

**NATIONAL COLLABORATIVE RESEARCH INFRASTRUCTURE  
STRATEGY**

**STRATEGIC ROADMAP (EXPOSURE DRAFT)**

**NOVEMBER 2005**

**NCRIS Committee**

# DRAFT

## TABLE OF CONTENTS

<b>Section</b>	<b>Page</b>
1. Strategic direction for Australia's research infrastructure	3
2. Role of the Strategic Roadmap	4
3. Developing the Strategic Roadmap	4
4. Prioritisation of capabilities	6
5. Implementing the Strategic Roadmap	7
6. Overview of priority capability areas	9
6.1 Evolving bio-molecular platforms and informatics	10
6.2 Integrated biological systems	13
6.3 Characterisation	16
6.3.1 Neutron scattering	
6.3.2 X-ray techniques	
6.3.3 Optical and electron microscopy/microanalysis	
6.4 Fabrication	21
6.4.1 Fabrication of advanced materials (including nano-materials)	
6.4.2 Bio-and chemo- pre-commercial synthesis, fabrication and rapid prototyping	
6.4.3 Micro/nanofabrication enabling microelectronic, photonics, optoelectronics and integrated optics	
6.5 Biotechnology products	26
6.6 Translating health discovery into clinical application	28
6.7 Population health and clinical data linkage	30
6.8 Networked PC3 containment and biomolecular facilities for emerging infectious disease, bioterrorism and forensics	32
6.9 Heavy Ion accelerators	34
6.10 Optical and radio astronomy	36
6.11 Terrestrial ecosystem research network	38
6.12 Integrated marine observing system	40
6.13 Structure and evolution of the Australian continent	42
6.14 Low-emission, large-scale energy processes	44
6.15 Next generation solutions to counter crime and terrorism	46
6.16 Systemic Information Infrastructure	48
6.16.1 Data access and discovery, storage and management	
6.16.2 Grid enabling technologies and infrastructure	
6.16.3 Technical expertise	
6.16.4 High performance computing	
6.16.5 High capacity communications networks	
7. Landmark infrastructures	59
7.1 Blue-water research vessel	
7.2 Square Kilometre Array	
7.3 Extremely Large Telescope	
8. Responding to the Strategic Roadmap exposure draft	61
8.1 Invitation to respond in writing	
8.2 Guidelines for respondents	
<u>Appendices</u>	
1. NCRIS Committee terms of reference and membership	63
2. Expert advisory arrangements	64
3. NCRIS forward process and timeline	67

# DRAFT

## 1. STRATEGIC DIRECTION FOR AUSTRALIA'S RESEARCH INFRASTRUCTURE

The Australian Government has recognised the need to bring more strategic direction to Australia's investment in research infrastructure<sup>1</sup>. In the 2004-05 Budget, the Government announced that the National Collaborative Research Infrastructure Strategy (NCRIS) would be implemented to provide the greater focus and coordination required.

Funding of \$542 million to 2010-11 was allocated to fund the Strategy in the *Backing Australia's Ability: Building Our Future through Science and Innovation* package.

In October 2004 the Hon Dr Brendan Nelson MP, Minister for Education, Science and Training, appointed an Advisory Committee, chaired by Professor Rory Hume, to advise on how NCRIS should be implemented. The Advisory Committee submitted its recommendations to the Minister in July 2005 following a public call for submissions and extensive consultations with stakeholders. The Minister has accepted the recommendations as the basis for the implementation of NCRIS.

The key principles underpinning NCRIS, reflecting the Advisory Committee's advice, are that:

- Australia's investment in research infrastructure should be planned and developed with the aim of maximising the contributions of the R&D system to economic development, national security, social wellbeing and environmental sustainability.
- Infrastructure resources should be focussed in areas where Australia is, or has the potential to be, world-class (in both discovery and application driven research) and provide international leadership.
- Major infrastructures should be developed on a collaborative, national, non-exclusive basis. Infrastructure funded through NCRIS should serve the research and innovation system broadly, not just the host/funded institutions. Funding and eligibility rules should encourage collaboration and co-investment. It should not be the function of NCRIS to support institutional level (or even small-scale collaborative) infrastructure.
- Access is a critical issue in the drive to optimise Australia's research infrastructure<sup>2</sup>. In terms of NCRIS funding there should be as few barriers as possible to accessing major infrastructures for those undertaking meritorious research.
- Due regard be given to the whole-of-life costs of major infrastructure, with funding available for operational costs where appropriate.
- The Strategy should seek to enable the fuller participation of Australian researchers in the international research system.

---

<sup>1</sup> The need for a more strategic approach to providing the high-quality infrastructure necessary for world-class research was identified in the Chief Scientist's 2000 discussion paper *The Chance to Change* and in the same year in the final report of the Innovation Summit Implementation Group *Innovation: Unlocking the Future*. In May 2003, as part of the *Our Universities: Backing Australia's Future* policy, the Australian Government announced that it would establish a taskforce to develop a nationally integrated research infrastructure strategy to apply to public higher education institutions and publicly funded research agencies. The National Research Infrastructure Taskforce (NRIT) reported in March 2004, recommending a set of principles and a national process to identify, prioritise and fund research infrastructure needs. The Government's response to NRIT led to the announcement of NCRIS in the 2004-05 Budget, as part of the *Backing Australia's Ability: Building Our Future through Science and Innovation* package.

<sup>2</sup> In the course of developing the Strategic Roadmap, several access related issues came to the attention of the NCRIS Committee. For example, Australia's capabilities in medical imaging appear to be well developed but that capability is largely dedicated to clinical applications and can be difficult for researchers to access.

# DRAFT

## 2. THE ROLE OF THE STRATEGIC ROADMAP

The Strategic Roadmap is being developed by the NCRIS Committee<sup>3</sup> to inform decisions on where Australia should make strategic infrastructure investments to further develop its research capacity, both in key areas and more broadly.

When finalised, the Roadmap will provide a framework of capabilities, *prioritised on the basis of the NCRIS principles*, that is the recommended focus for medium to large-scale<sup>4</sup> research infrastructure investment over the next 10 years. It will focus on the capabilities that Australia should strive to develop, rather than specific infrastructures, and also make some recommendations on the appropriate means to support them.

The Roadmap will help to facilitate a coordinated approach to infrastructure investment across governments and agencies that:

- concentrates effort nationally on areas of most strategic impact;
- increases collaboration within the research system and between it and the wider community; and
- reduces the duplication and sub-optimal use of resources arising from lack of co-ordination.

The Strategic Roadmap, if accepted by the Minister, will specifically provide a framework for the process of the allocation of the NCRIS program funding available from 2006-07 onwards.

The Committee agrees with the Advisory Committee's recommendations that:

- the NCRIS funding programme should be part of an ongoing investment in research infrastructure;
- there should be more than one round of NCRIS funding available; and
- the Roadmap should be an evolving planning tool that guides subsequent funding allocations. There is an intention, therefore, to keep the Roadmap updated to reflect changing priorities; the emergence of new opportunities and a better supporting information base over time.

### **Important note:**

The Strategic Roadmap identifies priorities for investment in research infrastructure, based on the NCRIS principles. It is not a general statement of research priorities.

## 3. DEVELOPING THE STRATEGIC ROADMAP

This exposure draft has been developed from expert advice and consultation with the research and wider communities over the past year. Development has proceeded through several steps: consultation on an initial concept; a further round of consultations to more comprehensively scope the options and, most recently, through an expert advisory process.

---

<sup>3</sup> Established by the Hon Dr Brendan Nelson MP, Minister for Education, Science and Training in August 2005 to implement, monitor and review NCRIS. See [Appendix 1](#) for information on terms of reference and membership.

<sup>4</sup> The NCRIS Advisory Committee recommended that given the available funding, and the likely needs, that funding through the NCRIS program should be limited to a \$60 million upper limit.

## DRAFT

In November 2004 the NCRIS Advisory Committee released a discussion paper for public consultation proposing a set of principles and processes to underpin NCRIS<sup>5</sup>. The paper also proposed that a Strategic Roadmap might be developed as a mechanism to advise government on priority areas for infrastructure investment and to assist in coordinating the development of major infrastructures. Stakeholders were invited to comment on the concept and an initial outline of potential priority capabilities.

Feedback on the Roadmap concept was positive. Most of the stakeholders who responded recognised the value of a planning document providing a strategic overview of Australia's infrastructure requirements and a focus for coordination of effort.

The Advisory Committee also received a significant number of submissions (from the total of around 80 submissions in response to the discussion paper) putting forward suggestions for priority areas that should be recognised in the Roadmap.

The Advisory Committee subsequently decided to scope potential areas of priority capability more completely. In May 2005 the Advisory Committee released a document (the *Capability Scoping Document*) that summarised the inputs to date and again sought feedback on gaps and omissions<sup>6</sup>. A substantial and broad ranging response was received, which, together with the initial submissions, provided a large body of information on the infrastructure requirements of Australia's research systems and possible priorities within those needs. An expert forum<sup>7</sup> was also organised to help scope the Roadmap and begin to provide a strategic overview of needs.

