infrastructure is an important enabler of knowledge management. Such systems also enhance knowledge sharing through enabling collaboration and the sharing of knowledge between researchers, businesses and government in a real-time environment.

A key component of ICT infrastructure for businesses and researchers is Internet connectivity and access to high-speed broadband infrastructure. A recent report has highlighted businesses productivity improvements involved in the Internet Economy.[29] Businesses were found to have raised nearly three times the revenue per employee than compared to that of a non-internet business. Moreover, firms with a broadband connection obtain nearly two-thirds more revenue than a non-broadband business with Internet connectivity.

Internet and computer usage by Western Australian households and businesses is comparable to the national average. For example, nationally, 76 per cent of all businesses used computers while 56 per cent had Internet access, and 17 per cent employed their own specialist ICT staff. By comparison, Western Australia performs well with 75 per cent of all Western Australia businesses using computers, 54 per cent with Internet access, and 16 per cent employing their own specialist ICT staff.[30]

[29] The Allen Consulting Group, 2002, *Built For Business II: Beyond Basic Connectivity: the Internet Economy and Australian Business in 2002*, prepared for Cisco Systems.

[30] Houghton, J., 2002, *Information and Communication Technologies*, supporting paper prepared for TIAC's *Directions for Industry Policy in Western Australia Within the Global Knowledge Economy*.

In terms of Internet usage, 46 per cent of Australian businesses considered themselves as active Internet users and 6 per cent conducting e-commerce on a commercial basis. By comparison, 47 per cent of Western Australian businesses were active Internet users, and 7 per cent conducted e-commerce on a commercial basis. Forty-two per cent of Western Australian businesses used Internet banking during 1999-2000, compared to a national average of 36 per cent.[31]

Consistent with above, the quality and usage of ICT facilities in Western Australia is generally well regarded.[32]

> "Clearly, Western Australian businesses are up with, and in some key areas of e-commerce, surpassing the very high levels of business use of ICTs elsewhere in Australia. This puts Western Australian businesses at the forefront in international comparisons of ICT application and use."

Despite this statement, there are emerging concerns over Western Australia's ability to accommodate the need for newer and faster technologies such as broadband.

A recent submission by the Western Australia government to the Broadband Advisory Group acknowledged that there are impediments to broadband take-up, particularly in key productivity sectors such as small business, education, health and community services.[33] Regional Western Australia has been disadvantaged more than the metropolitan region in terms of the lack of broadband infrastructure.[34]

A Joint Steering Committee comprising the Western Australian Technology and Industry Advisory Council and the Ministerially appointed ICT Industry Development Forum is currently engaged in a study to assess the drivers and impediments of broadband take-up in Western Australia, to be released in mid-2003.

3.4 Knowledge Use

3.4.1 Commercialisation of Research

An indication of the level of research commercialisation in the State can be observed through the following indicators:

- start-up or spin-off companies;
- royalties to Universities; and
- patent filings.

[31] Houghton, J., 2002, *Information and Communication Technologies*, supporting paper prepared for TIAC's *Directions for Industry Policy in Western Australia Within the Global Knowledge Economy*.

[32] Houghton, J., 2002, *Information and Communication Technologies*, supporting paper prepared for TIAC's *Directions for Industry Policy in Western Australia Within the Global Knowledge Economy.*

[33] The Western Australian Government, 2002, Submission to the Broadband Advisory Group on Broadband Issues, June 2002.

[34] For example, regional users living more than four kilometres from a Telstra exchange are unable to receive broadband services through ADSL. Satellite remains the only option for regional users to obtain broadband services. However, cost is prohibitively high.

Start-Up Companies

A survey of national research commercialisation ranked The University of Western Australia third overall in terms of the number of start-up companies (four) established in 2000, while Murdoch University was ranked seventh with two start-up companies.[35] No start-up companies came from the other Western Australian universities responding to the survey.

In total, 6 of the 32 start-up companies established in Australia in 2000 came from Western Australia.

Royalties

The total royalty income received by higher education institutions responding to the *National Survey of Research Commercialisation* was $83.8 million. The University of Western Australia was ranked 20th in terms of royalty income received ($62,173 or less than 0.1 per cent) while Murdoch University, Edith Cowan University and The University of Notre Dame did not receive any royalty payments.

Patents

Approximately 10.4 per cent of patents filed in Australia (by Australians) were sourced from Western Australia. Western Australia is also ranked the highest in the nation in terms of the number of patent filings in Western Australia on a per capita basis.

However, as indicated in Figure 3.4, Western Australia's share of total patents has declined steadily over the past decade. In 1991/92, 12 per cent of total patents were filed by Western Australian residents declining to 10.5 per cent in 2001/02. The upswing in patent activity in 1999/00 may be attributable to the establishment of the Hamersley HIsmelt facility in Kwinana.

Table 3.5

PATENT FILINGS IN AUSTRALIA, 2001/02

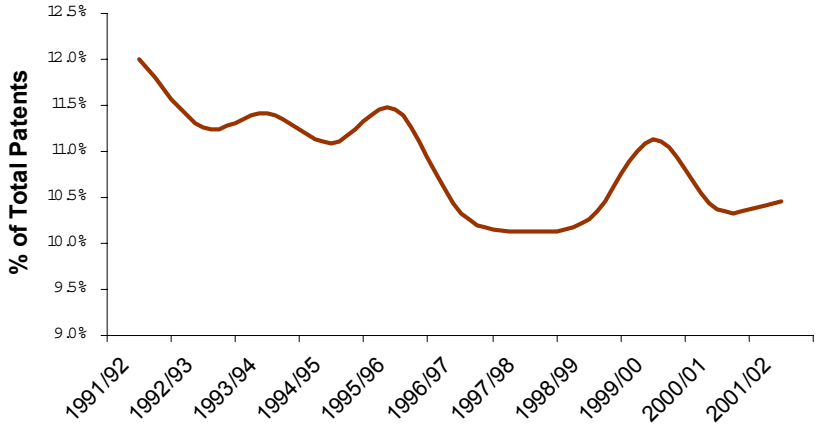
State	Total Patent Filings	Filings per 1,000 persons
New South Wales	3,153	4.8
Victoria	2,391	5.0
Queensland	1,600	4.4
South Australia	657	4.3
Western Australia	967	5.1
Tasmania	133	2.8
ACT	314	9.8
Other Australian	33	1.6
Total Australia	9,248	4.7

Source: IP Australia, unpublished statistics.

[35] ARC, CSIRO and NHMRC, 2000, *National Survey of Research Commercialisation*. Curtin University did not respond to this survey.

Figure 3.4

PATENT FILINGS, WESTERN AUSTRALIA AS A PROPORTION OF TOTAL FILINGS BY AUSTRALIAN RESIDENTS



Source: IP Australia, unpublished statistics.

3.4.2 Investment Capital

The ability for Western Australian innovators to access pre-seed and venture capital in order to commercialise the results of research and development is essential for the State's innovation system to support the further development of new ideas.

A recent report by Barnett and Mazzarol examined the venture capital environment in Western Australia and identified five sources of investment capital for research:[36]

- Commonwealth programs;
- angel investors and high net-worth individuals;
- local and national formal venture capital funds;
- corporate venture capital investors; and
- share market.

In general, the size of venture capital in the State was regarded as being inadequate and fragmented, particularly for early stage investments and start-up businesses. Early stage ventures in Western Australia currently rely on unstructured angel investor networks and Commonwealth government Programs.

Aspects of individual sectors of the venture capital market are discussed below as well as a discussion of investment skills.

Commonwealth Sources

The Commonwealth government operates a number of programs designed to assist seed, start-up and early expansion activities of businesses and researchers.

[36] Barnett, R. and T. Mazzarol, 2002, *Creating an Effective Venture Capital Environment in Western Australia: Guidelines for Government, Industry and Universities*. Discussion Paper prepared by the Graduate School of Management (UWA) and Australian Venture Consultants.

Commonwealth funds are considered to be vital in early stage ventures where private markets for these ideas do not exist.

Western Australian's have performed reasonably well in securing Commonwealth funds from COMET the BITS incubator fund (relative to Gross State Product). However, there are some noticeable Commonwealth funds where Western Australia has not performed as well: the Biotechnology Innovation Fund, R&D Start Program and the Pre Seed Fund (see Section 4 for a more detailed discussion).

Angel Investors

Angel investors are high-net worth individuals with the ability to provide large amounts of venture capital into early stage projects.

Barnett, R. and T Mazzarol (2002) estimate that there are between two and three hundred potential angel investors in Western Australia.[37] However, the angel investor market is regarded as being fragmented and unorganised, relying on existing professional and social networks. Persons seeking to source angel investors currently have no direct means of locating them.

Moreover, angel investors in the State tend to have displayed a lack of interest in investing in projects outside of the State's resources sector due to historical factors.

Formal Venture Capital Funds

Approximately 50 venture capital funds are registered in Australia, of which only two (or 4 per cent) are based in Western Australia: Foundation Capital and Rothschild Golden Arrow Fund.[38] The Rothschild Golden Arrow Fund focuses on investments in the resources sector while Foundation Capital invests in general technology. A number of national and international venture capital funds also have representation in Western Australia.

In 2000, the total value of venture capital received by Western Australian organisations from formal venture capital funds was $137 million, or 6 per cent of the national total.[39] The key industry sector recipients of this venture capital were Mining (40 per cent of total value) and Manufacturing (26 per cent of total value).

The majority of formal venture capital in Western Australia has focused primarily on the later stage investment rather than early stage development.

Corporate Venture Capital

Corporate venture capital is cited as being small in Western Australia due to the small corporate presence in the State. The key Western Australian corporations also tend to favour venture capital investments in resource and engineering based projects. Companies that have undertaken venture investments in the past include Clough Engineering, Woodside Petroleum, the GRD Group, and Wesfarmers.

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[37] Barnett, R. and T Mazzarol, 2002, *Creating an Effective Venture Capital Environment in Western Australia: Guidelines for Government, Industry and Universities*. Discussion Paper prepared by the Graduate School of Management (UWA) and Australian Venture Consultants.

[38] Barnett, R. and T Mazzarol, 2002, *Creating an Effective Venture Capital Environment in Western Australia: Guidelines for Government, Industry and Universities*. Discussion Paper prepared by the Graduate School of Management (UWA) and Australian Venture Consultants.

[39] Barnett, R. and T Mazzarol, 2002, *Creating an Effective Venture Capital Environment in Western Australia: Guidelines for Government, Industry and Universities*. Discussion Paper prepared by the Graduate School of Management (UWA) and Australian Venture Consultants.

Share Market

The share market is regarded as an important and accessible source of venture capital funds for small companies. Western Australian companies have been successful in attracting funds through this channel. This is evident by the large proportion of IPOs under $15 million (29 per cent) and the number of listed companies (40 per cent) with market capitalisation under $10 million being sourced from Western Australia during recent times.[40]

However, there are disadvantages in relying on the share market as a source of funds. The availability of funds is determined largely by market sentiment and investor confidence. The other disadvantage of sourcing capital from the share market, particularly for early stage development companies, is the high compliance costs associated with requirements to report to shareholders by being in a publicly listed environment. As a consequence, this would impede on the ability of listed ventures to focus on its core activities.

Investment Skills

In addition to pools of money, successful investment capital markets also require a pool of skills to attract investment (domestically and internationally) and to assess the risk and return of potential venture investments.

Generally, there has been an absence of specialist skills and early stage investment experience amongst venture capital investors in Western Australia. This is due in part to the lack of critical mass in the formal venture capital market in Western Australia.[41]

3.4.3 Clusters

A great deal of debate has focused on the issue of developing clusters — an idea which through the work of Michael Porter and others is in good currency.[42] A concern of policy makers is that relatively few globally competitively clusters can be identified in Australia beyond some outstanding examples in mining, energy, agriculture, processed food (the wine industry), the automotive component industry and the medical and scientific instruments industry.

Michael Porter's analysis of clusters with its emphasis on the identification of areas of unique potential (which are things like specialised skills and specialised technology and the ability to translate and commercialise technology rapidly) and then providing support, strongly suggest the need for a partnership between business, government and the universities.[43]

There is an active and as yet unresolved debate about whether clusters can be created or at the very least some pre-existing conditions should be present before an active cluster development effort is engaged.

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[40] Barnett, R. and T Mazzarol, 2002, *Creating an Effective Venture Capital Environment in Western Australia: Guidelines for Government, Industry and Universities*. Discussion Paper prepared by the Graduate School of Management (UWA) and Australian Venture Consultants.

[41] Barnett, R. and T Mazzarol, 2002, *Creating an Effective Venture Capital Environment in Western Australia: Guidelines for Government, Industry and Universities*. Discussion Paper prepared by the Graduate School of Management (UWA) and Australian Venture Consultants.

[42] The concept of economic clusters has a long history in the economic literature. A case can be made the initial contribution came from Alfred Marshall's, *The Principles of Economics.*

[43] James. D., 2002, "How to kick global goals. If Australia wants global success, it must learn to exploit its unique local strengths" *Business Review Weekly*, 28 March-3 April, Pp 50-55.

Naturally, Western Australia has strong clusters in the areas of mining, energy and agriculture due primarily to the fact that Western Australia is traditionally a primary producer with much of its wealth emerging from these sectors.

Environmental sciences are also emerging as a potential cluster in Western Australia as a direct result of dryland salinity problems in the State. Other potential clusters include information communications and technology; health and medical science; and defence and engineering.