The next step in the process has been the development of this exposure draft. The NCRIS Committee recognised that while the range of potential capabilities had been widely scoped, the Roadmap process required more strategic insight and expert advice to gauge their relative fit with the NCRIS principles.

The NCRIS Committee convened four expert subcommittees comprising a broadly representative group of researchers (see [Appendix B](#)) to assess the information gathered to that point and advise on strategic direction. The subcommittees were organised to specifically examine the strategic requirements of each of the National Research Priorities against the advice received in consultations and submissions.

The subcommittees and NCRIS Committee also took into account the outcomes of other exercises such as the Pharmaceutical Industry Action Plan, the National Nanotechnology Strategy, the Marine Science Action Plan, the Decadal Review of Australian Astronomy and the National Strategic Plan for the Geosciences. In addition the Committee has consulted with the e-Research Consultation Committee, the Australian Research Information Infrastructure Committee (ARIIC) and the Australian Research and Education Network Advisory Committee (ARENAC).

A State and Territory Government official's reference group, chaired by Dr Mike Sargent, has been formed to provide a conduit for information and advice between the NCRIS Committee and state and territory governments.

---

<sup>5</sup>[http://www.dest.gov.au/sectors/research\\_sector/policies\\_issues\\_reviews/key\\_issues/ncris/draft\\_implementation.htm](http://www.dest.gov.au/sectors/research_sector/policies_issues_reviews/key_issues/ncris/draft_implementation.htm)

<sup>6</sup>[http://www.dest.gov.au/sectors/research\\_sector/policies\\_issues\\_reviews/key\\_issues/ncris/capability\\_scoping\\_document.htm](http://www.dest.gov.au/sectors/research_sector/policies_issues_reviews/key_issues/ncris/capability_scoping_document.htm)

<sup>7</sup> The expert forum was held on 25 May 2005 in Canberra. Participants were invited from the Learned Academies, funding and research agencies and professional associations.

# DRAFT

## 4. PRIORITISATION OF CAPABILITIES

The consultation process made it clear that the potential exists for Australia to further develop a wide range of research capabilities, many of them to a level that would be competitive in the international context.

Consistent with the NCRIS principles, the Committee has sought to identify those capabilities it considers will provide the most strategic impact in terms of delivering national benefit, producing world-class excellence in both discovery and application driven research, and/or enhancing the overall capacity of the research and innovation system by providing enabling research platforms and promoting accessibility and collaboration.

The prioritised capabilities are intended to broadly address the requirements of research in the National Research Priorities (NRP) and the priority goals. However, in many cases there is no neat correlation between the capabilities and an NRP. This is because many of the areas of compelling research capability are enabling platforms with application across two or more NRPs or serving several priority goals. Indeed the Committee views this as a strength.

The Committee has paid particular attention to identifying an integrated set of capabilities that provide for critical linkages to be maintained and for a value-adding chain of research and innovation activities to be enabled in key areas. For example the Committee has:

- identified an integrated set of capabilities critical to deriving effective outcomes and value from human health research. These link the broadly based platforms for bio-molecular research to the development of effective models of human disease and the capabilities required to translate discovery based research to beneficial health outcomes.
- identified complementary capabilities in relation to environmental research, intended to enable complex research questions such as the causes and impact of climate variability to be approached in a multi-disciplinary way;
- sought to link discovery-oriented research to the capabilities required for pre-commercial development in key sectors. Examples include the links between the enabling platforms for the characterisation of materials and those focussed on fabrication of new- and nano-materials; and the connection between bio-discovery platforms and the capability for scale-up of bio-products;
- identified several information and communications technology platforms that have systemic application and therefore underpin the other capabilities and support a broad e-research capacity.

The scope of the priority recommendations has been necessarily constrained by the Committee's estimate of how much funding might realistically be available through the NCRIS program and from other possible sources, which might either be leveraged by NCRIS funds or applied to the capabilities in their own right.

Despite the prioritisation undertaken so far (and reflected in this Exposure Draft), it will not be possible to implement all the requirements outlined below within current resources. Further prioritisation will be required before the Roadmap is finalised.

**Stakeholders are invited to comment on the scope of the prioritised capabilities and specifically to provide any views or information that might help to further prioritise those capabilities (see [Section 8](#) for more information on responding to the exposure draft).**

# DRAFT

## 5. IMPLEMENTING THE STRATEGIC ROADMAP

The Exposure Draft provides a discussion of the perceived strategic infrastructure and support requirements, and associated issues, relating to each of the capabilities that have been identified. There are varying degrees of specificity in the requirements as outlined thus far, reflecting differing levels of maturity in current thinking on the issues. In some cases the Roadmap points to options, while in others more specific suggestions are put forward regarding the delivery of a capability.

**The Committee is seeking comments from stakeholders that will assist in further articulating the strategic infrastructure and support requirements, together with any associated issues, relating to the capabilities identified in the exposure draft (see Section 8 for more information on responding to the exposure draft).**

### Final recommendations

In the final draft of the Roadmap, to be provided to the Minister by the end of 2005, the Committee proposes to make recommendations regarding the implementation of the Roadmap. This may include:

- recommendations for investment of NCRIS funding in particular infrastructures during the period 2006-07 to 2010-11;
- advice on processes that might need to be undertaken to enable the development of a capability;
- advice on conditions that might need to apply to any funding; and
- recommendations for action on issues that relate to the development of the capability but are not infrastructure issues in themselves.

As noted above, the Committee's recommendations will require a further prioritisation of the capabilities. In formulating its recommendations the Committee will take into account factors such as:

- further judgements about the relative strategic impact of investment of NCRIS funds (the Committee will take into account the views of stakeholders in response to the exposure draft);
- the feasibility of undertaking the proposed implementation action within the NCRIS funding envelope and timeframe; and
- the immediacy of the need and/or maturity of the options.

### Funding proposals

The Committee's view is that the primary responsibility for determining how the specific capabilities identified in the Roadmap are implemented should lie with the research community itself. While the Committee's recommendations (if accepted by the Minister) will provide a framework for implementation, the development of detailed proposals to develop the requisite capabilities will fall to relevant research organisations and groups.

## DRAFT

### IMPORTANT NOTE:

Readers should note that this document is **not a call for proposals** for NCRIS funding. Formal funding allocation processes, including calls for proposals where relevant, are expected to commence in the second quarter of 2006, after the Minister has considered the final Strategic Roadmap and determined NCRIS priorities. The forward process for NCRIS is set out in greater detail in [Appendix C](#).

Detailed decisions regarding the delivery of a capability will be made either in the context of competitive processes, where appropriate, or through negotiations with relevant parties.

Organisations regarding themselves as potential funding recipients, or participants in NCRIS projects, should take particular note of the NCRIS principles, which require that NCRIS funded projects will support the development of national capabilities that:

- substantially enhance collaboration across Australia, internationally, between disciplines and across research sectors;
- focus on the delivery of services to the research sector and the maintenance of world-class technological capability;
- generally enable excellence in research and the development of world-class niches and international leadership in key areas;
- have a clearly defined and appropriate management structure;
- do not lead to further duplication of research infrastructure; and
- are broadly accessible on the basis of merit.

It is unlikely that proposals not fulfilling these requirements will receive funding.

# DRAFT

## 6. PRIORITY CAPABILITIES

### Summary of priority capability areas

6.1 Evolving bio-molecular platforms and informatics
6.2 Integrated biological systems
6.3 Characterisation <ul style="list-style-type: none"><li>6.3.1 Neutron scattering</li><li>6.3.2 X-ray techniques</li><li>6.3.3 Optical and electron microscopy/microanalysis</li></ul>
6.4 Fabrication <ul style="list-style-type: none"><li>6.4.1 Fabrication of advanced materials (including nano-materials)</li><li>6.4.2 Bio- and chemo- pre-commercial synthesis, fabrication and rapid prototyping</li><li>6.4.3 Micro/nanofabrication enabling microelectronics, photonics, optoelectronics, integrated optics</li></ul>
6.5 Biotechnology products
6.6 Translating health discovery to clinical application
6.7 Population health and clinical data linkage
6.8 Networked PC3 containment and bio-molecular facilities for emerging infectious disease, bioterrorism and forensics
6.9 Heavy Ion accelerators
6.10 Optical and radio astronomy
6.11 Terrestrial ecosystem research network
6.12 Integrated marine observing system
6.13 Structure and evolution of the Australian continent
6.14 Low-emission, large-scale energy processes
6.15 Next generation solutions to counter crime and terrorism
6.16 Systemic information infrastructure <ul style="list-style-type: none"><li>6.16.1 Data access and discovery, storage and management</li><li>6.16.2 Grid enabling technologies and infrastructure</li><li>6.16.3 Technical expertise</li><li>6.16.4 High performance computing</li><li>6.16.5 High capacity communications networks</li></ul>

# DRAFT

## 6.1 Evolving bio-molecular platforms and informatics

### Description

The last decade has seen rapid and continuing advances in technologies supporting analysis of the molecular basis of biological systems. These technologies are enabling vast amounts of information to be generated, and are promoting the emergence of new areas of research within the biological sciences.

The technologies and their associated areas of research focus on different (but related) areas, relating respectively to:

- gene discovery and genome analysis (*genomics*);
- the structure and function of primary gene products (*proteomics*);
- the analysis of metabolites in particular cells, tissues, fluids, organs or organisms at a given point in time (*metabolomics*); and
- how genes are expressed in differing contexts (such as in different tissues, populations and species) as well as through time (*transcriptomics*).

The sheer volume of information being produced creates major information management challenges. Technologies and an area of research focus have emerged to address these challenges (*bioinformatics*).

### Rationale

Research in these fields is producing a continuing stream of advances in our understanding of the structure and function of living systems. Over 300 genomes have now been sequenced. Together with advances in genetics, high-throughput biochemistry and bioinformatics, this research effort has created a comprehensive and rapidly growing pool of knowledge and resources. However, this revolution in the biological sciences is just beginning.

The potential benefits flowing from research in these areas are enormous, including in areas such as:

- discovery and development of drugs, including new generation genetically based treatments;
- development of novel functional foods with enhanced nutritional/fibre/nutriceutical value now recognised to play a crucial role in promoting a better quality of life and longer life expectancy;
- development of novel crop varieties with enhanced capacity to withstand stresses such as salinity, drought, frost, mineral deficiencies and toxicities) and pathogens/pests;
- development of crops with reduced dependency on fertilisers, promoting both the environmental sustainability and competitiveness of Australian agriculture;
- improved bio-security through the rapid detection and characterisation of threatening human pathogens (e.g. avian flu) and agricultural pests.

Opportunities to link the explosion of emerging information with other large data collections are also emerging. Clinical data sets relating to (for example) cohorts, populations, clinical research, tissue banks and clinical trials have the capacity, through linkage to the evolving bio-molecular information base, to build understanding of the complex origins and development of important diseases.

Australia has maintained an internationally competitive position in several of the platform technologies needed to support research in these areas. These platforms are stimulating and transforming fields such as cellular biology, botany, zoology, ecology, microbiology, biochemistry and genetics, while drawing disciplines such as chemistry, informatics, physics

## DRAFT

and mathematics into collaborative research efforts and approaches. However, the rapid pace of progress within these technologies creates a requirement for the development and maintenance of a capability that is at the forefront internationally, with respect to both development and use.

### Infrastructure/support requirements

A number of possible areas for investment have been identified, relating to infrastructure within Australia and to participation international research efforts.

#### *Infrastructure*

There is a need to both address current gaps in capability and to better build on the many existing centres across Australia, coordinating them into national, collaborative efforts. Specific areas for investment might include:

- development of a national metabolomics facility – currently, only one major group in Australia has significant physical infrastructure and intellectual capacity in this area. The establishment of a national metabolomics facility (incorporating sophisticated separation and detection equipment capable of evaluating a wide variety of metabolites along with advanced bioinformatics capability) would allow researchers to conduct high-throughput micro-analysis of metabolites;
- high throughput “omics” analysis platforms;
- crystallography, nuclear magnetic resonance and mass spectrometry facilities supporting analysis of biological structures and the modelling/prediction of their behaviour;
- microscopy, spectroscopy, access to cell imaging etc.

#### *Participation in International Networks and Programmes*

Australia needs to participate in relevant international bionetworks and programs in order to stay abreast of developments in these fields.

A specific option is for Australia to participate in the European Molecular Biology Organisation (EMBO) and the European Molecular Biology Laboratory (EMBL). Such participation would provide Australian researchers across the life sciences with access to levels of resources, technology and critical mass unavailable in Australia, together with research training placing our young researchers at the cutting edge of their fields and promoting the diffusion of research knowledge into its areas of application in industry and elsewhere.

### Conclusions/Issues

The key question is how best to structure investment in this area so as to provide Australia with a world-class research capability that builds on important existing capabilities and addresses key existing gaps. The NCRIS Committee has identified several areas where investment might most strategically be focused:

- Support for Australia’s participation in EMBO/EMBL;
- Approaches that build on and integrate existing capacity in the various “omics” platforms to create national, collaborative and broadly accessible capabilities in these areas;
- Development of a national metabolomics facility.

The Committee welcomes views on the following issues:

## DRAFT

- how best to promote multidisciplinary interactions and preserve adaptability in the face of rapid evolution in these research fields and in their accompanying technology platforms;
- the costs and benefits of dispersing effort across many centres or nodes, versus focusing investment in major centres;
- the appropriateness/desirability of structuring investments along narrow discipline- or problem-based lines, (e.g. cancer, neuroscience, obesity), given that the technology platforms have applications across the breadth of biological research;
- the benefits of integrating existing capabilities into “systems biology” approaches;
- how best to ensure that the requirement for training/skills development in certain key areas, e.g. informatics, is effectively met in the future;
- other international networks and programmes besides EMBO/EMBL that Australian researchers would benefit from participation in.

# DRAFT

## 6.2 Integrated biological systems

### Description

Understanding biological systems requires not only an understanding of their constituent elements and sub-systems, but also of how these interact with each other and with the wider environment. These interactions are attracting increasing attention in a number of areas of biological research.

To support this research, capabilities are required that: enable the generation and maintenance of genomic resources; provide the capacity to identify the functions of particular genes; and provide suitable “model systems” that can be studied to improve understanding of more complex organisms and processes. Potential areas for further investment have been identified in relation to animal, plant and invertebrate systems.

### Rationale

#### *Animals*

Progress in understanding and treating human disease can be significantly enhanced by the development of appropriate animal models in which the course of a disease and effects of treatment can be tested.

Australia invests significantly in research to understand and utilise animal models of human disease. A recent example of world class Australian research in animal disease models is the development by Australian researchers of the world’s first animal model of human epilepsy.

The past 10 years has seen revolutionary advances in gene targeting and stem cell technologies, cell and tissue storage, animal phenotyping and xenotransplantation. Concurrently, there have been advances in medical imaging techniques which provide non-invasive and direct insights into normal and abnormal systems biology. There is an opportunity to build a national integrated capability in Australia which captures these advances and facilitates development of novel animal models of diseases, including access to phenotyping and imaging facilities at a level comparable to those available to international researchers.

Such a capability would help build on Australia’s strengths in neuroscience, cardiology, respiratory and renal medicine, oncology, perinatology, endocrinology, metabolic and degenerative diseases and surgery, while enabling researchers to more rapidly move from research outcomes to the development of therapeutic approaches. Further development of non-invasive medical imaging technologies would help to reduce the number of animals used in medical research.

#### *Plants*

The major challenge facing the plant science community, locally and internationally, is to develop improved capabilities to accurately “phenotype” mutant or new plant varieties. To date, a major focus in botanical/agricultural systems has been genome sequencing and the study of how genes are expressed. The challenge is to obtain an integrated picture of plant performance, under controlled conditions, throughout the plant lifecycle. While Australia has traditionally excelled in molecular biology and plant physiology, no concerted effort has yet been made to bring together nodes of expertise in these fields to address plant phenomics.

Australian agriculture would benefit significantly from enhanced capability in plant phenomics through the development of techniques to improve both yield and quality of crops through

## DRAFT

minimising the effects of environmental and biological (pathogens/pests) stresses, and a reduced dependence on pesticides, fungicides, herbicides and fertilisers.

### *Invertebrates*

Invertebrate collections provide an important supporting infrastructure for research relating to models of disease, biosecurity and biodiversity, as well as supporting environmental remediation and management. For example, microbes and invertebrates such as insects can be used as bio-indicators, while genetically modified bacteria have the potential to contribute to treatment of waste-water and toxic wastes. There is an opportunity to more fully digitise and link existing collections and thereby leverage more value from them.

### Infrastructure/support requirements

#### *Animals*

Key components contributing to an integrated capability supporting animal disease models include:

- Gene targeting technologies;
- Cell and tissue storage;
- Archiving and distribution of mutant strains;
- Animal phenotyping facilities;
- Specialist animal holding, breeding and surgical facilities;
- Application and development of new bioimaging technologies for small and large animal models of disease.

Potential areas for investment include:

- Development of a mouse phenotyping facility, together with linkages between centres working with genetically altered mouse models with those working with advanced disease models;
- Support for advanced imaging facilities, relevant to a range of animal models of disease, structured in a way which would promote enhance co-ordination between existing facilities, promote systematic transfer of knowledge across discipline, disease and national boundaries and provide a focus for continued development of imaging techniques;
- Development of stronger linkages between centres dealing with human disease and those with expertise in animal models.