Clusters of collaboration between industry, government and research institutions are identified in Table 3.6. Included here are lists of government departments, businesses, university research centres and research collaboration such as the CRCs, which are considered to contribute to the process of building clusters.

Table 3.6

EMERGING CLUSTERS IN WESTERN AUSTRALIA: RESEARCH CENTRES

Cluster	Industry	Government	Higher Education
Mining and Energy	– Alcoa World Alumina – AngloGold Australasia Ltd – Australian Petroleum Production and Exploration Association – BHP Billiton Innovation Pty Ltd – Comalco Aluminium Ltd – Hamersley Iron Pty – Rio Tinto Research & Technology Development – Wesfarmers – WMC Resources Ltd – Worsley Alumina Pty Ltd	– CSIRO (Australian Resources Research Centre)	– CRC for AJ Parker CRC for Hydrometallurgy – CRC for Landscape Environments and Mineral Exploration – CRC for Predictive Mineral Discovery – CRC for Mining Technology and Equipment – Australian Petroleum CRC – CRC for Coal in Sustainable Development – Centre of Excellence in Mass Spectrometry – Centre of Excellence for Exploration and Production Geophysics – Western Australian School of Mines – Centre for Strategic Mineral Deposits – Tectonics Special Research Centre – Australian Centre for Geomechanics
Agriculture, Forestry and Fishing		– CSIRO Marine – CSIRO Mediterranean Agricultural Research – Australian Institute of Marine Science – Department of Agriculture – Department of Fisheries – Forest Products Commission	– CRC for Australian Sheep Industry – CRC for Cattle and Beef Quality – CRC for Molecular Plant Breeding – CRC for Sustainable Aquaculture of FinFish – CRC for Sustainable Production of Forestry – CRC for Value Added Wheat

Environmental sciences		- CSIRO Land and Water - Department of Conservation and Land Management - Department of Agriculture - Forest Product Commission - Perth Zoo	- CRC for Plant-based Management of Dryland Salinity - CRC for Australian Weed Management - CRC for Biological Control of Pest Animals - CRC for Conservation and Management of Marsupials - CRC for Greenhouse Accounting - CRC for Sustainable Tourism - CRC for Waste Management and Pollution Control - CRC for Water Quality and Treatment - Centre for Organic Waste Management - Centre for Water Research - Centre for Land Rehabilitation - Centre for Excellence in Natural Resource Management
Information and Communications Technology	- IBM Programming Centre - Imago Multimedia Centre		- UWA-Motorola Software Centre of Excellence - National Networked Tele-Test Facility for Integrated Systems - Australian Telecommunications CRC - Centre for Intelligent Process Operations and Management
Health and Medical Science	- Pfizer (formerly Pharmacia and DeltaWest)	- Department of Health	- CRC for Asthma - Australian Research Centre for Medical Engineering - Telethon Institute for Child Research - Lions Eye Institute - Western Australian Biomedical Research Institute - Western Australian Institute for Medical Research - Centre for Biomolecular Control of Disease
Defence and Engineering		- Defence Science Technology Organisation - Munster Marine Industry Technology Park	- Centre for Marine Science and Technology. - Centre for Offshore Foundation Systems

3.4.4 International Linkages

International linkages are important for the State in sharing and using research through gaining access to technologies and know how from international centres of excellence and world-class researchers. Moreover, international linkages also enhance the ability of Western Australians to access foreign markets and foreign investment capital.

The number of international research linkages in Western Australia can be observed by the number of Australian Research Council funded "Linkage International" fellowships awarded to this State. This program aims to build strong ongoing collaborations between research groupings or centres of excellence in Australia and overseas through the exchange of researchers. In 2002, 12 international fellowships were awarded by the ARC, of which one was awarded to a Western Australian institution. The collaboration would involve collaborative research into geology with members from Curtin University and the University of Leicester.

The University of Western Australia's School of Physics operates the Australian International Gravitational Research Centre, which involves collaboration with, inter alia, the Californian Institute of Technology and the Inter-University Centre for Astronomy and Astrophysics (India). The University of Western Australia's Centre for Offshore Foundation Systems also collaborates with the Norwegian Geotechnical Institute.

In addition to collaboration with international research institutions, a number of international linkages with multinational companies have been observed. These include the:

- UWA-Motorola Software Centre of Excellence;
- Rio Tinto's HIsmelt plant;
- Pharmacia's Perth operation; and
- IBM Programming Centre.

More recently, the European Space Agency (ESA) has established a Deep Space Ground Station for space age research at New Norcia (in the State's Mid-West). The facility would complement a network of ESA earth stations in Sweden, Belgium, Spain, the Canary Islands and French Guiana.

3.5 Conclusions

This chapter examined Western Australia's knowledge infrastructure in terms of infrastructure that facilitates knowledge creation, sharing and use.

Western Australia has built a valuable platform to *create* knowledge through its education infrastructure as evidenced by strong performances in recognised literacy and science tests. The tests suggest Western Australia's education system is producing good outcomes compared to other Australian States and leading countries internationally for that matter. There is however some weakness in participation levels, in particular, participation in higher education.

Western Australia's research and development base is diverse, with capabilities in higher education, Commonwealth and State research agencies, medical institutes and business. The State also possesses areas of research excellence. There are however, concerns over declining levels of State government research expenditure and relatively low levels of research expenditure undertaken at the universities.

In terms of *sharing* knowledge, there are good examples of research collaboration and participation by Western Australian research bodies in CRCs, some local centres of excellence and industry collaborations. Major collaborative initiatives include the Australian Resources Research Centre and the UWA-Motorola Centre of Excellence.

The expansion of knowledge sharing, both within and beyond Western Australia, will be improved by the availability of information and communications technologies with higher bandwidths. There are currently emerging concerns over Western Australia's ability to accommodate the need for newer and faster information and communication technologies.

Western Australia also has had an indifferent experience with the *use* of knowledge as evident from the performance of research commercialisation. Currently, there are low amounts of royalties paid to universities and declining levels of patent activity. While some successes can be identified, there is a concern that the rate of commercialisation and the creation of new start-up businesses are falling well short of the potential.

This may be attributable to the size and nature of venture capital in the State, which is small and fragmented, particularly for early stage investments and start-up businesses. There is also a shortage of specialist investment skills and early stage investment experience amongst venture capital investors in Western Australia.

Important for bridging the gap from minds to markets is the presence of strong and emerging clusters. Currently, Western Australia possesses some strong clusters in the areas of minerals and energy and primary industries. Clusters are also starting to emerge in environmental sciences, health and medical, information and communication and technology and engineering and defence. Building these clusters will be of considerable importance for Western Australia's future positioning.

However, there is a real concern that the research system as a whole is fragmented and lacking critical mass and linkages. The distance of Western Australia from eastern Australian States and international centres of research excellence suggests that greater efforts are warranted to build national and international linkages.

Section Four

Mapping Government Knowledge Infrastructure Programs and Initiatives

4.1 Introduction

This section identifies Commonwealth and State government programs and initiatives that are currently being directed to building and supporting Western Australia's knowledge infrastructure.

Government programs and initiatives are "mapped" against a number of elements which together constitute the State's knowledge infrastructure.

- Creating Knowledge
  - *Education and skills* - programs to build, retain and/or acquire skills.
  - *Research and Development* - programs that support innovation through investments into research projects and/or investments into research centres and equipment.
- Sharing Knowledge
  - *Building critical mass and linkages* - programs which aim to increase collaboration between different research organisations and where possible to support the emergence of critical mass and clusters.
  - *Strengthening information and communications networks* – programs to strengthen and develop information and communication systems.
- Using Knowledge
  - *Commercialisation processes* – programs that seek to improve the prospects for the successful commercialisation of new technology.
  - *Developing clusters* – Programs which strengthen existing and emerging clusters.
  - *Attracting and securing investment* – programs which increase the pool of investment capital available for research and development.
  - *Developing international linkages* – programs which facilitate international linkages in research and development.

Government programs are identified on the basis of whether or not they are consistent with one or more of these enablers, recognising that some programs may encompass one or more of them.

4.2 Commonwealth Programs

4.2.1 Creating Knowledge

Education and Skills

The Commonwealth is the major source of funding for the universities in Australia. Funding is provided under the *Higher Education Funding Act 1988*. The distribution of funding to the universities is based on the number of higher education placements (i.e. through the Higher Education Contribution Scheme) as well as through grants for operating, capital and research purposes.

While the States are the major sources of funding for the schools system and the TAFE system, the Commonwealth government also provides financial support to the States for these purposes.

The Commonwealth Department of Education, Science and Training also administer a number of other programs such as the Higher Education Innovation Programme and the Higher Education Equity Programme.

The Australian Research Council also provides a number of fellowships for researchers at the postdoctoral level to undertake research that is considered to be of national and international significance.

Research and Development

The Commonwealth has a number of schemes to fund general and specific research projects. These include:

- Research Infrastructure Block Grants Scheme;
- Australian Research Council (ARC) Grants;
- National Health and Medical Research Council (NHMRC) Grants;
- Major National Research Facilities;
- ICT Centre of Excellence;
- Biotechnology Centre of Excellence; and
- Rural R&D Corporations.

As well as providing funding for research through granting schemes of one kind or another, the Commonwealth also funds its own research agencies such as CSIRO, AIMS, ANSTO and DSTO.

4.2.2 Sharing Knowledge

Building Critical Mass

The Co-operative Research Centre (CRC) Program was established in 1990 to encourage long-term collaborative research partnerships between researchers from universities, CSIRO and other government laboratories, private industry, and public sector agencies. Research must be in a field of natural sciences or engineering. There are currently 64 CRCs.

Western Australian universities have secured funding from the Co-operative Research Centre (CRC) Program. Five of the 64 CRCs established under the program are based in Perth, and specialise in the fields of:[44]

- Information Technology and Communications
  - Australian Telecommunications CRC
- Mining and Energy
  - AJ Parker CRC for Hydrometallurgy
  - Australian CRC for Renewable Energy[45]
  - CRC for Landscape Environments and Mineral Exploration
- Environment (dryland salinity)
  - CRC for Plant-based Management of Dryland Salinity

[44] Source: Commonwealth Department of Education, Science and Training, 2002, *2002 CRC Compendium*, May 2002.
[45] This CRC will cease to operate in 2003.

Western Australian organisations are also key collaborative research partners of other CRCs located in other States.

The Commonwealth has devoted significant funding to establish an ICT Centre of Excellence (New South Wales) and a Biotechnology Centre of Excellence (Victoria). The Commonwealth provided funding of $129.5 million and $45.6 million respectively to these Centres. Western Australia was not selected to host these major initiatives.

Under the Major National Research Facility program Western Australia currently has one (of 15) Major National Research Facility: the National Networked Tele-Test Facility for Integrated Systems at Edith Cowan University. The Major National Research Facility (MNRF) Program is part of the Commonwealth government's Backing Australian's Ability policy to strengthen innovation through the provision of large-scale world-class, specialised facilities which are not otherwise available.

Strengthening Information and Communications Networks

In 2001, the Commonwealth government announced a $50 million National Communications Fund to assist the rollout of the infrastructure and applications to enable high-speed telecommunications networks to deliver education and health services in regional Australia. Applications for this fund closed on February 2002.

The "Network WA" project was one of eight national projects awarded to develop the regional telecommunications network. The project will secure $8 million (16 per cent) from the NCF.

4.2.3 Using Knowledge

Commercialisation Processes

The Commonwealth government has several programs to improve the prospects for business to achieve successful commercialisation of new technology.

- *BITS Incubator*. "Incubators" established under this program will provide advice and services to assist the start-up of IT businesses.
- *Commercialising Emerging Technologies (COMET).* This program assists innovation and commercialisation in 'spin off' and early growth companies through funding the cost of commercialisation activities and providing funding to meet the cost of undertaking management skills courses.
- *R&D Start*: This program assists companies in undertaking research and development and commercialisation through the provision of grants and loans.
- *R&D Tax Concession*. Tax concessions to firms that undertake research and development activities.
- *Biotechnology Innovation Fund*. The program provides partial funding (50 per cent up to a maximum of $250,000) to companies at the technical testing and product analysis at the pre-seed stage. The program aims to increase the flow of Australian biotechnology projects proceeding to commercialisation.

Attracting and Securing Investment

The Commonwealth government provides capital to support the growth of new technology–based businesses through a number of investment funds.

- *Innovation Investment Fund* – This program aims to promote the commercialisation of Australian research through the injection of venture capital into small, high-tech companies at the seed, start-up or early expansion stages of development. The Commonwealth will provide $220.7 million to licensed fund managers under the program. There are currently nine licensed IIF fund mangers, of which one is based in Perth (Foundation Management specialising in general technology). Foundation Management was awarded a contract to manage $22 million of Commonwealth funds under this program.
- *Pre–Seed Fund for Universities and Public Sector Research Agencies* – The Fund aims to assist universities and public sector research agencies to commercialise discoveries; create new business opportunities; develop the management and entrepreneurial skills of public sector researchers; and build linkages with the finance and business community. Currently, four private-sector firms have been offered fund manager licences, giving them the opportunity to manage more than $62.7 million in Commonwealth funds. None of these fund managers are based in Perth.
- *BITS Incubator Program* – This program is a source of venture capital for IT companies. The BITS incubator in Perth has invested in five Western Australia ventures. This portfolio represents 7 per cent of the total number of venture investments made under the BITS program.

The main source of investment funds for large projects is through the Strategic Investment Co-ordinator Program, which aims to attract large scale projects with significant net economic and employment benefits and to increase sustainable investment in Australia.