Other potential areas for investment include: a mutant animal archive; animal oncology and reproductive facilities; an Australian node of international mouse knockout library efforts; animal phenotyping facilities linked to expertise in disease modelling; frozen mouse embryo storage facilities; xenotransplantation facilities; specialist large animal breeding, holding and surgical facilities; a large animal imaging facility; and accessible, integrated databases supporting both animal models of disease and preclinical research and development capabilities.

Provision of appropriate support would facilitate Australian linkages with, and participation in, international efforts such as the European Mouse Mutant Archive and the NIH's stem cell mouse genome initiative, and would better assist our researchers to produce and contribute to world class outcomes in model animal research and related research focus areas.

# DRAFT

## *Plants*

Existing facilities within Australia have varying infrastructure dedicated to the growth of experimental plants within conventional glasshouses and/or plant growth cabinets. There are nodes of expertise in non-invasive analysis of plant performance, such as optical, hyperspectral and chlorophyll fluorescence imaging, focussed on individual plant species and/ or small scale research projects which include laboratory and field-based research.

The infrastructure gap is in bringing these two key areas together (controlled plant growth conditions and cutting edge plant performance monitoring). This would be most effectively achieved by creating a central focus for these activities feeding out through interaction with this centre.

## *Invertebrates*

A number of collections exist across Australia and provide an important capability for research in areas such as evolutionary biology, models of disease, resource management, and biosecurity. Full databasing and linkage of existing collections, along with provision of associated informatics capabilities, would be desirable and enable better utilisation of genomic resources in this area.

## *Participation in International Networks and Programmes*

The Committee favours providing support for Australia's participation in the International Neuroinformatics Coordinating Facility (INCF). The INCF is an international project aiming to coordinate international efforts to manage the vast, complex and rapidly escalating quantities of data generated in neuroscience. Participation would build on and integrate the outcomes of existing research efforts in neuroscience across Australia, including the National Neuroscience Facility (MNRF) and related technology (e.g. imaging, phenotyping etc) and clinical capabilities (e.g. neuroscience clinical trials).

## Conclusions/Issues:

There are a broad range of potential areas for investment relating to this capability. The possibilities that the Committee is most attracted to at this stage are:

- Development of a national centre dedicated to phenomic analysis of plant performance that brings together capabilities in controlled plant growth conditions and cutting edge plant performance monitoring;
- Development of a national mouse phenotyping facility (as well as associated linkages between centres which have a capability in genetically altered mouse models and those working with advanced disease models and further, between animal modelling centres and clinical research centres);
- Initiation of planning for a national framework to enable non-invasive imaging of large animal models and support the development and knowledge transfer of new imaging techniques relevant to a range of animal models of disease;
- Databasing and linkage of existing invertebrate collections, along with provision of associated informatics capabilities;
- Support for Australia's participation in the International Neuroinformatics Coordinating Facility (INCF).

The Committee welcomes views on where NCRIS funds would be most productively applied to building Australia's national, collaborative research capability in this area.

## 6.3 Characterisation

One of the fundamental requirements of researchers in the physical sciences, life sciences and engineering is for equipment that enables them to characterise the physical, chemical and structural attributes of matter (both non-living and living) and determine how those attributes change over time (for example, if subjected to external stresses). While some characterisation work can be performed on relatively inexpensive laboratory equipment, a number of key techniques are expensive, require specialised skills and are best operated as central facilities open to all researchers.

Neutron scattering, x-ray techniques and high-level microscopy and microanalysis fall into this latter category. Each has been identified as needing additional investment to deliver the suite of characterisation capabilities required to underpin world-class Australian research in the physical sciences, life sciences and engineering.

### **6.3.1 Characterisation – neutron scattering**

#### Description

Because neutrons can non-destructively penetrate deeply into materials, researchers can use them to obtain information on the properties of both organic and non-organic materials. Neutron scattering involves firing a beam of neutrons at a sample and making inferences about the nature of the material based on how the neutrons scatter after contacting the sample.

Neutron scattering finds particular application in the study of “soft-matter” materials such as polymers, complex fluids and those comprising biological systems, as well as in magnetic and electronic materials. It provides different but complementary information to that obtainable using other characterisation techniques. In biological applications, for example, while x-rays offer high temporal and spatial resolution of a structure, neutrons offer contrast variation for selective investigation of the component parts of a large complex. For this reason neutron scattering is increasingly regarded as an important tool in the range of techniques available for structural biology. At the other end of the scale, neutrons can easily travel through centimetres of solid steel, making them ideal for studying stresses in engineering components and for applications in materials science in general.

#### Rationale

Australia has a long and distinguished track record in neutron science dating back to 1958. It now possesses a world-class neutron scattering capability in the recently commissioned OPAL (Open Pool Australian Light-water) reactor at ANSTO, which will be one of the top three research-reactor centres in the world for neutron scattering techniques. When fully operational in 2006, this facility is likely to raise Australia’s capability in neutron science to the highest international level while increasing competitiveness in other key areas such as nanotechnology and attracting leading international research teams to Australia.

Knowledge derived from neutron scattering has a wide range of applications in the manufacturing, minerals, agriculture and pharmaceuticals industries. It addresses many of the Priority Goals identified in Australia’s National Research Priorities. To take one example, relating to the goal of *reducing and capturing emissions in transport and energy generation*, neutron scattering has been used to build knowledge about how hydrogen (a promising alternative fuel) might be stored and used efficiently to generate electricity<sup>8</sup>.

---

<sup>8</sup> For example, studies using neutron scattering have characterised the hydrogen adsorption capacity of carbon nanotubes and aspects of the operation of membranes used in polymer electrolyte fuel cells.

# DRAFT

## Infrastructure/support requirements

The new OPAL neutron source, with an initial suite of nine instruments each providing a different method and scientific/technological focus, will come on line in 2006<sup>9</sup>. A survey of likely demand conducted in April 2005<sup>10</sup>, showed that half of the initial suite of instruments will be oversubscribed from the outset, and that some of its capabilities will need to be duplicated soon after OPAL starts operating. It is anticipated that OPAL's usage will double over the first few years of operation. Growth could be even more rapid if investments are made in extra beamlines and additional guides (up to nine extra beamlines, for example, could be accommodated by OPAL to further enhance its capacity and functionality).

The most immediate priority, however, is provision of a deuteration<sup>11</sup> facility for either low or high molecular weight compounds. The ability to deuterate samples has long been a key issue for biological and organic molecular neutron scattering. Tools and facilities are required for the specific and selective isotopic-labelling of complex bio-molecules (eg proteins, nucleic acids and lipids), synthetic macromolecules, amphiphiles (eg surfactants) and small organic molecules (eg. drugs). The provision of these deuterated molecules should greatly enhance both the quality and quantity of neutron experiments that can be done at OPAL. In addition these deuteration facilities would enable more sophisticated NMR experiments, which will be important, for example, to the proteomics community. The lack of such a facility will be a major limitation for soft matter research.

## Conclusion

The Committee considers that the most suitable means for further developing this capability would be via development of a deuteration facility for the OPAL reactor.

## **6.3.2 Characterisation – X-ray techniques**

### Description

X-ray techniques are central to the characterisation of both hard and soft matter, and are widely employed on the laboratory scale. They enable determination of structures, chemical composition and imaging in both two- and three-dimensions of complete samples, and can image both engineering components and biological systems.

X-rays provide information on the crystallographic and molecular structure of materials that is different from, but complementary to, the information obtainable from neutron scattering. While many x-ray techniques can be performed in the laboratory, the major advance in x-ray techniques has been the advent of synchrotrons, which produce beams of very intense electromagnetic radiation covering a major part of the spectrum, from far infrared light to hard x-rays. In third generation machines, the intensity obtainable will be up to 10<sup>9</sup> times greater than the intensity from a conventional laboratory source. This enables very short exposure times, and the possibility to do time dependent studies of chemical and physical processes.

### Rationale

Synchrotron techniques are increasingly important in a broad range of biological, health, physical science and engineering disciplines. In relation to industrial research, there are

---

<sup>9</sup> <http://www.ansto.gov.au/opal/about1.html#neut>

<sup>10</sup> [http://www.anbug.org/opal\\_user\\_survey\\_results.html](http://www.anbug.org/opal_user_survey_results.html)

<sup>11</sup> Deuteration introduces "heavy water" into a sample to improve the quality of neutron scattering data.

## DRAFT

growing applications in the minerals, agriculture and food processing sectors, for drug discovery, development and production.

They are also important for environmental research programs. For example, spectrographic beamlines enable the measurement of very small concentrations of toxic materials in soils, streams, seawater or the atmosphere. In this context, they have been used to investigate the uptake of heavy elements by plants and micro-organisms in order to develop mine and industrial site remediation strategies.

The ability to access world-class synchrotron techniques will address a current substantial unmet need for synchrotron techniques among Australian scientists that is limiting their ability to perform cutting-edge research in a broad range of fields. New tele-presence capabilities (as for example will be supported on the Australian synchrotron), moreover, are likely to greatly facilitate and encourage collaborative efforts amongst researchers both within Australian and with research groups internationally.

### Infrastructure/support requirements

Australian researchers have been accessing synchrotrons overseas through DEST's Australian Synchrotron Research Program and Access to Major Research Facilities Program. However, the acquisition of a domestic, world-leading capability has become essential. There is currently substantial unmet need for synchrotron techniques among Australian scientists that is inhibiting their ability to perform world class research. There are major logistical limitations and cost penalties involved in accessing overseas synchrotrons, particularly affecting life sciences and time critical industrial applications. Moreover, data gathered at some overseas synchrotrons can be subject to intellectual property ownership restrictions. These problems make it difficult for researchers to support industry requirements, which usually require rapid response, and impact particularly on students and early career researchers.

#### *Australian Synchrotron*

The Australian Synchrotron is under construction and will come on stream in 2007. It will be a third generation machine designed for optimum performance in the x-ray range. It is expected that over 1,200 people nationwide will use the facility each year. When operational it will provide a world leading capability in a number of areas.

The Victorian Government is funding the construction of the buildings and main machine. A consortium of universities, CSIRO, ANSTO, medical research institutes (AAMRI), state governments and New Zealand have so far committed in-principle funding toward the cost of an initial suite of 9 beamlines. These will perform a range of techniques expected to be able to meet 95% of the anticipated needs of the Australian and New Zealand scientific and industrial research community for synchrotron techniques. Further beamlines developments and the use of tele-presence are also planned. This will be achieved through coupling with the AARNet and the Australian Government's e-research initiative.

The initial beamline suite (and subsequent beamlines) requires additional capital funding to become operational. However, prior to any commitment of NCRIS funding it is critical that issues related to the operating budget of the facility are resolved satisfactorily.

#### *Access to International facilities*

The Australian Synchrotron Research Program was supported in the previous Major National Research Facilities Programme (MNRF) round and its funding is due to finish in June 2007. It would be desirable to extend its funding to cover the Australian Synchrotron phase-in period and access to capacity that will not be available.

# DRAFT

## Conclusion

The Committee considers that: NCRIS funding could be used to support the initial suite of beamlines at the Australian Synchrotron, contingent on the provision of an adequate operating budget for the facility from sources other than NCRIS; and that an extension of funding be provided for the Australian Synchrotron Research Program while the strategy for developing an integrated national capability is being developed.

## **6.3.3 Characterisation – high-level microscopy and microanalysis**

### Description

Optical, scanning probe and electron microscopes permit characterisation of matter on a fine scale. *Optical microscopy* provides imaging of surfaces, thin sections and dispersions of particles down to the micron scale. Over the past few years, several techniques have increased the level of resolution that is achievable and opened the possibility of optically characterising biological specimens, including live cells. *Scanning probe microscopy* covers several related technologies for imaging and measuring surfaces down to the level of molecules and groups of atoms. *Electron microscopy* has been steadily evolving over the past 40 years, with the most recent transmission electron microscopes (used for characterising advanced materials as well as biological tissue) able to resolve structures at the atomic level, below 0.1nm.

### Rationale

Optical, scanning probe and electron microscopy enable a wide range of research. A number of centres around Australia, mostly within universities, are equipped with at least some of these facilities. While in many cases this equipment is modern and of a high standard, a significant proportion is quite old, expensive to maintain and has limited capability. Those who run these facilities often report the equipment is under-utilised because of lack of staff and funding to support a wider program. In some cases the particular research focus of the host institution has narrowed the range of applications as well.

Well-run centres equipped with advanced instruments and skilled staff would facilitate excellent research as well as providing a clearing house for the latest ideas because of the wide range of activities undertaken and the drive and resources to develop the techniques to their full extent. Interaction with the staff with other researchers using the centre would stimulate collaboration.

### Infrastructure/support requirements

The Committee considers that the most suitable means of supporting a strong Australian capability in high-level microscopy and microanalysis would be by providing a network of optical, scanning probe and electron microscopy and microanalysis facilities, with:

- nodes in each major capital city;
- a full, modern suite of instruments, building on existing investments, together with sufficient skilled staff to ensure that the potential of the techniques is fully realised and the facilities operate at a high level of productivity;
- electronic linking of the centres, together with central, long-term archiving, in a common format, of images and experimental data produced by them. (The storage format will need to be designed so that images of the same sample made by different techniques (including x-ray and infra-red imaging at the Australian Synchrotron) can be compared and

## DRAFT

superimposed.) Key pieces of equipment should ideally be equipped with a tele-presence capability so that particular capabilities that one centre may have developed can be made available nationally.

- access available to all researchers, irrespective of their institution, based on the scientific excellence of their work. It will be critical to ensure that centres truly service their region and are not 'captured' by their host institution.

It would be highly desirable also to link the centres to a nationally networked database and capability for interpreting structural data at the nanoscale.

### Conclusions/issues

The Committee considers that a national network along the lines outlined above would be the most cost-effective means of delivering world-standard capabilities in high-level microscopy and microanalysis to the Australian research community. Comments are invited on this proposal, together with any additional observations as to how such a network might best be designed, managed and operated.

# DRAFT

## 6.4 Fabrication

Australia needs a capacity to produce industrial trial quantities of materials, fabricate product components, and rapidly produce prototypes for testing in order to help provide paths to market for world-class Australian research.

Three important areas have been identified as having capability gaps that could be addressed through NCRIS funding. These are: advanced materials (including nanomaterials), bio- and chemo-based products, and microelectronics, photonics, optoelectronics and integrated optics.

### **6.4.1 Fabrication of advanced materials (including nano-materials)**

#### Description

Advanced materials are fundamentally important to all modern technologies from aerospace, automotive to biomedical devices, with potential to address a wide range of the goals identified in Australia's National Research Priorities. For example, in relation to the goal of *reducing and capturing emissions in transport and energy generation*, nanomaterials are playing an important role in efforts to increase the efficiency of photovoltaic cells, as well as in efforts to lower the prospective cost of hydrogen-driven transportation by reducing the amount of platinum needed in Proton Exchange Membrane Fuel Cells.

One of the hallmarks of advanced materials – whether they be polymeric, metallic or inorganic in nature - is the rational design and controllable processing of their building blocks. Increasingly the building blocks for advanced materials with novel and/or improved properties are found in the nanosized range. It is widely recognised that building blocks at the nanoscale such as nanoparticles, nanotubes and nanofibres often hold the key to materials' properties and performance. These building blocks can be produced in several ways: by "top down" approaches e.g. grinding, atomisation or electrospraying, or by "bottom up" approaches from the atomic or molecular constituents, e.g. crystallisation, colloidal precipitation, or growing from a gaseous deposition.

These precursor materials or building blocks can be useful products themselves, but often need to be built into engineered products or devices using processes such as powder compaction, sintering, spin coating, spray coating, extrusion, and other forming techniques.

#### Rationale

A number of Australian research centres are producing world class research in the area of 'Advanced materials'. There is good capability to synthesise and test materials in the laboratory, but generally only small quantities (often only grams) can be produced at a time. In contrast, research organisations overseas can access facilities enabling them to make and characterise kilograms of materials. This gives them the ability to test advanced materials and their production processes on a pre-pilot scale, which is crucial for fully testing their properties and performance and for convincing potential users or investors to support scale-up production or pilot trials. Such scale-up and prototype facilities are not available in any Australian research organisation, and are needed to enable research in advanced materials to move from the laboratory bench into useful applications.

#### Infrastructure/support requirements

This capability could be supported by the establishment of one or two national advanced materials prototyping and small scale production facilities to enable the manufacture of advanced materials at a scale of several kilograms.

## DRAFT

Several commercial ventures have been spun out of research centres in Australia for production of nanopowders. These enterprises specialise in specific technologies and families of powders so could not be expected to provide a broad service to researchers. However it is possible that these facilities could provide the basis for establishing one or two scale-up centres linking to the key research centres in advanced materials and nanomaterials.

An option would be to have two centres of scale up facilities established in Australia, each specialising in a focused area, such as soft materials including polymeric, organosilicate, and nanocomposites and biomaterials; and another in hard materials including inorganic particles, thin films and coatings, and consolidated materials sintered from powders. The type of equipment, processing units and tools, as well as advanced materials performance testing facilities would include heaters and autoclaves for sol gel and hydrothermal processing, powder compaction, sintering furnaces, electrospraying, spin coaters and dip coaters, air spraying, catalytic vapour deposition reactors and flame particle synthesis reactors. Specialised equipment for soft materials such as polymer nanoparticles such as layer-by-layer processing, and self-assembled amphiphile colloidal particles at a larger scale than a few hundred grams would also be desirable.