Since 1997, the government has granted investment incentives to eight projects totalling $570 million, of which three of these projects are based in Western Australia with all three of these projects relating to large scale minerals and energy projects.

Developing Clusters

The Commonwealth's Co-operative Research Centre Program (CRCs) facilitates the development of clusters by bringing together partners from industry, government and higher education institutions.

An example of cluster formation under this program is the experience of the Photonics CRC, headquartered at the Australian Technology Park in Sydney. The Australian Photonics CRC is a joint venture between five universities, TAFE NSW, the DSTO and 21 industry and business participants. The CRC generated a number of spin–off companies.

Developing International Linkages

The Commonwealth operates a number of "linkage" programs to assist the development of research and technology linkages.

The main Commonwealth program is the Innovation Access Program which aims to improve access by Australian researchers and firms to global research and technologies. The Commonwealth also has negotiated a series of Science and Technology Agreements with other countries.

Australian Research Council also awards "Linkage International" fellowships. This program aims to build strong ongoing collaborations between research groupings or centres of excellence in Australia and overseas involving the exchange of researchers. In 2002, 12 international fellowships were awarded by the ARC, of which one was awarded to a Western Australian institution.

4.2.4 Summary

The Commonwealth government funds, operates or manages a number of programs which directly impinge on the creation, sharing and using of knowledge. Commonwealth programs and initiatives are mapped according to the main elements identified as forming the knowledge infrastructure. These are summarised in Table 4.1.

Table 4.1

MAP OF COMMONWEALTH KNOWLEDGE INFRASTRUCTURE PROGRAMS

Program	Objective of Program	Funding/WA Share
CREATING KNOWLEDGE		
Education and Skills		
Grants under the Higher Education Funding Act	Funds to higher education institutions for operating, capital development and research purposes.	$5.8 billion per annum. $550 million (9.3%) would be allocated to WA institutions.
ARC Fellowships	Supports researchers at postdoctoral level.	451 fellowships in 2003. 41 (9.1%) of these fellows are based in Western Australia.
Research and Development		
Research Infrastructure Block Grants Scheme	Allocates grants to publicly-funded universities on the basis of an index which measures institutional success in obtaining competitively awarded research funding.	$82 million in 2001. $6.3 million to Western Australian higher education institutions.
Australian Research Council	Provides funding for research projects for a wide range of disciplines.	$94.7 million in 2003. $7.8 million of the (or 8.2%) of available ARC project funding will be allocated to Western Australian projects.
National Health and Medical Research Council	Provides funding for research projects with a health and medical focus.	$369 million in 2003. Approximately $26 million (or 7.3%) will be allocated to Western Australian projects.
Rural Industries Research Development Corporation	Provides funding for research in rural and agricultural research projects.	$20.2 million in 2001 to fund rural research projects. Approximately 10.2% will be allocated to Western Australian projects.
Grains Research Council	Provides funding for grains research projects.	$101 million in 2002. $24.2 million or (23.9%) allocated to Western Australian based projects.
Fisheries Research Development Council	Provides funding for grains research.	$20 million in 2002. $3.6 million or 17.8% allocated to Western Australian projects.
SHARING KNOWLEDGE		
Building Critical Mass		
Collaborative Research Centres Program	Collaborative research partnerships between universities, CSIRO and other government laboratories, private industry, and public sector.	$145 million in 2002. $14.9 million (or 10%). Will be allocated to CRCs based in Western Australia.
ICT Centre of Excellence	A national focus for ICT research.	$129.5 million. No funding to Western Australia.
Biotechnology Centre of Excellence	A national focus for biotechnology research.	$45.6 million. No funding to Western Australia.
Major National Research Facilities Program	Developing new large scale scientific infrastructure.	$155 million has been allocated over 5 years. $4.75 million (3%) allocated to a Western Australian project.
Strengthening Information and Communications Technology Networks		
National Communications Fund	Assist in the rollout of the infrastructure and applications to enable high-speed telecommunications networks.	$50 million. $8 million (16%) to Western Australia.
USING KNOWLEDGE		
Commercialisation Processes		
BITS Incubator Program	Increase the success rate of start-up IT businesses.	$78 million to establish 10 incubators. $10million (or 12.8%) to a Western Australian based incubator.
COMET Program	Assist innovation and commercialisation of 'spin off' companies.	$12.3 million in 2001. $1.6 million (13%) to Western Australian companies.
R&D Start	Assist companies in research commercialisation.	$163.6 million in 2000/01. $11m (6.7%) to Western Australian companies.

Program	Objective of Program	Funding/WA Share
R&D Tax Concession	Encourage business R&D through tax incentives.	10.1% of registrants to the R&D Concession program were from Western Australia.
Biotechnology Investment Fund	Assist companies in the proof of concept stage of development and for the commercialisation of biotechnology.	$12 million in the first two rounds of funding. $0.74 million (6.1%) allocated to Western Australian companies.
Attracting and Securing Investment		
Pre Seed Fund	Assist universities and public sector research agencies to commercialise discoveries through pre-seed investment capital.	$62.7 million to licensed fund managers. None in Western Australia.
Innovation Investment Fund	Promote the commercialisation of Australian research through the injection of venture capital into start-up high tech companies.	$220.7 million to licensed fund managers. $22 million (10%) to a Western Australian fund manager.
Strategic Investment Co-ordinator Program	Attract large scale projects with significant net economic and employment benefits.	$570 million. 3 out of 7 projects in Western Australia.
Developing Clusters		
Collaborative Research Centres Program	Collaborative research partnerships between universities, CSIRO and other government laboratories, private industry, and public sector.	$145 million in 2002. $14.9 million (or 10%). Will be allocated to CRCs based in Western Australia.
Developing International Linkages		
Innovation Access Program	Supports international research and development cooperation.	
ARC Linkage Fellowships	Build strong ongoing collaborations between research groupings or centres of excellence in Australia and overseas.	In 2002, 12 international fellowships were awarded by the ARC, of which one was awarded to a Western Australian institution.

4.3 State Government Programs

4.3.1 Creating Knowledge

Education and Skills

While the Commonwealth government has primary responsibility for funding the higher education system, the State government is primarily responsible for the schools and vocational education and training systems. The Department of Education and Training's budget was $2.3 billion in 2002/03.[46]

Nevertheless, the State government has introduced some programs which relate to attracting high level researchers in the universities and other research centres. The two main ones are:

- The Premier's Research and Fellowship Program which aims to attract overseas or interstate researchers to Western Australia through fellowship packages of $250,000 per annum for four years. One Research Fellowship will be awarded in 2002/03 and one in the following year.
- The Strategic Research Fund for the Marine Environment, which will provide ten scholarships (total of $600,000) for researchers with a marine focus.

In total, these programs amount to $2.6 million over five years, or approximately half a million per year to building and retaining skills.

Research and Development

The State government provides funding to research centres and research projects through a number of programs.

[46] Department of Treasury and Finance, 2002, *Budget Papers*.

The Centre of Excellence Program provides funding to support and facilitate the establishment of research centres with a significant base in Western Australia. The fund is available for research institutions and is to be used for the purposes of purchasing science and innovation infrastructure. The government has pledged $34.3 million to the program over the next four years, with $21 million provided to existing Centres of Excellence under the old program and $13.3 million to be spent in 2002-03 to assist new Western Australian bids for Commonwealth programs.[47]

There are also a number of competitive research grants available for research projects.

- $4.5 million per annum from the Medical and Health Research Infrastructure Fund. The fund is primarily used to support projects who were successful in receiving nationally competitive research grants.
- $600,000 per annum from the Minerals and Energy Research Institute for projects relating to minerals and energy.
- $2.3 million per annum in grants from Healthway. Grants are available for research projects with a health promotion.

There are also a number of grants that are not research specific but may be a source for funding for researchers. These include grants from the Lotteries West and the Waste Management Recycling Fund.

In total, the State government distributes approximately $16 million in grants per year to support research projects.

In addition, the State government also funds and conducts its own research projects through its government agencies, which is estimated to incur expenditures of $92 million per year.[48] Key State government research agencies include: Department of Agriculture; Department of Conservation and Land Management; Forest Products Commission; Fisheries WA and the Chemistry Centre.

4.3.2 Sharing Knowledge

Building Critical Mass and Linkages

Large scale initiatives have been undertaken by the State government to build critical mass in key research areas.

- *Australian Resources Research Centre*: Collaboration between CSIRO, Curtin University and the State government to develop a focus for minerals and energy research.
- *UWA-Motorola Software Centre of Excellence*: A collaboration between State government, UWA and Motorola to develop a research centre into third generation (3G) wireless technology.
- *IBM Australian Programming Centre.* State government grant to IBM to expand its software development centre. The Western Australian government provided $1.9 million in financial assistance to this initiative.
- *The Strategic Research Fund for the Marine Environment*. A joint venture between the State government and the CSIRO to build marine research capacity.

Under the *Innovate WA* policy, the State government has pledged an additional $13.3 million to assist Centres of Excellences in securing new or more Commonwealth funding. The State government also provides business planning support to research centres to prepare business plans through the Office of Science and Innovation.

[47] Ministerial Statement (State Development) "Minister announces Centre of Excellence for Collie", 23 May 2002.
[48] Premier's Science Council, 2002, *Report on Research in Western Australian State Government Agencies*, February 2002.

On a smaller and more general scale, the State government has established the Premier's Collaborative Research Program to enhance inter-agency research collaboration and cooperation between State government agencies, industry and academia. Grants are available to State government agencies, for projects with two or more participating agencies and one or more external partners. The maximum funding available to a project is in the order of $600,000 over three years, or approximately $200,000 per annum.

The WA Science and Technology Innovation Fund provides financial support for Western Australian training providers to collaborate with industry, university, government and other bodies to undertake innovative science and technology projects. The State government will fund up to $1 million in grants in 2003 ranging from $50,000 to $200,000.

Technology Park in Bentley is another initiative by the State government to promote innovation and entrepreneurship in Western Australia by providing technology-based infrastructure for technology based enterprises. Since commencing in 1985, the Technology Park in Bentley is regarded as a leading Park in Australia and is rated by the International Association of Science Parks as second best in Asia and ninth best in the world.[49]

Strengthening Information and Communications Technology Networks

In 2002, the Western Australian government announced the provision of Broadband bandwidth to all metropolitan schools over three years. Under the "e2c" strategy, 400 metropolitan high schools and primary schools will receive 10 megabytes per second while rural schools would receive 2 megabytes per second. The State government has allocated $90 million over four years for this program.

In addition, the State government has initiated the Statewide Telecommunications Enhancement Program (STEP), which is a whole-of-government mandatory Common Use contract for the procurement of data carriage services and managed data services for country Western Australia by Western Australian government agencies. The purpose of this program is to aggregate government demand for data carriage services and managed data services to improve on cost efficiencies and services provided by Telstra and other service providers. Consultation with the Department of Industry and Resources indicate the State government spends approximately $125 million per annum on information and communications technologies.

4.3.3 Using Knowledge

Commercialisation Processes

The State government does not have any programs which aim to improve the prospects for companies to successfully achieve commercialisation of new technology.

Previously, the Western Australian government operated the Western Australian Innovation Support Scheme which provided small grants to businesses on a dollar-to-dollar basis to support research and development of innovative products with commercial merit. The scheme aimed to offset the risks involved for companies in bringing new ideas to a commercial, marketable stage. This fund has now ceased to exist and there are currently no commercialisation programs available for businesses. However, consultation with the Department of Industry and Resources indicate that this program may be resurrected and restructured along the lines of the Commonwealth R&D Start program.

[49] Source: http://www.techparkwa.org.au

The key activities undertaken by State government in assisting organisations to commercialise ideas are mainly through the provision of information rather than direct funding. The State government holds "Innovation Success Seminars" to give business an insight into commercialising new ideas and technology and has established the "Western Australian Innovation Centre" website which provides information on partnerships and potential funding sources.

Outside of State government, the University of Western Australia has funded and established the UWA Pathfinder Fund. The University works with early stage investors, venture capitalists and other commercial interests to commercialise the University's research outcomes.

Attracting and Securing Investment

As mentioned previously, the Department of Industry and Resources maintains the "Western Australian Innovation Centre" website and organises "Innovation Success Seminars". These services provide information on partnerships and potential funding sources.

Developing Clusters

The State government is currently in the process of developing a new technology park focusing on marine related technology. The site is located adjacent to Lake Coogee in Munster and aims to attract technology intensive industries with common-user infrastructure and encourage synergy.

The Technology Park will be part of the Australian Marine Complex, comprising the following precincts:

- Shipbuilding Precinct (including a Marine Support Facility);
- Support Industry Precinct;
- Fabrication Precinct; and
- Technology Precinct.

The Marine Complex would be developed to facilitate and enhance the opportunities created by the clustering of Western Australia's regional advantages in the marine, defence and resources industries.

In addition, the State government has established the Strategic Research Fund for the Marine Environment to build marine research capacity.

Developing International Linkages

The State government is spending $800,000 over the next four years in a bid to lure a $1 billion international Square Kilometre Array (SKA) project in Geraldton.

The SKA telescope project involves collaborative strategic research with partners from The Netherlands, Canada, India and the USA; overall co-ordination is provided by working groups within the International Astronomical Union (IAU), the International Union of Radio Science (URSI), and the OECD Megascience Forum.

4.3.4 Summary of State Government Programs

A summary "map" of State government programs to support key elements of the knowledge infrastructure is presented in Table 4.2.