### Conclusions/Issues

The Committee welcomes views on how NCRIS funds might most productively be applied to build Australia's national, collaborative research capability in relation to the fabrication of advanced materials (including nano-materials).

### **6.4.2 Bio- and Chemo- Pre-Commercial Synthesis, Fabrication and Rapid Prototyping**

#### Description

Australia maintains a significant research effort devoted to an area that can loosely be described as biomaterials research. This area includes bulk biomaterials, and surfaces and systems that are either biomimetic, bioresponsive, biocompatible or bioregenerative, including the promotion of tissue growth. Other related areas are BioMEMS (MicroElectroMechanical Systems), microfluidics and chemoresponsive surfaces and systems.

The capability required includes pre-commercial scale synthesis of materials (such as biological, polymer, organic, inorganic and inorganic-organic hybrid materials), design skills (eg. micro-electronics, microfluidics and micro-mechanical-systems), a range of microfabrication and nanofabrication techniques for polymers, silicon and glass *inter alia*, surface modification equipment to provide the desired functional behaviour. The fabrication and surface modification processes generally must be carried out in clean room environments at positive pressure, while the facilities to handle bioactive agents frequently require clean rooms at negative pressure. Ideally, these rooms should be co-located to minimise transport and handling of the products between processes.

Some of the technology areas where this capability is required include implants, biomedical devices, biosensors, chemosensors, tissue growth scaffolds and controlled release vehicles for biologically active molecules.

#### Rationale

Australia has a world-class scientific and engineering research community in this area, with a reasonable track-record in commercialising the R&D. The intention is to move this commercialisation track-record from a ranking of reasonable to one of world's best practice.

## DRAFT

Australia has traditionally been strong in research relating to the biological/materials and biological/materials/electronics interfaces. A common concern and frustration by R&D personnel is the time taken and difficulty of producing pre-commercial quantities of materials and samples of fabricated components, and rapidly making prototypes for testing and further research. The equipment for the individual steps in making some products exist on a one-off, laboratory-scale in Australia but they are scattered and access is restricted.

### Infrastructure/support requirements

To overcome this problem, additional investments could be made in supporting the establishment of one or more comprehensively equipped facilities where the required pre-commercial production processes was housed under one roof. A national user facility could be established with the entire range of equipment, to provide a fully-integrated approach to the development process, from materials selection or creation through to pilot-scale manufacturing. Alternatively, the infrastructure required for each of the areas of bulk biomaterials, surface chemical modification for bio- and chemo-applications, and device fabrication may be sufficiently different to be able to have three separate specialist facilities.

The investment strategy would desirably cater for operating costs and costs associated with maintaining and upgrading existing equipment as well as for the costs of purchasing new state-of-the-art equipment. Provision of facility staff with cross disciplinary skills and the networks to promote collaboration with experts in other fields would be important, as would an open peer-reviewed scheme to provide access to the infrastructure on the basis of the excellence of the research being proposed. Equipment from existing sites could be transferred to the facility(-ies) in order to consolidate the infrastructure.

### Conclusions/Issues

The Committee welcomes views on how NCRIS funding could be most productively applied to build Australia's national, collaborative research capability in this area, and in particular on the suggestion that well-equipped, pre-commercial production facilities be brought together, either under one roof or in separate specialist facilities for bulk biomaterials, surface chemical modification and device fabrication.

### **6.4.3 Micro/nanofabrication enabling microelectronics, photonics, optoelectronics, integrated optics**

#### Description

A wide range of systems developments are underpinned by key device capabilities arising from micro/nano electronics, photonics, optoelectronics, microfluidics and integrated optics. Micro/nanofabrication generally centres on the capability to structure inorganic and in some cases polymeric materials on micron-to-nanometre scales.

This capability incorporates:

- materials growth by a range of techniques including Molecular Beam Epitaxy (MBE), Metal-Organic Chemical Vapour Deposition (MOCVD), plasma-enhanced, laser and other forms of CVD, various forms of thin film deposition including thermal, electron-beam and laser evaporation, rf plasma and laser sputtering techniques;
- means to modify such materials including high and low energy ion implantation, in some cases with nanoscale precision;

## DRAFT

- means to spatially structure the material on micron to nanoscales including electron-and ion-beam and optical lithography, imprinting and embossing, plasma and other forms of dry etching, as well as conventional wet etching, laser machining, and unique techniques associated with organics;
- a range of in-situ and post-processing nanoscale diagnostics;
- the processes of lithography itself including fabrication of masks and mask alignment; and
- pre-and post processing of samples including dicing, polishing, annealing, metalising, wire bonding, optical-fibre pigtailling and other forms of device integration.

The vast majority of these techniques must be undertaken in high-level clean-room environments.

### Rationale

Research in micro/nano electronics, photonics etc, which collectively represents a major research strength of Australia is necessarily underpinned by a range of sophisticated micro/nanofabrication facilities. Extending our capabilities to make real nano-electronic, photonic and optoelectronic devices in Australia offers the opportunity to develop internationally competitive technologies with significant potential for direct commercial outcomes.

Current world-class research in Australia spans the “core” semiconductor materials technologies of silicon, the III-Vs (GaAs, AlGaAs, InGaAs etc and increasingly GaN, GaAsN, InGaAsN etc), mercury cadmium telluride and related materials, and the key optical materials technologies of lithium niobate, silica and chalcogenide glasses (including optical fibre technologies).

There are leading edge research groups in all mainland Australian states with particular concentrations of effort in Perth, Melbourne, Canberra, Sydney and Brisbane<sup>12</sup> that are supported by a range of small, but good quality specialist facilities, equally widely distributed. Although there are several formal and informal networks which assist in communication between these facilities and to some degree in providing access to the facilities, the national infrastructure for micro/nanofabrication is scattered, uncoordinated, patchy and generally lacking critical mass. Most of the existing facilities are under resourced and their inability to fully support operating costs restricts capacity and therefore access.

### Infrastructure/support requirements

It is apparent that there remain significant gaps in Australia’s micro/nanofabrication capacity and capability. A national approach through NCRIS to providing the infrastructure required in this area might comprise three key elements:

- Support of existing distributed facilities through funding of operating, maintenance and expansion/enhancement costs;
- Establishment of new facilities to fill critical gaps in capability<sup>13</sup>;
- Provision of overall management, integration and coordination skills

A specific model for national infrastructure might take the form of fully equipped and supported micro/nanofabrication clean-room facilities located in at least 3 capital cities) with a range of satellite specialty facilities located elsewhere in those cities and in other nodes around Australia, the operation of which satellite facilities is supported as part of the national facility and access to

---

<sup>12</sup> see [www.nanotechnology.gov.au](http://www.nanotechnology.gov.au)

<sup>13</sup> Capability gaps might include lithium niobate fabrication, specialty techniques for nanofabrication of organic materials including laser-based rapid prototyping, and facilities for fabrication of devices integrating multiple materials technologies such as micro-optic active devices.

## DRAFT

which is available for qualified researchers on a nationally managed basis. At the very least, access to clean-room facilities fully equipped for standard micro/nanoprocessing, diagnostics and device fabrication at acceptable cost to researchers is a minimum requirement.

Implicit in the proposed model is much improved leveraging of existing facilities.

### Conclusions/Issues

The Committee welcomes views on how NCRIS funding could be most productively applied to build Australia's national, collaborative research capability in this area, and in particular on the model suggested above.

# DRAFT

## 6.5 Biotechnology products

### Description

Bioproduct development relies on the efficient and controlled use of microbial cells, cells from animal and plant sources, and cell components. Recent scientific advances in fields such as genomics (the understanding of the genes and gene activity in cells), proteomics (the understanding of the proteins present in cells and being made by cells) and metabolomics (the profiling of all cellular metabolites) are now opening up the field of metabolic engineering, where the genomics and proteomics of cells can be manipulated in a controlled fashion to improve the cells ability to make a specific bioproduct.

Bioproducts include, but are not restricted to, proteins, antibodies, plastics, recombinant biopharmaceuticals, nutraceuticals, vaccines and biomass conversion (bioethanol/biodiesel). They may constitute a final product in themselves or be a component of a more complex end product.

Key components of this capability include:

- Bioreactors and bioprocessing at precommercial scale for microbial, plant and animal cells;
- Downstream processing / product recovery;
- Production of "smart surfaces" for stem cell growth.

This capability also requires access to physical, chemical and biological/biomolecular characterisation techniques.

### Rationale

There is an increasing demand for biotechnology derived products and processes. The impact of such products will be one of the main technological drivers of the 21<sup>st</sup> century.

Primary manufacturing capabilities for the development of the active ingredient of biopharmaceutical products (i.e. recombinant proteins, monoclonal antibodies etc) in Australia are currently limited. 2001 estimates<sup>14</sup> indicated that Australia's protein manufacturing capacity is around 1% of global capacity. Global demand is predicted to exceed supply in the immediate future, placing further constraints on the achievement of translation of discovery to market product and extending the timescale over which it occurs.

The potential to produce novel nutraceuticals and to convert agricultural waste residues (biomass) to fuels (bioethanol and biodiesel) through fermentation technology would promote human health, reduce our dependency on fossil fuels, and enhance the sustainability of our agricultural sector. Applications and benefits of microbial fermentation research will also provide rational approaches to detoxify liquid wastes derived from human activities including those from the mining and chemical industries.

Australia has supporting infrastructure and expertise in a number of centres, but is heavily reliant on offshore capabilities (up to \$60M in such business goes offshore each year). Strategic investment in appropriate facilities and supporting technologies would better position Australia to maximise research outcome development within Australia.

---

<sup>14</sup> Kelvin Hopper and Lyndel Thorburn, 2001 Australian Bioindustry Review, Aoris Nova Pty Ltd, December 2001

## DRAFT

### Infrastructure/support requirements

Support for this capability might be focused on the development of several hubs of activity clustered around existing capabilities across Australia. Identified focus areas include:

*Bioreactors and bioprocessing:* A key requirement is the provision (and appropriate equipping and configuration) of a range of bioreactors which are suitable for both basic research and for the scale-up of bioprocesses (ranging from several to hundreds of litres) and pilot scale reactors for microbial, mammalian and plant cell culture (up to a thousand litres in capacity). The design, fabrication and optimisation of flexible plastic reactors will be of increasing importance as the new bioprocesses based on stem cells are developed.

*Downstream processing, product recovery:* State of the art equipment for downstream processing is necessary to complement the developments occurring in the bioreactor stage. Computer controlled protein purification equipment, suitable for process scale-up, for example, is required to allow the flexible production of batches of material for early stage characterization and subsequent application. The facility needs to have flexibility, so that a range of unit operations are available, catering for the wide range of bioproducts currently under development. Facilities to allow research on protein formulation and stabilization are required, as well as the full range of recovery options such as lyophilisation, spray drying etc.

*Production of 'smart surfaces' for stem cell growth:* Facilities are needed which are suitable for developing novel methods for the production of the highly porous polymeric scaffolds required for use in tissue engineering and drug delivery. This is a rapidly evolving field which includes work being carried out to create highly functional 'biomimetic' surfaces which allow specific cell-surface interactions within a three dimensional porous scaffold, such as the work on developing the 'artificial niche' for the controlled growth of stem cell cultures. In addition to scaleable mini-reactors, extruders and injection molders, electro-spinning systems are required to enable nanofibres to be fabricated from novel polymers. Photolithography equipment for micro-scale patterning and device fabrication is also required.

### Conclusions/Issues

The Committee welcomes views on how NCRIS funding could be most productively applied to build Australia's national, collaborative research capability in this area. In particular, it seeks comments on the relative needs and demand for the proposed capabilities in relation to bioreactors, downstream processing; and smart; surface production.

*Note: There would be an expectation for multiple agencies and ultimately industry to assist in the development of this pre-commercial capability.*

# DRAFT

## 6.6 Translating health discovery into clinical application

### Description

The goal of biomedical research is to have a positive impact on human health. This generally requires clinical trials to be conducted. Moving from the research laboratory to the clinic requires proof of principle in humans. To achieve this in a seamless and timely fashion requires a set of pre-clinical capabilities able to be applied to therapeutic molecules, cell therapy, medical devices, biomaterials and viral and nucleic acid delivery (sufficient to meet regulatory and production standards) including:

- Use of animal disease models
- Small chemical drug and radiochemical compound development
- Protein-based drug and imaging agent development
- Scale up of materials to clinical trial quantities
- Testing facilities to establish stability, delivery mechanisms and toxicity.

The above capabilities are not intended to include full scale development or manufacturing, activities which should be the responsibility of industry. Nonetheless, pre-clinical work should be performed mindful of the possible need to conduct full scale manufacturing at a later date so as to obviate the need to repeat clinical trials.

### Rationale

Australia has a strong base in basic biomedical and clinical research. What is frequently lacking, however, is the capacity to move from the laboratory to the clinic. To capture the full value of Australia's public and private investment in health research, pre-clinical capabilities need to be up to international standards and accessible in a timely fashion.

Moving from cellular or animal systems to humans requires skills and infrastructure different to those used in the biomedical discovery phase. Lack of access to these capabilities is a major issue and barrier for Australian biomedical research and industry. The capabilities that are available are spread across a number of institutions and are primarily dedicated to the needs of those institutions or are only made available on a fee-for-service basis that most researchers cannot afford.

The consequence is that too often basic research discovery either fails to proceed to the clinical stage or is sold too early for Australia to participate meaningfully in the returns.

Where local companies are involved in the development of biomedical discoveries, they tend to struggle because the scale and complexity of pre-clinical capabilities needed is difficult to provide in an environment where capital is scarce. Developing this capability in the public sector will therefore provide significant assistance to the local biotechnology industry by helping SMEs through the risky stages of development.

### Infrastructure/support requirements

The need has been identified for a co-ordinated and integrated approach that addresses the gaps in the establishment, or barriers to the use, of pre-clinical capabilities in Australia.

Some investment in new physical infrastructure to address gaps is required. However the main priority identified is for better integration and accessibility of existing infrastructure, and the removal of cost barriers. This need has not been fully scoped for the Strategic Roadmap exposure draft. However it seems likely that funding to establish a 'virtual' network of pre-clinical research facilities, based on existing capacity and strategically enhanced to address gaps, would provide a major part of the solution to this problem.

## DRAFT

Specific areas of pre-clinical capability requiring additional investment and coordination (taking into account the Pharmaceutical Action Agenda and related gap analyses) include:

- Preclinical development of molecules with therapeutic potential.
- Preclinical testing (i.e. pharmacology and toxicology safety testing). There are currently gaps in this capability in universities (where it primarily resides) due to lack of pre-clinical focussed capacity and relevant skills.
- Formulation – pilot studies and production of clinical standard batches that be used in safety pharmacology/toxicological assessments
- Non-clinical aspects of drug development (i.e. scale up and manufacture). The priority capability for *Biotechnology products* (see Section 4.5) will help to address this gap.

### Conclusions/Issues

The Committee welcomes feedback on how to enhance Australia's pre-clinical research capability, in particular the suggestion that most appropriate way forward may be to develop a strategy (linked to funding) to develop a co-ordinated approach to linking and integrating preclinical research capacity and removing cost barriers. The strategy would identify specific infrastructure requirements.

# DRAFT

## 6.7 Population health and clinical data linkage

### Description

A significant quantity of health-related data is collected in Australia that could potentially be a valuable research resource if it were better integrated and linked. Elements of this capability include the ability to:

- Link data from existing research studies and other sources of medical information (including administrative sources);
- Provide a focal point for Australian involvement in major international research collaborations, data pooling and studies involving up to millions of subjects;
- Support individual researchers and institutions to link and use longitudinal health-related datasets, and engage in multi-centre studies;
- Build the capacity of the research community to analyse and draw out the clinical implications of the linked information, by providing training opportunities for population health scientists and assisting in the development of measures and methodologies for longitudinal studies;
- Analyse, understand and develop protocols for responding to the legal, regulatory and ethical issues attending the linking of records and the conduct of longitudinal research; and
- Develop strategies and proposals to further invest in this capability as needs and opportunities arise.

### Rationale

Australia has significant existing strength in bio-medical and public health research. It collects large amounts of health-related information via the health insurance, pharmaceutical and medical/hospital systems, as well as through research studies. However, this information is largely unlinked. Australia is falling behind other countries, where population health indices are being linked with administrative datasets and biological data.

This is imposing significant costs. To take one example, opportunities to quickly identify, and thus prevent or minimise harm from, inappropriate drug use are being lost because data on drug prescriptions is not linked to data on subsequent adverse health events.

A relatively small investment (in relation to total health costs) could leverage great research value from extant datasets, whether they be from research studies, disease registers, tissue banks, bio-repositories, screening programs, exposure records, clinical or pathology records. This in turn would facilitate identification of opportunities for prevention through avoidance of hazard, including iatrogenic harm. It could also help identify opportunities for reducing health system waste (eg from non-performing drugs and procedures).

The capability would complement the activities and powers of agencies such as the Australian Bureau of Statistics and the Australian Institute of Health and Welfare. It would benefit a number of key sectors, including:

- *The health care system* - leading to greater effectiveness by facilitating economic studies of strategies, systems, and therapies.
- *Bio-medical researchers* – affording bio-medical researchers with opportunities to link molecular and cellular measures to health and disease precursors, processes and outcomes.
- *Clinical researchers* – enhanced capability would provide premorbid measures or specimens that could explain response to therapy, thus enabling better targeted therapy.