Table 4.2

MAP OF STATE KNOWLEDGE INFRASTRUCTURE PROGRAMS

Program	Objective of Program	Funding
CREATING KNOWLEDGE		
Education and Skills		
Premier's Research Fellowship Program	Attract overseas or interstate researchers to Western Australia through fellowships.	Two fellowships of $250,000 per year over four years, or a total value of $2 million.
Strategic Research Fund for the Marine Environment	Attract researchers with a marine focus to Western Australia through scholarships.	10 scholarships with a total value of $600,000 over five years.
HECS for Science Students	Reimbursing HECS fees to students undertaking science degrees.	$3.7 million.
Research and Development		
Centre of Excellence Program	Support and facilitate the establishment of science and technology research centres with a significant base.	$34.3 million over four years.
Medical and Health Research Infrastructure Fund Grants	Grants to support medicine and health research projects.	Approximately $4.5 million per annum.
Minerals and Energy Research Institute Grants	Grants to support minerals and energy related research projects.	Approximately $600,000 per annum.
Healthway Research Grants	Grants to support health related research projects.	Approximately $2.3 million per annum.
SHARING KNOWLEDGE		
Building Critical Mass and Linkages		
Australian Resources Research Centre	Provide a national focus for research into petroleum and mineral resources.	$35 million grant.
UWA-Motorola Software Centre of Excellence	Provide a research centre with a focus on 3G wireless technology.	$5.4 million over five years.
IBM Australian Programming Centre	Provide a centre for software development.	Industry grant of $1.9 million.
Strategic Research Fund for the Marine Environment	Joint venture with CSIRO to enhance and build marine research capacity.	$5million to the CSIRO.
Premier's Collaborative Research Program	Enhance research collaboration and cooperation between State government agencies.	$1.8 million. One grant of $600,000 per year, paid over three years.
WA Science and Technology Innovation Fund	Financial support for RTOs to collaborate with industry in science and technology projects.	Approximately $1 million per annum.
Technology Park	A commercial and research precinct with a focus on general technology.	$350,000 recurrent costs per annum to manage the Park. Capital investment costs since 1985 acquisition costs have amounted to $22 million.
Strengthening Information and Communications Networks		
STEP	Aggregating State government demand for telecommunication services.	State government spends approximately $125 million per annum on voice, data and other ICT services.
Education to Community (E2C)	Increase in bandwidth to metropolitan and regional schools.	$90 million over four years.
USING KNOWLEDGE		
Commercialisation Processes		
WA Innovation Support Scheme	Small grants to businesses on a dollar-to-dollar basis to support research and development of innovative products with commercial merit.	No funding in 2002. The WAISS program is under review.
Attracting and Securing Investment		
Innovate WA funding.	Attract Commonwealth funding.	$13.3 million.
Developing Clusters		
Strategic Research Fund for the Marine Environment	Enhance and build marine research capacity.	$5million to the CSIRO.
Munster Marine Technology Park/ Australian Marine Complex.	Development a new technology park focusing on marine related technology.	$23.6 million in State government funding for land acquisitions, planning activities, and construction of precinct and support facilities.
Developing International Linkages		
SKA Radioastronomy Project	To lure the international $1 billion SKA radioastronomy project to WA.	$800,000 over four years.

4.4 Conclusions

The previous two sections have presented mappings of the State's knowledge infrastructure and the support being provided by the Commonwealth and State governments for the key elements of the knowledge infrastructure. Not surprisingly, the pattern of support reflects the different roles in the Federation of the Commonwealth and State governments. Table 4.3 presents a direct comparison of the support being provided by both levels of government for the knowledge infrastructure.

Table. 4.3

COMMONWEALTH AND STATE ROLES

	Commonwealth	State
CREATING KNOWLEDGE		
Education	Commonwealth is the major source of funding for higher education. The Commonwealth government is also a provider of scholarships to attract quality researchers.	The State government supports school and vocational education. The State government also provides scholarships to attract quality researchers.
Research and Development	Commonwealth government is a major supplier of research funding in the form of competitive grants to research projects and CRCs. Commonwealth also conducts research directly through CSIRO, AIMS, DSTO and ANSTO.	State government performs research through a number of State government research in areas of agriculture, fisheries environment and conservation. It also offers some small research grants to researchers and establishes Centre of Excellences.
SHARING KNOWLEDGE		
Critical Mass and Linkages	The Commonwealth develops critical mass through the CRC program as well as strategic investments in Centres of Excellence and Major National Research Facilities.	The State government undertakes strategic investments into collaborative research arrangements. Including the UWA Motorola Centre of Excellence and the ARRC. It is providing funding to Centres of Excellence to leverage off Commonwealth programs.
ICT Networks	The Commonwealth provides funding to develop and roll out major ICT networks.	The government is aggregating government demand for telecommunication networks and is rolling out broadband infrastructure to schools.
USING KNOWLEDGE		
Commercialisation	The Commonwealth government funds a number of competitive commercialisation programs for research intuitions and business.	State government provides information services through the internet and through seminar series.
Investment Capital	The Commonwealth government funds a number of venture capital funds. The government also directly undertakes strategic investments through the SIC to attract foreign direct investments.	State government provides information services through the internet and through seminar series.
Clusters	The Commonwealth develops clusters through the CRC program.	The State government provides hard infrastructure in the form of technology parks and has undertaken strategic investment into targeted areas such as marine research.
International Linkages	The Commonwealth provides competitive grants and fellowships for international research collaboration.	State government has provided funding in a bid to lure the international SKA projects.

Knowledge Creation

The Commonwealth government, through its support for the higher education system, the provision of a number of research granting schemes and the direct operations of Commonwealth Research Agencies plays an important strategic role in supporting knowledge creation in Western Australia.

The Western Australian government is the major funds provider for the schools and vocational and training systems which is an important part of the knowledge infrastructure relating to the knowledge creation process. It also is a direct investor in the research and development infrastructure, both in terms of its own research institutes and to a limited extent, in the higher education system and medical research institutes. Beyond this, the State government provides some minor funding for attracting and retaining research stars in the State.

Knowledge Sharing

The Commonwealth government's main impact in this area is through its funding of the Cooperative Research Centres program which is the major Commonwealth program supporting research collaboration and training of postgraduate researchers in an environment linked to end users. The Commonwealth, both through the activities of Telstra and certain programs of the Department of Communications, Information Technology and the Arts, is an important investor in the State's ICT infrastructure.

The Western Australian government supports research collaboration through its Centre of Excellence program. Under this program, the Western Australian government has allocated $21 million over the next four years to existing Centres and a further $13.3 million will be spent in 2002–03 to assist Western Australian bids for Commonwealth government programs. The State government has also supported the development of research precincts, notably at Bentley Park near Curtin University. The State government is currently undertaking significant investment in ICT infrastructure for schools.

Knowledge Use

The Commonwealth government funds a number of programs relating to business research and development and the commercialisation of new technologies. There has been a particular emphasis in recent years on improving the environment for commercialisation of intellectual property being generated by the universities and government funded research agencies — the COMET program, the Biotechnology Innovation Fund and the Pre–Seed Capital Fund for universities and government funded research agencies are examples. The Commonwealth government has also funded a significant international innovation program to build linkages and Australian and international research and development.

The Western Australian government has been involved in supporting knowledge use to a much more limited extent. One area where it has been active is in establishing clear rules for the exploitation of intellectual property generated by State government agencies.

Section Five

Building Western Australia's Knowledge Infrastructure – Key Messages and Recommended Actions

5.1 Introduction

A transition is underway in developed economies around the world that is changing the fundamentals of economic performance and prosperity. Put simply, obtaining value from the creation, sharing and use of knowledge is becoming an increasingly dominant factor in determining which economies prosper and which do not. This capacity for systemic "innovation" is set to be a differentiator of competitive performance of countries and of regions for the foreseeable future.

Western Australia is not immune from this. The need to create a strong and vibrant Western Australian knowledge economy with high quality knowledge infrastructure as its foundation should be seen as both a challenge that has to be met and an opportunity that should be grasped. Ultimately, the State's success or otherwise in this regard will have a marked bearing on the future quality of life experienced by all West Australians.

The challenge for Western Australia in terms of positioning itself in the global knowledge economy can be stated in terms of three propositions:

- using knowledge to add value to the State's traditional industries;
- using and sharing knowledge to create new businesses; and
- connecting the State to global knowledge networks.

The Western Australian government has recognised the challenge to the State's future prosperity represented by the need to build the State's innovative capability in order to increase the potential of public and private sector stakeholders to create, share and use knowledge to add value to existing and new activities. There are a significant number of government initiatives in place or in progress that are concerned with Western Australia's knowledge infrastructure, most notably the Innovation Fund announced by the Premier in 2002, with a commitment of $50 million over five years.

However, notwithstanding the range of initiatives being undertaken and the investments already made, there remain a number of important matters that need to be addressed, some of which require urgent attention. It is early days in what will need to be a long-term and ongoing commitment by the government, in partnership with private sector stakeholders, to build the State's knowledge infrastructure to where it is internationally recognised and regarded for its broadly-based high skill, high value workforce as a major contributing factor in business and economic performance and competitiveness.

In formulating key messages and recommending actions to emerge from investigations a considerable amount of effort has gone into analysing the now extensive literature, both conceptual and empirical, including previous reports prepared for the Western Australian Technology and Industry Advisory Council (TIAC) and associated working papers, concerned with the successful transition of Western Australia to a knowledge economy. Further research and extensive consultations with stakeholders conducted as part of this study have been used to verify and amplify this earlier work. Documentation which formed the basis of stakeholder consultations is set out in Appendix Two.

Based on knowledge of the international literature on innovation and analysis of approaches being followed by comparable entities to Western Australia in Canada and the USA outlined in Box 5.1 below is a set of best practice principles for knowledge infrastructure creation. These best practice principles have been used as a reference point throughout the process of investigation and are reflected in the formulation of key messages and recommended actions.

Box 5.1

BEST PRACTICE PRINCIPLES FOR KNOWLEDGE INFRASTRUCTURE CREATION

Eight best practice principles for effective creation of knowledge infrastructure are proposed.

1. Whole of government approach:
   - clear strategic directions and goals; and
   - effective intra-governmental coordination arrangements, integrated program and services delivery and performance monitoring system.
2. High quality education system:
   - emphasis on meeting world literacy, mathematics, science attainment levels; and
   - high participation rates in higher education and vocational training.
3. High quality research system:
   - excellence in attracting, retaining and encouraging star researchers;
   - emphasis on building critical mass; and
   - good linkages between research creators and users.
4. First class commercialisation system:
   - IP rules for government research bodies and universities; and
   - venture capital market and entrepreneurship/innovation management skills.
5. Excellent ICT Infrastructure:
   - computing power; and
   - effective networks including high speed broadband.
6. Developed clusters with strong internal and external linkages.
7. Strong international networks and connections.
8. Effective performance measurement and monitoring arrangements.

In seeking to "*provide practical policy options for the State government to encourage...the creation of the appropriate knowledge infrastructure*" an emphasis has been placed on proposing actions which:[50]

- have a sound rationale (e.g. overcoming an acknowledged market failure);
- are realistic in terms of the capacity for the Western Australian government to take such action;
- are prerequisites for or could be regarded as giving impetus to being catalysts for further systemic developments;
- potentially offer a significant "risk weighted return" (i.e. low cost relative to potential positive impacts and downside risks);
- take account of the likely interests of government and other stakeholders, recognising the importance of partnerships as a success factor in knowledge infrastructure creation/development; and
- should be capable of being implemented within a short to medium timeframe if there is a will to act.

[50] Technology and Industry Advisory Council (2002) Terms of Reference: *Creating the Knowledge Infrastructure: Opportunities for High Skilled, High Wage Employment in a Western Australian Knowledge Economy.*

The recommendations represent actions designed to address priority areas for government action, having regard to the quantum and scope of the existing knowledge infrastructure and assessed gaps and other shortcomings. Put simply, to build on and improve what currently exists and to create and develop new infrastructure necessary for the goals associated with high value workforce and global competitiveness to be achieved.

The key messages and recommendations are set out under the following headings:

- setting clear strategic directions and goals;
- ensuring effective intra-governmental coordination arrangements;
- improving government programs and services;
- building and retaining skills;
- building critical mass and linkages;
- attracting and securing investment;
- developing clusters;
- strengthening ICT networks;
- improving leverage potential with national programs and initiatives; and
- developing international linkages.

In systemic terms, this set of complementary initiatives is designed to result in a "virtuous cycle" of knowledge infrastructure creation and development, adding value through innovation, productivity gains and increased GDP growth and higher value jobs. This process is illustrated in Figure 5.1.

Figure 5.1

THE "VIRTUOUS CYCLE" FOR WESTERN AUSTRALIA

5.2 Setting Clear Strategic Directions and Goals

Taking concerted and systematic action is clearly central to the effectiveness of building Western Australia's knowledge infrastructure. In this context, it is difficult to understate the importance of the government communicating effectively to the community the key concepts, strategies and specific plans of action being pursued and the benefits of building the State's knowledge infrastructure.

It is too easy for discussion and debate concerning innovation and knowledge infrastructure creation, including public communication, to take on the character of a technical treatise that sounds more concerned with means that it is with ends and runs the risk of being impenetrable to many in the community and therefore misunderstood, ignored or rejected as irrelevant to community needs.

Community support is a necessary condition for the government successfully pursuing a well thought out and sustained agenda directed at tangible improvements in the knowledge infrastructure in Western Australia for the purposes of significant community benefits. It is therefore vitally important that the Western Australian community be able to access relevant and understandable information so that each citizen is well informed about what is at stake. Giving attention to ways and means of ensuring such a flow of information should be an important objective of the government.

Investigations conducted as part of this study have shown that even stakeholders directly involved in some or a number of the government's innovation initiatives are unsure of many aspects of the government's agenda, even more so in respect of the overall strategy being pursued.

This situation needs to be redressed. While there is no "silver bullet" solution to effective communication about such issues, more could be done to ensure the community fully understands the centrality of investing in the knowledge infrastructure economy for the future of Western Australia, their own living standards and the quality of life.

This is not to say the government has not been active in attempting to convey core messages. A number of significant public statements have been made, particularly by the Premier and the Minister for State Development, over the past two years setting out issues, priorities and objectives concerning development of Western Australia's innovation system including the creation of the knowledge infrastructure.

What has not yet been conveyed to intended audiences is a sense of a coherent strategic plan of action or "game plan" for the development of the State's innovation system and how this needs to be pursued in order to achieve the objectives set (e.g. a high value workforce and global competitiveness) and the benefits this is expected to generate for the State.

> ***Recommendation 1***
> *The West Australian government, as part of its innovation policy statement, set out clearly defined goals in respect of building Western Australia's knowledge infrastructure and the details (principal initiatives and mechanisms) of a strategic plan of action by which it will seek to achieve them.*

5.3 Ensuring Effective Intra-Governmental Coordination Arrangements

Where successful knowledge infrastructure development has occurred in other jurisdictions a key feature is proactive and demonstrable leadership by government and, in this context, the degree of attention paid to ensuring intra-governmental decision-making, advisory, coordination and operational structures and arrangements are relevant and effective. In effect, this represents a "do as we do" approach to leadership in an area of policy and functionality synonymous with networks and

partnerships. Accordingly, the way the Western Australian government seeks to develop and manage its own knowledge infrastructure affairs (and is perceived to do so by other stakeholders) will have a major bearing on the success or otherwise of actions designed to influence others outside government to contribute strongly to knowledge infrastructure creation with the aim of producing benefits not just for themselves but also the community in general.

Figure 5.2 provides an outline of the main bodies within the Western Australian governmental system with a direct or indirect decision making, advisory or operational functions/roles relating to knowledge infrastructure creation and development and the linkages between them.

While it is beyond the brief of this study to recommend specific changes to the government's structural and coordination arrangements, it is, nevertheless, appropriate to suggest that it is an area where the government needs to satisfy itself that the current arrangements are optimal. Some of the main messages to emerge from this study in respect of the effectiveness of inter-governmental arrangements are as follows.

- There is no clearly established Ministerial authority concerning knowledge infrastructure matters and, by implication, no visible "product champion", also leading to bureaucratic lines of responsibility/authority being unclear.

- It is not clear, given the existence, but opaque makeup and functional arrangements, of Cabinet sub-committees, how the government would deal with innovation and knowledge infrastructure matters that required Executive decision but were not the focus of an expenditure proposal (i.e. under the Expenditure Review Committee) or requiring full Cabinet consideration in the first instance.

- While there is a number of potentially complementary advisory structures in place (i.e. those set out in Figure 5.2), it is not apparent to what extent, if at all, there is a functional whole-of-government coordination/networking system in place that links these bodies and integrates their advice. Certainly, the existing structural arrangements (Figure 5.2 refers) suggest "ministry silos" with cross portfolio coordination, to the extent it does occur, being heavily focused at the decision making level (i.e. between Ministers and their respective Ministerial offices).

Figure 5.3 provides, for illustrative purposes only, some elements of intra-governmental coordination/networking arrangements currently lacking specific definition and incorporating possible new initiatives that could conceivably be considered.

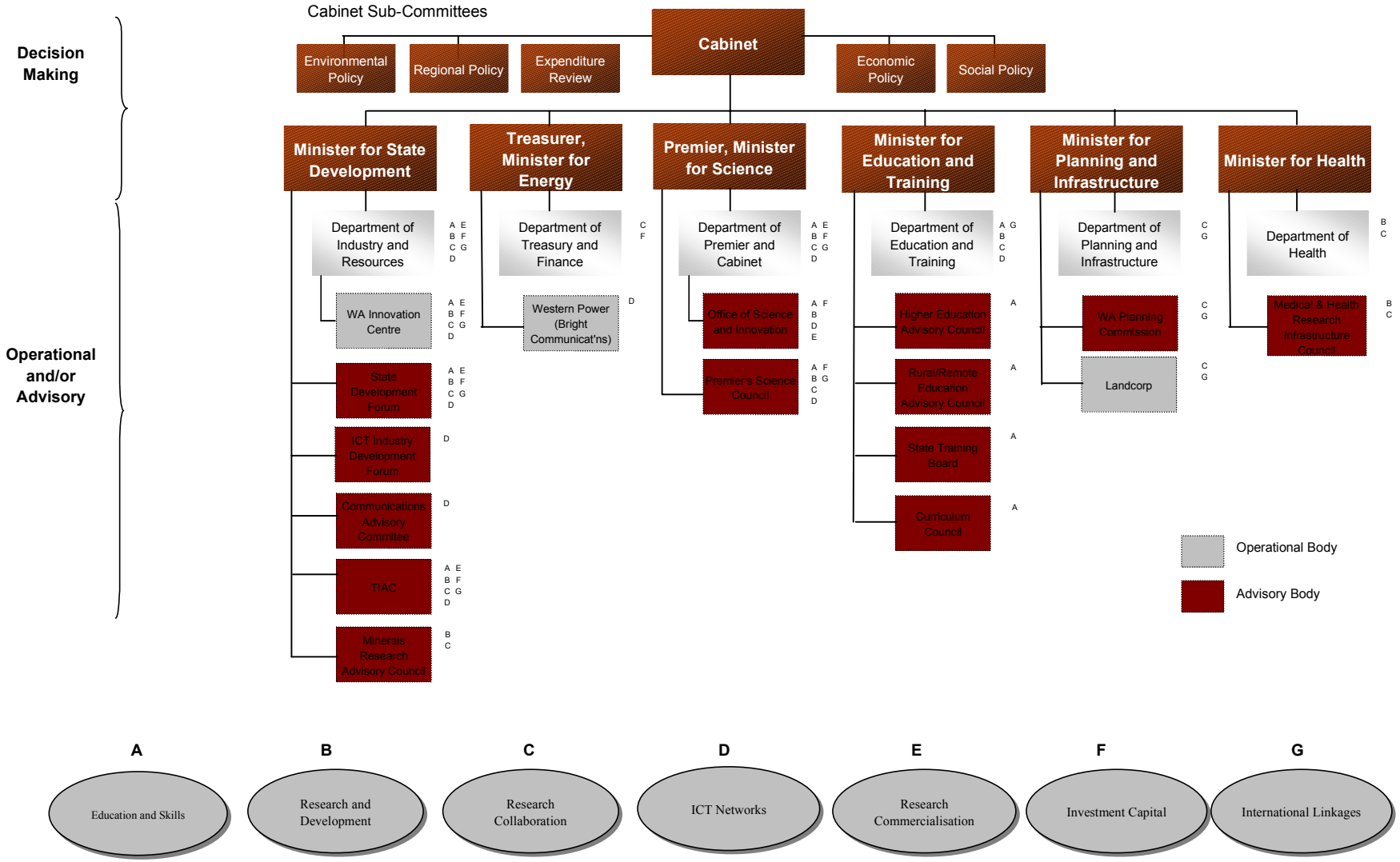
Beyond these messages, a number of interlocutors have suggested that a medium-term goal of the government should be to establish a Minister/Department for the Knowledge Economy, with responsibilities encompassing policy and operational functions across the innovation system/knowledge infrastructure spectrum.

While offering no specific comment on that proposal, it is sufficient to suggest that the matter of entrenching a more coherent and transparent "whole-of-government" set of coordination responsibilities and arrangements within the existing structures should be investigated.

> ***Recommendation 2***
> *The Western Australian government assign explicit Ministerial responsibility for knowledge infrastructure matters, carrying with it the responsibility for developing and implementing effective 'whole-of-government' (including inter-Ministerial and inter-agency) coordination/networking arrangements.*

Figure 5.2

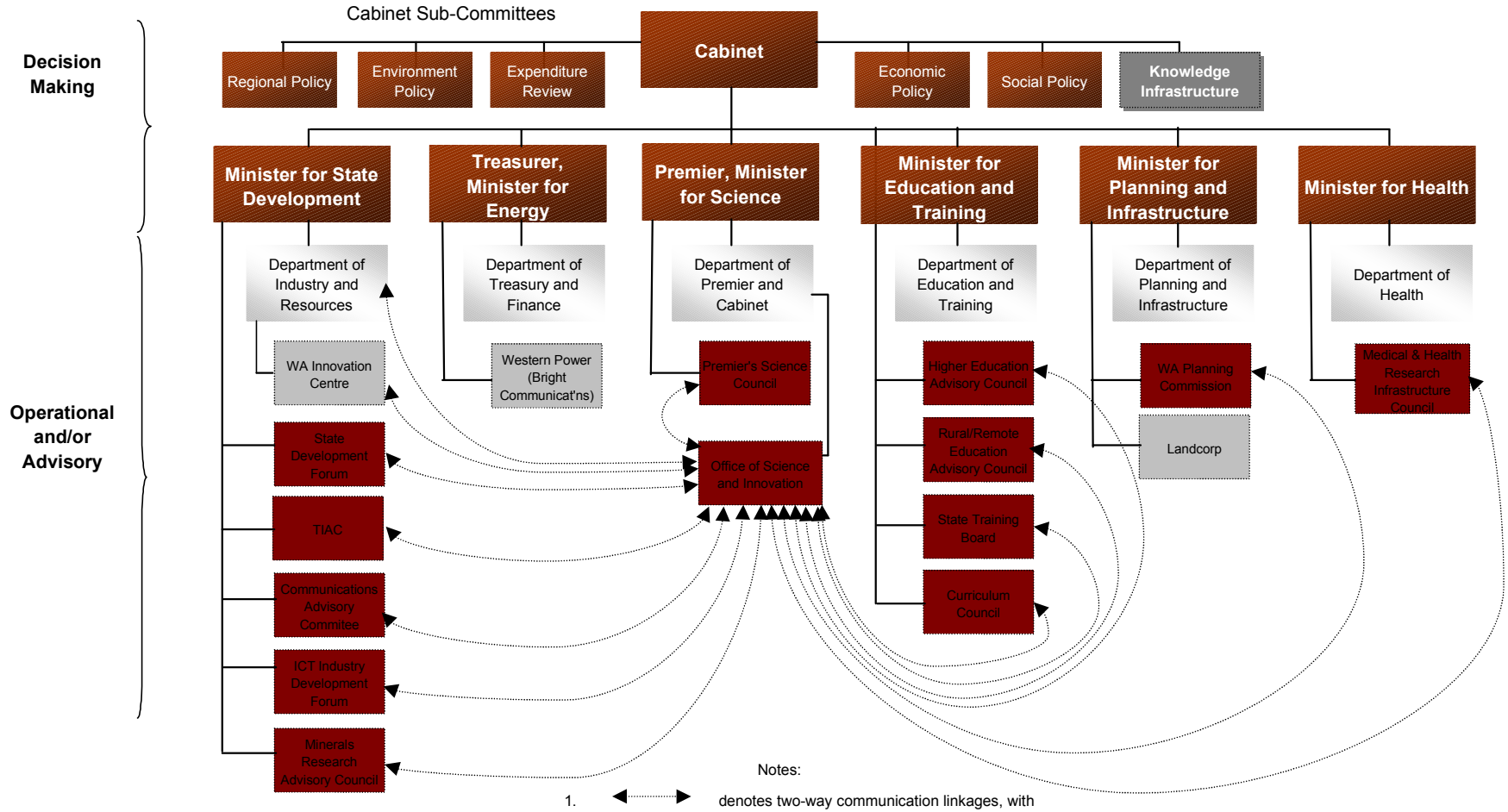
WESTERN AUSTRALIAN GOVERNMENTAL SYSTEM RELATING TO KNOWLEDGE INFRASTRUCTURE



Source: The Allen Consulting Group

Figure 5.3

ILLUSTRATIVE CHANGES TO INTRA-GOVERNMENTAL COORDINATION/ NETWORKING ARRANGEMENTS FOR THE KNOWLEDGE INFRASTRUCTURE FIGURE 5.2



Notes:

1. ⟷ denotes two-way communication linkages, with information synthesis/co-ordination in respect of knowledge infrastucture by the Office of Science and Innovation in collaboration with the Department of Industry and Resources.

2. A Knowledge Infrastructure Cabinet sub-committee to provide a focal point for executive government coordination of such matters.

5.4 Improving Government Programs and Services

There is a considerable body of literature on the design and delivery of government programs. While there is no universally agreed paradigm for best practice, it is possible to distil some key criteria by which a program or group of programs can be measured. For the purposes of this report, these are:

- a clear program objective demonstrably relevant to overarching policy goals/objectives (i.e. creating high-value jobs and improving business and economic competitiveness) and that address market failures in these respects;
- a program structure and set of functional arrangements that complement the program objective;
- a high degree of synergy between program components/mechanisms;
- transparent and easily understood program management rules (e.g. application procedures, eligibility criteria et cetera);
- an effective client "interface" (e.g. a 'one-stop' entry point for enquiries and access to program information);
- low entry (e.g. application) and compliance costs relative to the size of the program;
- transparent and recurrent evaluation/review (e.g. performance against program objectives) and program redesign arrangements in place; and
- where appropriate, termination or "sunset" arrangements (i.e. a practical or notional end point for the program, beyond which re-activation would require an explicit policy decision).

Following the review of the array of existing Western Australian programs and initiatives described in Section 4 of this report, it is not possible to conclude that all programs would be able to satisfy these requirements. While offering no comment on the merits of particular programs (as this is not part of the study brief), it is clear that some would not perform well against some or all of the above criteria.

Quite a number of Western Australian programs are small and administratively costly. Others have not been or are currently not subject to regular review (including in the context of current or prospective infrastructure priorities). Taken in aggregate, there is apparent fragmentation of effort, leading to concerns about whether sufficient critical mass exists in key areas for effective results to be produced (even if the program objectives and mechanisms are appropriate).

Recommendation 3
The Western Australian government consolidate available resources into an integrated set of key programs which have (i) clear objectives relating to agreed policy priorities (ii) appropriate scale (iii) low administrative overheads (iv) strong inter-program and external synergies and (v) clear evaluation and review arrangements.

Recommendation 4
The Minister for State Development recommend that the Department of Industry and Resources extend the online innovation portal known as the 'WA Centre for Innovation' into a full 'one stop' entry point for external stakeholders (i.e. a 'hub' for government information) to (i) consolidate, synthesize and disseminate information on Western Australia's innovation system (ii) act as a repository for relevant national/international developments and (iii) act as both a physical as well as virtual (i.e. online) 'portal' for stakeholders concerning innovation system and knowledge infrastructure issues.

5.5 Building and Retaining Skills

People are integral to the success of the knowledge economy. Skills acquisition, development and retention, creativity and entrepreneurship (the State's human capital), are the 'engine' which drives it. The better the professional and technological training the higher the productivity of the workforce.

The fundamental importance of developing the education and training system so that these skills and characteristics are produced and readily available is well understood. Coupled with this 'education and training supply chain' requirement, however, is the equally important matter of effective integration of this system with other parts of the knowledge economy 'vehicle'. In this regard:

> "effective policies for promoting knowledge-based development call for a new paradigm that emphasises Western Australia as a region built around institutional collaboration within a State structure but linked to national and transnational knowledge systems"[51].

Analysis and consultations undertaken as part of this study have indicated that not only is education and training an issue of fundamental importance it is also an area of differing perspectives and strong opinions. Some of the key messages that have emerged from consultations are:

- While Western Australia is producing good quality graduates, particularly in areas where the State is strong (e.g. engineering and physical sciences) there is nevertheless a supply shortfall in these disciplines.

- In respect of secondary education, striking the balance between increasing retention rates and retention and skills development and the linkage to tertiary entry requirements and industry needs (e.g. the need for increased interaction between business and curriculum developers, particularly in respect of assessment of the medium term outlook).

- A potential disjunction exists between education as an export industry (e.g. students as a revenue stream in an educational export business model versus as students as participants or partners in a life-long relationship with Western Australia, the universities they attended and the bodies they may have worked in.

- State government leadership is required to address the disparities in the funding capacities of the four public universities.

- There is a demonstrable need for enhanced production of high level skills in, inter alia, entrepreneurship/business development to complement science and technologies skills development and, in this context, a need to address the problem of multiple schools/courses lacking international market status/recognition "cannibalising" each other, including in terms of fragmenting elite teaching resources.

There are a number of features of Western Australia's education and training system that are important in it potentially fulfilling its pivotal role in the future development of the State's knowledge infrastructure. The secondary schools system has a track record of maintaining high standards in student education (against national and international benchmarks). The TAFE system is market oriented and has generated a number of innovative learning platform models that have major relevance for connecting skills development to business needs and outcomes. Western Australian universities are strong in a number of disciplines, in terms of both educational (i.e. quality of graduates) and research (i.e. graduate and post-graduate courses and institutes).

[51] TIAC (2002) *The Organisation of Knowledge: Optimising the Role of Universities in a Western Australian 'Knowledge Hub"*

However, some serious issues that need to be addressed if these features and strengths are not to be compromised and the potential contribution of the education and training sector to knowledge infrastructure creation (in terms of scale and quality required for global relevance) is to be realised. The matters raised in consultations point to some of the main challenges in these regards. Breaking down a propensity to not think and act beyond the bounds of the corporate objectives of the individual entity (whether it be at the level of an individual university faculty or at the level of organisations/institutes as a whole) is clearly a centrally important issue. It is difficult not to draw comparisons between the situation pertaining to international exemplars referred to in Section 2 and that of Western Australia. The apparent differences epitomise why Western Australia has some way to go to approach the level of world's best practice and be regarded as an exemplar for others.

Recommendation 5
The Western Australian government take action to encourage the graduate business schools in the Western Australian universities to collaborate to establish an internationally recognized and regarded (i.e. a "WA brand") post graduate course with a curriculum focus on entrepreneurship and innovation management in a global knowledge economy and the outcomes achieved in this process be used as a basis for assessing other potential collaborative initiatives in the Western Australia education sector.

Recommendation 6
The Western Australian government investigate vocational training models (i.e. learning platforms) such as those being developed by some of the TAFE's (e.g. Central TAFE's 'The Design Centre' pilot program to provide real and virtual vocational training solutions for industry) for their relevance in the context of creating the research incubator/knowledge hub proposed in Recommendation 8.

5.6 Building Critical Mass and Linkages

Perhaps the most consistent message to come out of the analysis and consultations undertaken as part of this study is the need for greater attention to, and improvement in, building critical mass and strengthening linkages within the innovation system in Western Australia. It was notable that only one interlocutor took the view that collaboration is not an important issue. This resonates strongly with the findings of Sheehan (2002) that:

> "In respect of achieving critical mass the problem in Western Australia is due in large part to what has recently been described, based on analysis of research and development data, as bifurcation in the innovation system. In this regard, recognising that the core of the innovation system is that those involved cohere together in mutually supporting ways so that synergistic effects are optimized, bifurcation means that this is not happening or, at the very least, is not a pronounced feature of the system."[52]

During public consultations, it was revealed that innovation system participants in Western Australia tended to seek their own diverse goals in isolation from one another. For example, prevalent "silo thinking", a "linear" rather than an "ecosystem'' approach and an inability/unwillingness to break out of sectoral bounds were but a few of the descriptions proffered.

[52] Sheehan, P (2002) *The Position of Western Australia: Three Aspects*, Research Paper for the TIAC report *Directions for Industry Policy in Western Australia Within the Global Knowledge Economy.*

Even within the specific enterprise precincts established by the government to be the nuclei of research, education and technology clusters (e.g. the Technology Park in Bentley) this tendency seems to be manifest according to a number of researchers with direct involvement. The prevailing situation in Western Australia is that research and development expenditure, a frequently referred to indicator of innovation, is low by national and international standards, made worse by the relatively high bifurcation in the research and development sector. This adds up to the deck being stacked against Western Australia achieving critical mass and effective linkages unless there is a circuit breaker.

Clearly, without attention to redressing this weakness any actions directed at building particular elements of the knowledge infrastructure are going to yield sub-optimal results relative to a well integrated system. Put simply, taking action to improve the level of collaboration between researchers, educationalists, business and the government is likely to yield considerable spin off benefits, while not doing so will potentially waste effort and resources put into developing the innovation system and knowledge infrastructure.

While a number of approaches to this issue by the government could be contemplated, it seems clear that trying to "talk up" collaboration is not likely to be effective. The outcomes of this study suggest a more direct and substantive set of actions are required. Overseas "exemplar" models of collaboration were discussed in Section 2 of this report. Such models were also repeatedly referred to in consultations as being what needed to happen in Western Australia, albeit initially on a scale appropriate to the State's size and focused on areas that will leverage the State's competitive research, educational and economic strengths.

The prevailing view amongst stakeholders seems to be that the government needs to take steps to show it is serious about fostering a collaboration culture in the State without stifling beneficial competition. In respect of government funding, striking this balance necessitates a clear policy objective and program guidelines concerning the imperatives associated with collaboration without necessarily making it a mandatory requirement. This, correctly, places the onus on potential recipients to investigate seriously collaborative options, knowing the government's objectives and the rationale. If they believe a non-collaborative proposal has overriding benefits these can and should be outlined and argued by them.

It is also apparent that there is widespread support for the government taking a leadership role in bringing relevant stakeholders together (i.e. as convenor/facilitator) focused on developing a tangible initiative that would build on and extend from the State's acknowledged economic strengths and existing clusters and networks. It should be understood that taking such a step would, in all probability, involve an investment of public funds. As is outlined in Section 5.7 of this report, such a decision should be guided by clear decision criteria that emphasise a demonstrable and soundly based rationale against a rigorous and transparent assessment of net benefits to the State.

Recommendation 7
The Western Australian government incorporate in the eligibility criteria for State funding of research programs and initiatives a requirement that all collaborative opportunities and pathways have been fully investigated by prospective recipients as a basis for awarding funds and that where funding is awarded on the basis of a collaborative initiative there be a mechanism to ensure collaboration continues after the funds are provided.

Recommendation 8
The Western Australian government develop a proposal, in collaboration with Western Australian universities, vocational training bodies, research institutes and potential business participants/sponsors, for establishment of a 'research incubator' modelled on successful international examples (such as Yamacraw in Georgia in the USA referred to in Section 2 of this report) that would (i) act as a 'knowledge hub' (ii) provide a focus for research collaboration and commercialization (iii) link research and training to business/market opportunities and (iv) assist growth in knowledge-intensive areas according to market determinants.

5.7 Attracting and Securing Investment

The ability to attract investment and to secure reinvestment from outside Western Australia (by ensuring that capability is strongly "anchored") is an important aspect of building Western Australia's knowledge infrastructure (i.e. strategic investments in this context transcend traditional notions of "hard" infrastructure investment). In the same way, fostering strong growth in knowledge infrastructure investment from within the State (both public and private) is also fundamental. Such external and intra-State investment will be to a considerable extent influenced by:

- the macroeconomic and microeconomic policy settings and conditions prevalent in Western Australia (a stable and robust economy is a necessary but now seldom sufficient precondition);
- the State government's own knowledge infrastructure investment decisions (what they are, where they are focused and the circumstances in which they occur);
- the extent and quality of complementary factors (such as the existence of high quality and functional clusters with synergies to the investment in question); and
- the nature and quality of information in the marketplace that "gets Western Australia on the radar screen" (Australia, much less Western Australia, is not necessarily always the name on the lips of key international investors).

A particular challenge for the government in the context of securing high quality investments in knowledge infrastructure (including "soft" infrastructure as described in Section 1) is getting to a position of being able to make informed decisions about what are worthwhile investments and how valuable they are in terms of the benefits they are likely to contribute to Western Australia.

This becomes a particular area of concern and importance when the government is either approached by external parties or proposals arise from within the government system to financially support a particular knowledge infrastructure investment or proposition. Analysis undertaken as part of this study indicated that there is an absence of coherent decision criteria supported by a defined and rigorous evaluation process for dealing with such cases. The risk of not addressing this issue is that government consideration of investment proposals could become ad hoc and inconsistent (relatively and in the context of government policy frameworks/settings).

A related matter is the issue of "onus". It is often the case in many governmental jurisdictions, as seems to be the case in Western Australia, that there can emerge an expectation that the onus rests with the government to show why any given proposal is/is not worthy of support. While it is true that the government is ultimately responsible for the basis (e.g. evidence-based decision making or otherwise) on which it takes decisions it is nevertheless good public policy for the initial onus concerning demonstrating a given proposal's benefits to rest with the proponent (whether inside government or external). Decision criteria and evaluation processes should reflect this. For illustrative purposes, a sample set of decision criteria for investments in Western Australia's knowledge infrastructure is set out in Box 5.2.

Box 5.2

CRITERIA RELATING TO KNOWLEDGE INFRASTRUCTURE INVESTMENTS IN WESTERN AUSTRALIA

The following (illustrative) decision criteria relate to public investment in the knowledge infrastructure in Western Australia.

1. The investment has demonstrable strategic importance to Western Australia, having regard to the stage of development of Western Australia's knowledge economy and innovation system, and when matched against market and knowledge infrastructure gaps.
2. The investment provides significant quantifiable net economic benefits to Western Australia, inter alia:
   - increase in high value employment and/or skills transfer;
   - increase in the education and training base;
   - increase in R&D activity and/or output;
   - increase in technology deployment and/or transfer; and
   - does not "crowd out" or otherwise introduce discriminatory bias in respect of existing investors/industry participants.

   The onus of demonstrating net economic benefits (i.e. benefits relative to costs) to the State initially rests with the applicant. The assessment should take into account the direct and indirect effects and should go beyond input-output analysis (i.e. beyond assessing gross benefits).
3. The investment complements and adds to Western Australia's areas of competitive advantage and has significant synergistic/spillover benefits to other industries, users or suppliers (e.g. cluster developments and broader integration with the State's innovation system).
4. Positively increases the international profile of Western Australia as a knowledge economy through the reputation and competitive position of the proponent (where a commercial business) in international markets/product systems.
5. Where a business undertaking, the investment is commercially viable when considered in the absence of governmental support.

   The onus of demonstrating the qualitative benefits to the State in respect of 3–5 initially rests with the applicant. In aggregate terms, the assessment should represent a combined public policy and commercial due diligence process.

Another key message to come out of the investigations is the lack of a clearly identifiable individual or body responsible for coordinating whole-of-government assessments of investment proposals. Advisory bodies relevant to knowledge infrastructure that do exist are either not mandated and/or not equipped to represent and deal bilaterally on investment matters. This matter is considered relevant as in many instances it is not prudent for high level dealings (at least initially) to be conducted by Ministers.

Recommendation 9

The Western Australian government, through the Departments of Premier and Cabinet, Treasury and Finance, Industry and Resources and Education and Training, develop decision criteria (for consideration by Cabinet) and which, once agreed, will be made public and used by the Western Australian government to guide its decisions in respect of major investments in the knowledge infrastructure (i.e. those requiring an explicit government decision at Cabinet or Ministerial level).

Recommendation 10

The Western Australian government give consideration to appointing/assigning a body to represent the Western Australian government in non-Ministerial liaison/negotiation with the Commonwealth government in relation to major knowledge infrastructure investment/development proposals and in this context, to be a coordinator of inputs and advice to the Western Australian government decision making process on such matters.

5.8 Developing Clusters

As outlined in Sections 2 and 4 of this report, the development of clusters is an important factor in giving form to the innovation system and of generating tangible economic outcomes from it.

There are relatively few well established and globally competitive clusters in Western Australia. However, competitive clusters that are recognised and regarded as such do exist in mining and energy and in agri-food. There also appears to be some other 'emergent' clusters (such as in environmental services, biomedical services, and maritime and defence engineering).

However, analysis as part of this study indicates that to date there appears not to have been any focused attempt to 'map' Western Australia's existing or emergent clusters (e.g. against world's best examples) as a basis for validating assumptions about what they actually comprise and for guiding governmental action directed at facilitating their further development. This is important for a number of policy reasons, including, for example, determining what role technology parks or enterprise precincts can/should play in cluster formation and development (recognising the government's previous and possible future investments in this area).

> ***Recommendation 11***
> *The Minister for State Development recommend that the Department of Industry and Resources undertakes work to 'map' Western Australia's existing and emergent clusters so that their substantive makeup and characteristics can be described in sufficient detail to assist policy making and public communication concerning their relevance and potential contribution to a Western Australian knowledge economy.*

5.9 Strengthening ICT Networks

The existence of a functional and robust ICT network is an essential infrastructure component of the knowledge economy, not just from the perspective that ICT companies potentially represent important high skill, high wage employers, but also because they are the providers of products and services that are the enablers for other sections of the knowledge economy to operate (including communicating) effectively, for example, in sharing knowledge. ICT networking is also one of the more important elements of knowledge infrastructure creation for regional and remote regions of Western Australia.

It is acknowledged that ICT networking in Western Australia, both from the perspective of the industry itself and the state of the network is not currently of sufficient quality and coverage to make it a driver of innovation. This is not to say that industry players are not competent but rather, taken as a whole the ICT market and network in Western Australia is relatively small and has not kept pace with leading ICT adopters such as South Korea and Canada.

The results of analysis and consultations undertaken as part of this study suggest that there is not a lot of options for government in seeking to upgrade the State's ICT networks or to stimulate the industry to take similar action (i.e. encourage carriers to invest) that would not either involve significant public expenditure and/or result in market distortions.

This is not to say the government should do nothing. There are actions that can be taken that potentially would have a positive long-term effect without significant public expenditure or market intervention, such as in the area of urban and industrial planning. It is also noted that another forthcoming TIAC report (*Broadband Bandwidth in Metropolitan Western Australia*) deals with ICT network issues in considerably more detail than is possible in this study and that other work is underway focusing on non-metropolitan ICT network issues.

Recommendation 12
The Western Australian government through the Department of Planning and Infrastructure, in consultation with Landcorp, Western Power (incorporating Bright Communications) and other relevant agencies collaboratively review the arrangements governing the development of industrial and residential land with a view to determining the extent of any impediments (such as legislative, planning or financial) to installing 'broadband ready' infrastructure (e.g. conduit fibre optic cables) as part of the development process, in order to ensure that all government sponsored and funded developments are 'broadband ready'.

5.10 Improving Leverage Potential with National Programs and Initiatives

Western Australia has not been particularly successful over recent years in securing what is considered to be a satisfactory proportion of resources available from national programs, except in areas such as agriculture and resources. The study findings indicate that there is a highly variable appreciation and regard for joint venture and alliance building as a winning strategy in competitive bidding processes, which tend to be the predominant character of Commonwealth programs relating to innovation. This, coupled with variability in the skill sets of researchers concerning preparation and presentation of high quality bids is hampering Western Australia's performance in securing Commonwealth funding.

There is also, paradoxically, evidence of a tendency for many Western Australian research bodies to be overly preoccupied with securing Commonwealth funds. While perhaps understandable in the circumstances of Western Australia's relative underperformance in this respect, this does, however, have the potential to divert attention away from research which is integral to achieving the primary mission of research bodies in pursuit of Commonwealth funding for projects which are of lesser priority.

Opportunities should only be pursued if they are consistent with strategic intent. Such opportunities are more likely to be of this character where the Western Australian research agency is able to develop a partnership with the Commonwealth agency. This has been the way State Department of Agriculture research institutes in some other States have gone about developing relationships with the grower and Commonwealth funded rural R&D Corporations. Accordingly, greater focus on developing Western Australian/Commonwealth partnering opportunities should be a priority.

Recommendation 13
That the Minister for State Development recommend that the Department of Industry and Resources develop and maintain a "tool kit" for prospective applicants for Commonwealth programs and establish a dedicated advisory service (potentially in association with the proposed establishment of the "one stop entry point" initiative at recommendation 4), with a view to improving the capacity of Western Australian applications achieving success in competitive bidding processes.

5.11 Developing International Linkages

The establishment and maintenance of effective networks lies at the centre of the most successful knowledge economies. Linkages and networks are in many contexts a by-product of other initiatives (e.g. initiatives to increase collaboration within and between clusters). However, there is an unambiguous need to also take direct action aimed at building networks and linkages beyond Western Australia, particularly internationally.

While there are a number of ways of building international linkages, the consultations conducted as part of this study identified an "alumni" approach to networking was one mechanism that could be built on. Analysis, supported by anecdotal evidence indicates there is quite an extensive informal, if fragmented, network of Western Australian expatriates, many in very senior research, business and other roles, spread around the globe.

While Western Australian university alumni exist and are an important network in their own right, it is considered that individually they do not present as sufficiently broad or interconnected to represent an effective networking tool in the context of developing Western Australia's innovation system at the level envisaged. A more encompassing networking initiative is required. Taking steps to establish a more encompassing and systematic approach to tracking, informing and interacting with expatriate Western Australians who are associated with the global knowledge economy is a potentially highly effective, low cost means of extending Western Australia's "sphere of influence". It also has relevance for attracting talent and investment.

Recommendation 14
The Western Australian government support the establishment and maintenance of a Western Australian alumni database and network (focusing on expatriate graduates and postgraduates from Western Australian universities and elite researchers/technologists, teachers and business leaders/executives with experience of Western Australia), with a view to developing a global network of contacts with connections to/appreciation of Western Australia, supported by an online information service.

5.12 Measuring and Monitoring Performance

Integral to an emphasis on adopting a strategic approach to building Western Australia's knowledge infrastructure has to be serious ongoing attention to measuring and monitoring performance. This has not been a feature of the Western Australian system to date.

Performance measurement and monitoring needs to operate effectively at two levels. At the "macro" level it involves measuring progress in Western Australia's knowledge infrastructure creation and of outcomes that can be attributable to the "investments" made (such as in relation to high-value jobs created, discernible improvements in business performance and competitiveness and broader economic results in relevant industries or the economy as a whole). The Porter-Stern framework for measuring the innovation capacity and performance of an economy was discussed in Section 2. This or other similar methodology is an appropriate basis for initiating a structured and consistent approach to measurement of progress in knowledge infrastructure creation and it's contribution to the abovementioned outcomes, as well as a basis for international benchmarking.

At the "micro" level (i.e. in respect of individual programs or initiatives) the imperative is to have performance measurement and monitoring integrated in their design and operation as the basis of a transparent and recurrent evaluation/review methodology. As outlined in Section 5.4, this is not a strong emphasis in relation to Western Australian programs associated with knowledge infrastructure. Performance measurement needs to focus on both effectiveness (i.e. measuring outcomes achieved against goals and objectives set) and efficiency (i.e. measuring program/initiative outputs relative to the administrative cost of delivering them).

Recommendation 15

The Minister for State Development recommend an annual "State of Knowledge Infrastructure in Western Australia" report, be prepared and publicly released by the Department of Industry and Resources, either as a stand alone volume or as part of a broader compendium, such as "The State of Western Australia's Innovation System". The report should be set against the best practice principles set out in Section 5.1 and should incorporate chapters on (i) high-value jobs created (ii) a description and, where appropriate, measurement of, the cost of and benefits derived from programs and initiatives taken by the government during the period and (iii) a performance assessment of Western Australia's knowledge infrastructure and innovation system, based on the Porter-Stern or other appropriate methodology, against relevant international benchmarks.

Appendix One

Terms of Reference

1. Review existing State and Federal government programs that stimulate new business formation and development in a WA knowledge based economy.

2. Precluding additional State government funding, identify regional natural advantages, local government incentives and other fiscal options and opportunities available for investment in the establishment of appropriate knowledge infrastructure in the State.

3. From a business development perspective, consider the current quality and depth in Western Australia of the following factors that have been identified as important to the attraction and development of world-class knowledge based enterprises, and which utilize highly skilled workers and provide high wage employment. These factors include:

    - R&D support and collaboration.
    - Infrastructure support such as technology parks, industry clusters, incubators and other measures which improve the State's innovation system.
    - Business, legal and patent commercializing advice.
    - Programmes which develop strategic partnerships, networking and other linkages both between firms and between firms and the State's education and R&D institutions.
    - Programmes that assist both local and foreign firms operating in the State to increase their integration into global product systems.
    - ICT infrastructure and enabling support.
    - Availability of venture capital and other financial institution support for business development.
    - Initiatives to attract foreign firms to invest in the State and mesh with local firms to strengthen the State's innovation system.
    - Skills development infrastructure.

4. Using the information obtained from items 1, 2, and 3 above, identify the gaps and provide practical policy options for the State government to encourage high skilled, high wage employment in Western Australia through the creation of the appropriate knowledge infrastructure.

Appendix Two

Consultation

The following questions were distributed to a wide range of stakeholders representing the business, government and education sectors of Western Australia as a basis for discussion. Consultations were conducted on a non-attribution basis.

GENERIC ISSUES AND QUESTIONS PROVIDED AS GUIDANCE FOR INTERVIEWS

1. If we take knowledge infrastructure in both its 'soft' and 'hard' aspects to mean something like:

   "People, institutions, processes, and the linkages between them, that combine to provide the essential building blocks for creating and transforming ideas into tangible economic performance";

   and the WA government's objective in seeking to create and develop such infrastructure is to expand and diversify the high skill, high wage component of the WA economy, what are, or should be, the main priorities for (i) the WA government and (ii) for your industry/organisation, in bringing this about?

2. What are WA's major opportunities and strengths (e.g. the basis of existing or future knowledge-based clusters) that need to be nurtured/developed and what does this mean for the knowledge infrastructure?

3. What are the main constraints and challenges standing in the way of the desired outcome being achieved in the foreseeable future?

4. Against this background, how would you describe the state of the current knowledge infrastructure base in WA, overall and in the following areas (generally regarded as characterising the key infrastructure elements):

   - The Talent Pool and Skills Development Infrastructure (e.g. education structures/systems)
   - Research Institutions and Researchers
   - Incubators and Other Centres of Innovation
   - Commercialisation and Intellectual Property Protection Services
   - Information and Communications Networks and Systems
   - Investment Capital – Markets and Mechanisms
   - Public-Private Partnerships, Networks and Alliances

5. What benchmarks do you think should be used to measure WA's performance in creating an developing knowledge infrastructure?

6. There is a plethora of State-based (see the indicative list at Addendum 1) programs and initiatives that could be regarded as being directly or indirectly related to creating/developing knowledge infrastructure in WA. There are also a lesser number of local/regional initiatives. Based on your knowledge of some or all of these progams/initiatives and your particular perspective, what do you believe are the gaps, overlaps, and most important focal points of resources devoted to government programs (recognising government fiscal constraints and 'bang for the buck' imperatives)?

7. To the extent that you are aware of international developments in the area of knowledge infrastructure creation, are there specific examples of actions, strategies, approaches from overseas that you believe have particular significance/relevance for WA?

8. Given the national and international dimension of much of the activity relevant to the question of developing WA's knowledge infrastructure, the issue of improving WA's leverage into national (e.g., Commonwealth government programs/initiatives) as well as internationally is seen as fundamentally important. What is your view of WA's current performance in this respect and by what means/pathways can/should leverage be improved?

9. Within a strategic framework for looking at what the WA government (as well as other stakeholders) should focus on and that might be characterised in terms of "Reinforcing Strengths and Overcoming Weaknesses", do you think the following six headings adequately capture the main thrusts?

   - Building and Retaining Skills
   - Building Critical Mass (supporting excellence) and Linkages
   - Facilitating Research and Development Collaboration
   - Improving Commercialization Pathways
   - Attracting and Securing Investment Capital
   - Growing 'High Skill' Companies and Clusters

10. If you could recommend three things to the WA government for creating the State's knowledge infrastructure, what would they be?

11. Similarly, if the WA government asked you what your industry/organisation can/should do, what would be your advice?

Appendix Three

Steering Committee and Consultation Team

The membership of the Technology and Industry Advisory Council (TIAC) Steering Committee for this project is listed below:

Ms Sharon Brown	TIAC Member (Chair)
Mr Rob Meecham	TIAC Member
Professor Beverley Ronalds	TIAC Member
Mr Bruce Sutherland	TIAC Member

The Steering Committee was assisted in its task by The Allen Consulting Group team:

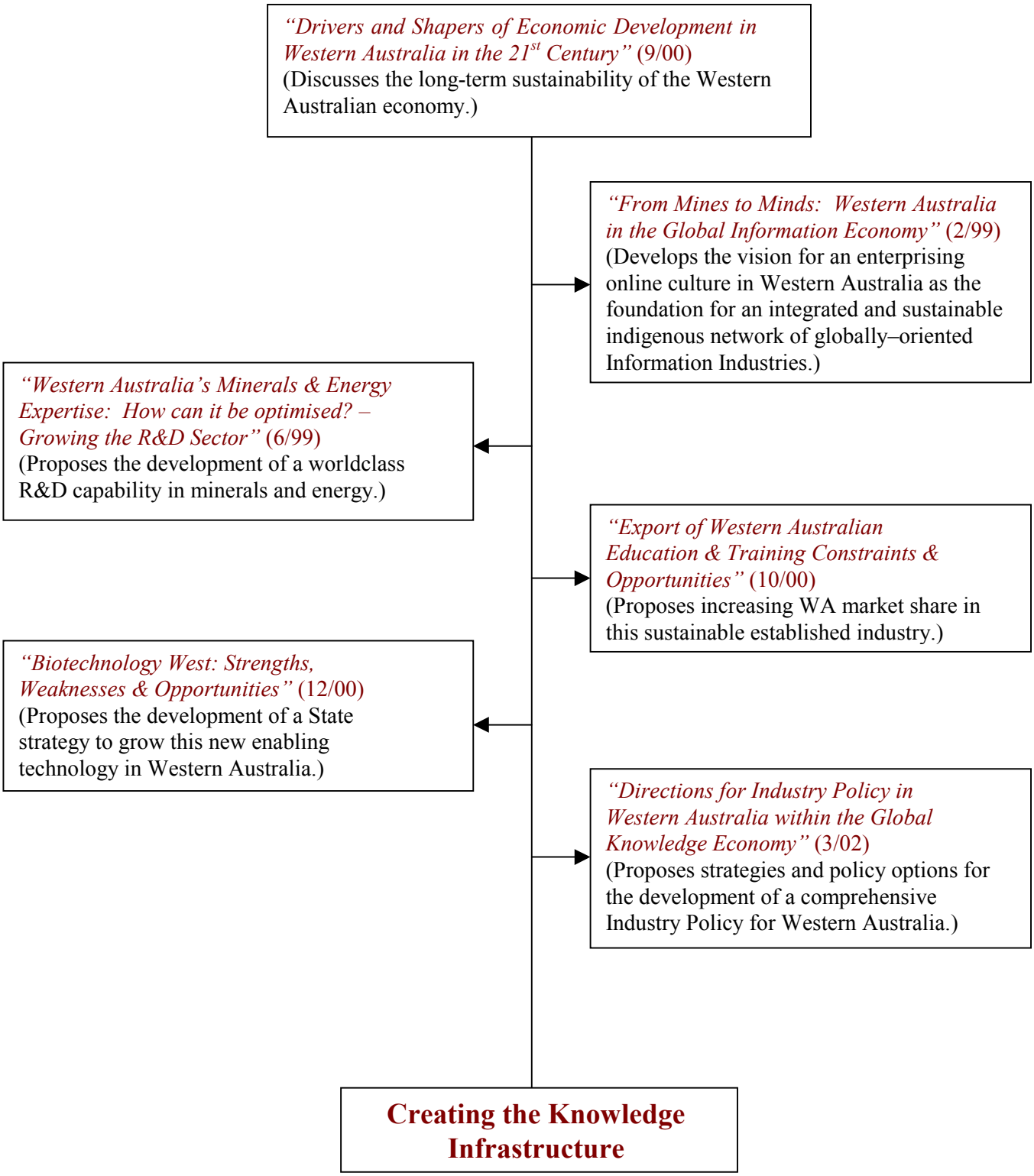
Mr David Purcell	Project Director
Dr David Charles	Consultant
Mr Robin Wong	Consultant

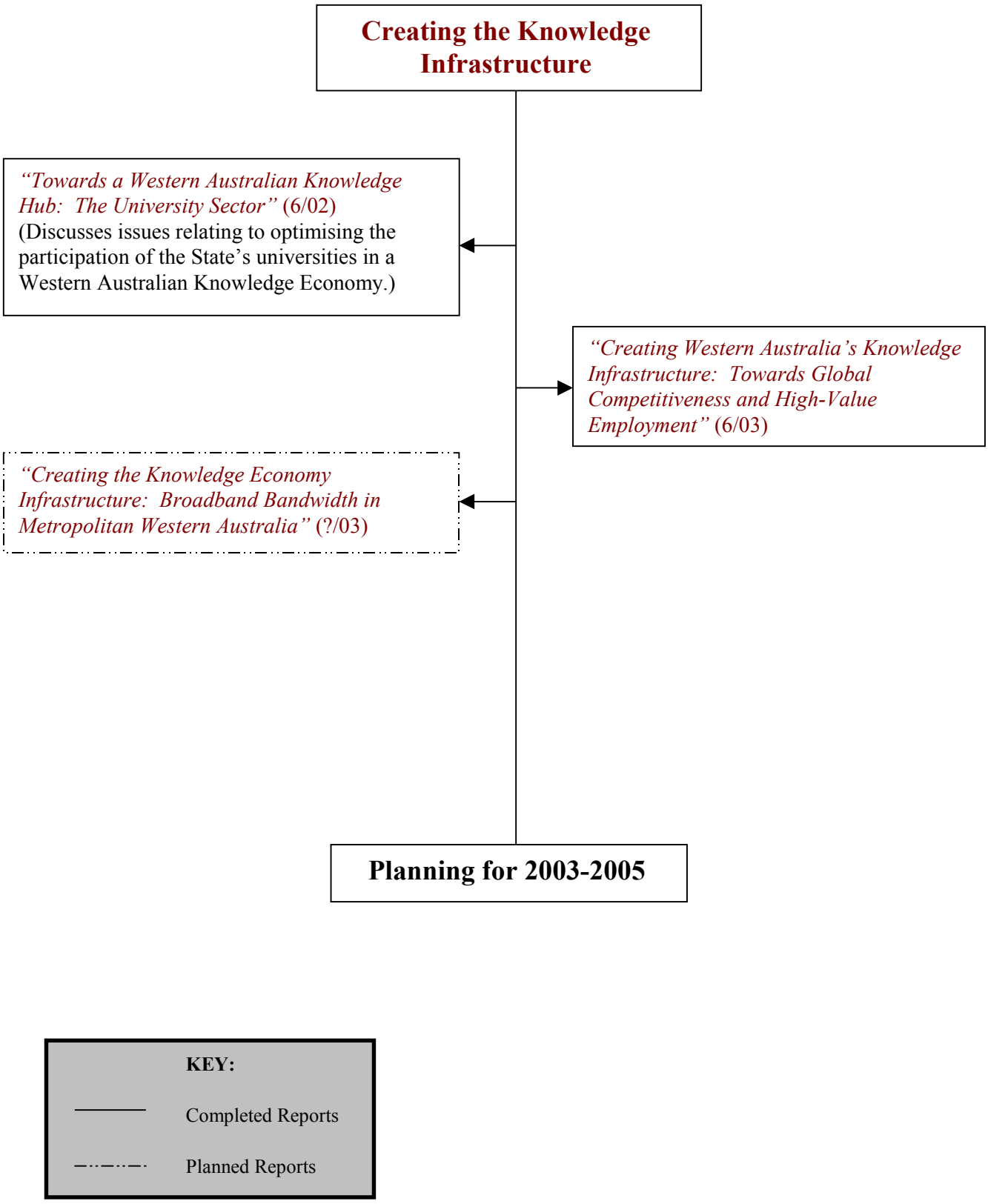
TIAC Executive Staff

Mr Earl White	Executive Officer
Ms Deanna Fleming	Senior Policy Adviser
Ms Shelley Rush	Executive Assistant

Appendix Four

Towards a Western Australian Knowledge Economy 1999 - Present





Copies of these reports can be obtained from our website – www.wa.gov.au/tiac

Appendix Five

Western Australian Technology & Industry Advisory Council

Background

The Technology and Industry Advisory Council (TIAC) was created by legislation in 1987 (*Technology Development Amendment Act - No. 32 of 1987*) and was continued under Section 20 of the *Industry and Technology Development Act 1998*.

TIAC was preceded by the Technology Review Group 1978-83, and the Science, Industry and Technology Council (SITCO) 1983-87.

Council is made up of representatives from various sectors of the State's economy who, in terms of the relevant Act, use their varied background and experience to provide independent policy advice to the Minister so as to make a significant contribution to the development of strategies relating to the State's economic development.

Members of the Council are appointed by the Minister, under Section 22 of the *Industry and Technology Development Act 1998* so as to be representative of the interests of the people of the State.

TIAC reports through the Minister to Parliament under Section 26(1) and Section 26(2) of the *Industry and Technology Act 1998*.

TIAC reports under the *Financial Administration and Audit Act 1985* through the Department of Commerce and Trade under Section 26(3) of the *Industry and Technology Development Act 1998*.

Objectives of the *Industry and Technology Development Act 1998*

The objectives of the *Industry and Technology Development Act 1998* under Section 3 are to:

(a) Promote and foster the growth and development of industry, trade, science, technology and research in the State.

(b) Improve the efficiency of State industry and its ability to compete internationally.

(c) Encourage the establishment of new industry in the State.

(d) Encourage the broadening of the industrial base of the State.

(e) Promote an environment which supports the development of industry, science and technology and the emergence of internationally competitive industries in the State.

Functions of the Western Australian Technology and Industry Advisory Council

The Council, under Section 21 of the Act is required to:

(a) Provide advice to the Minister, at the initiative of the Council or at the request of the Minister, on any matter relating to the objects of the Industry and Technology Development Act 1998.

(b) Carry out, collaborate in or produce research, studies or investigations on any matter relating to the objects of this Act, including matters relating to:

- (i) the role of industry, science and technology in the policies of government;
- (ii) the social and economic impact of industrial and technological change;
- (iii) employment and training needs and opportunities relating to industrial, scientific and technological activities in the State;
- (iv) the adequacy of, priorities among and co-ordination of, scientific, industrial and technological activities in the State;
- (v) methods of stimulating desirable industrial and technological advances in the State;
- (vi) the application of industrial, scientific and technological advances to the services of the government; and
- (vii) the promotion of public awareness and understanding of development in industry, science and technology.

The Ministerial advice takes the form of reports and discussion papers which undergo a public consultation phase before submission to the Minister.

Participation on State and Federal Government Advisory and Funding Committees and Councils

Council has accepted invitations for representation and participated in the:

(a) State's Co-ordination Committee on Science and Technology.

(b) Steering Committee for the CSIRO National Centre for Petroleum and Mineral Resources Research.

(c) "State Funding Advisory Committee" (SFAC).

(d) State's "Information and Communications Policy Advisory Council" (ICPAC).

(e) Department of Commerce and Trade's "Technology Operations Group" (TECHOP).

(f) Federal government's "Commonwealth, State and Territory Advisory Council on Innovation".

Promotion and Public Awareness Raising Activities

Council's promotional and public awareness raising programs consist of two main types:

(a) The 2020 Breakfast Seminars, which are short, economic development focused, information dissemination events.

(b) The Science and Technology Forums which were established under the State's Science and Technology Policy in April 1997 in order to "raise the awareness of science and technology in the community and increase the community's input in the State's directions in Science and Technology".

Financial Provisions

The expenses of Council are provided for under Section 15 of the *Industry and Technology Development Act 1998* via the Western Australian Industry and Technology Development Account.

Present Membership

Mr John Thompson
TIAC Chairman
National Chief Executive (Australia)
SGS Australia Pty Ltd

Mr Rex Baker
Chairman (formerly)
Executive Committee/Board of Directors
Worsley Alumina Pty Ltd

Ms Sharon Brown
Strategic Business Manager
AlphaWest

Dr Brian Hewitt
Chairman
Clough Engineering Limited

Dr Jim Limerick
Director General
Department of Industry and Resources

Mr Mick McGinniss
Agricultural Producer

Mr Rob Meecham
Director of the Business Development Unit
Challenger TAFE

Dr Nigel Radford
Chief Geochemist
Newmont Australia Ltd

Professor Beverley Ronalds
Woodside Chair
Centre for Oil and Gas Engineering
University of Western Australia

Professor Lance Twomey
Vice Chancellor
Curtin University of Technology

Mr Tim Ungar
Chairman
Telecommunications Services Australia

PUBLIC COMMENT
REPLY SHEET

TO: THE EXECUTIVE OFFICER
WESTERN AUSTRALIAN TECHNOLOGY AND INDUSTRY
ADVISORY COUNCIL

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Comments on the Report entitled:

CREATING WESTERN AUSTRALIA'S KNOWLEDGE INFRASTRUCTURE: TOWARDS GLOBAL COMPETITIVENESS AND HIGH-VALUE EMPLOYMENT

Closing Date: Friday, 18 July 2003

(Please tear out and return with your comments.)