## DRAFT

- *Health agencies and organisations* – the capability would support agencies and organisations involved in developing and conducting programs to prevent disease and injury including those focusing on socially disadvantaged populations.
- *The pharmaceutical industry* – the pharmaceutical industry may buy materials and data for its own studies, thereby helping to sustain the capability.

Support for this capability offers the potential for substantial returns at relatively low cost in an area of central concern for the research and wider Australian communities. Developing it effectively will require careful planning. It is recommended that an early start be made to this planning to enable the benefits to flow as quickly as possible.

### Infrastructure/support requirements

This capability could be delivered by a dedicated organisation charged with leading and co-ordinating the required effort. Such an organisation could be governed by a Board or committee of relevant and expert stakeholders and provided with both funding and staff capable of providing both intellectual leadership and administrative support.

It would ideally have the capacity to become a one-stop-shop, creating/endorsing national standards/conventions in the conduct of linkage studies. One of its key challenges would be to communicate/advocate in relation to the public benefits of health data linkage research and seek support from agencies with a stake in its outcomes. Strong leadership, communication and engagement with the public and data owners will be required to encourage data owners to share their information, and to build protocols and public trust relating to the handling of privacy and other sensitive legal and ethical issues.

The development of this capability would need to be closely coordinated with the work of the National E-Health Transition Authority, which has responsibility for overseeing the implementation of e-health in Australia, including the secure electronic use of medical information.

### Conclusions/issues

The Committee would welcome views on the options for developing this capability, including possible organisational/governance requirements. The Committee also seeks assistance in drawing out the implications of this concept in so far as it relates to broader e-health initiatives and issues.

## DRAFT

### **6.8 Networked PC3 containment and bio-molecular facilities for emerging infectious disease, bioterrorism and forensics**

#### Description

Responding to emerging infectious diseases, whether related to unknown agents, those arising from genetic drift or agents potentially used for bioterrorism, requires a multi-disciplinary capability. This capability involves being able to anticipate – that is survey and rapidly diagnose – then contain and respond to the threat. It has a strong research component as the potential threats, and the mechanisms required to manage them, are diverse and constantly changing.

Discipline specialists supporting this capability include entomologists, ornithologists, taxonomists, infectious disease physicians and veterinary specialists, microbiologists, virologists and molecular biologists.

A multidisciplinary capability, drawing together expertise across these disciplinary areas, would be based on cutting-edge infrastructure and trained personnel who are ready and able to act in emergencies in different geographic locations, investigate new strains of pathogens, and participate in appropriate surveillance studies of known pathogens of potential threat to Australia within countries to our immediate north.

#### Rationale

New diseases and strains of pathogens with the potential to harm humans and economically important livestock are continually emerging, both nationally and internationally. Recent examples include sudden acute respiratory syndrome (SARS) and 'bird flu'. Bioterrorism is also a recognised threat.

Vector borne diseases not frequently seen in Australia are becoming more common and drug resistant organisms such as tuberculosis are on the increase and taking human lives. The continued threat of emerging infectious disease represents a high risk to Australia's position as a 'safe' country.

As a large island nation, Australia has some natural geographic barriers to infectious diseases emerging overseas. However the risk and spread of such diseases cannot be eliminated due to genetic variation, movement of birds and insects, movement of humans, population and behavioural factors and climatic change.

There are few research centres in Australia regularly undertaking research on unknown pathogens, development of rapid diagnostics, and rapid field based tests for such emerging agents, remote detection of bioterrorism agents or molecular forensics (or have the personnel or range of disciplines needed available).

#### Infrastructure/support requirements

Adequate basic laboratory infrastructure and distributed PC3 containment facilities already exist in Australia (in a suitable geographic spread). These facilities are used for a range of human, veterinary and defence purposes depending on local circumstances. There is some top-end capability in specific centres and discipline focussed expertise in centres around Australia for infectious diseases of humans and animals. Not all of these facilities are suitably equipped with the range of equipment needed for modern molecular diagnostic testing and few have a multidisciplinary networked team.

A collective effort to develop a co-ordinated multidisciplinary capability in this area is needed to ensure that Australia is adequately prepared. Linkage of infrastructure and expertise through

## DRAFT

appropriate data bases, early posting centres and other information technology requirements would be integral to delivery of an integrated capability both within Australia and as part of a global response.

This capability would probably be based on networked infrastructure that builds on existing national and state/territory facilities (including PC3 containment facilities). It is envisaged that different laboratories within the network might specialise in different focus areas such as the development of reliable rapid diagnostic agents for particular diseases or the testing of those agents.

It would be anticipated that the states and territories would continue to ensure that they had appropriate medical and veterinary infectious disease personnel in such centres, and that the Commonwealth departments with responsibility for health and agriculture would maintain and potentially expand their current activities to complement the presence of the infrastructure.

While there is a current shortage of taxonomists, entomologists and some other expertise that is required, such expertise would be stimulated by the development of a networked capability in Australia.

### Conclusions/issues

While a reasonable basic infrastructure exists in Australia, few centres have the range of facilities and expertise required to respond adequately to emergency situations or the emergence of new human or animal disease pathogens.

It is the Committee's view that the development of a coordinated, multidisciplinary capability through networking of existing facilities would be desirable to address our current limitations. The Committee invites feedback on this and other potential approaches.

# DRAFT

## 6.9 Heavy ion acceleration

### Description

Heavy ion accelerators have become the central tool for fundamental investigations of nuclear structure and nuclear interactions. They also provide capacities for characterising and modifying materials that are useful in many research fields and disciplines.

Australia currently has accelerator facilities at the ANU (whose Heavy Ion Accelerator Facility provides Australia's premier nuclear physics experimental facilities) and at the Australian Nuclear Science and Technology Organisation (whose Ion Beam Analysis Group provides a national focus for applied research in Ion Beam Analysis and Accelerator Mass Spectrometry, complemented by the Accelerator Mass Spectrometry program at the ANU). Current investment in the ANU facilities is in excess of \$50 million, built up over decades through a combination of University funds, ARC project grants and other sources. At ANSTO the capital investment in the two accelerators is \$12M, also built up over decades through Government, University and ARC funding.

### Rationale

Heavy ion accelerators are useful in a wide range of research disciplines and application areas. Examples include the analysis of innovative materials, research in the environmental, biological and life sciences and archaeological and heritage studies. Australia's facilities at the ANU and ANSTO provide a vital resource for the Australian research community and industry, as well as being essential for postgraduate and postdoctoral training which feeds personnel into research and academic institutions; applied-science areas including diagnostic, therapeutic and nuclear medicine; nuclear safeguards and security; mining and other industry around Australia; environmental management, water, soil erosion; and policy analysis and defence intelligence.

Australian research has a solid international reputation<sup>15</sup> in both basic nuclear physics and the applications of heavy ion beams. There is a strong case for viewing Australia's accelerator facilities, and their accompanying expertise in Accelerator Science and Nuclear Physics, as key, strategically important national assets. In addition, the availability of local research facilities (enabling the conduct of internationally competitive international research in this area in Australia) has been crucial in building the credentials of Australian researchers and thus securing access to overseas facilities, which are oversubscribed. Currently, however, the resourcing needed to support the proper operation of Australia's facilities as national facilities is outside the scope of current facility resources at the ANU and ANSTO.

### Infrastructure/support requirements

There is a need to more effectively exploit the capacity of Australia's Heavy Ion Accelerator facilities (and the expertise associated with them) to support enhanced national and international research programmes and meet the needs of a wide range of disciplines and application areas.

---

<sup>15</sup> Australian researchers have strong publication records in high-profile international journals and are sought-after as experts, reviewers and consultants by similar laboratories overseas and key organisations such as the International Atomic Energy Agency (IAEA). Australian research has had a significant impact internationally, influencing for example, a re-direction in the study of heavy ion fusion as reflected in the US Long-Range Plan for Nuclear Science, and at the other extreme, developing a leading edge capability for Accelerator Mass Spectrometry with both fundamental and commercial applications.

## DRAFT

To ensure the continued operation and optimal utilisation of Australia's heavy ion accelerator facilities and the expertise associated with them, the ANU and ANSTO facilities could be restructured as a National Facility. This might be accompanied by an upgrading of the existing facilities upgraded through the enhancement and development of accelerator and beam-line instrumentation to develop their full capacity.

Such a national facility could: provide technical, operational and administrative support for its Australian and international users; expand links to key overseas facilities in Germany, Japan, France, the USA and Canada; support University-based training in nuclear physics and the application of nuclear techniques; and foster the development of closer linkages between ANSTO and academic institutions.

### Conclusions/issues

The Committee welcomes views on the suggestion to restructure Australia's existing heavy ion facilities to create a National Facility better positioned to support research and education programs and develop international linkages. Comment is also invited on the needs for further investment in the facilities to develop their potential as national facilities.

# DRAFT

## 6.10 Optical and radio astronomy

### Description

Access to the next generation of optical and radio telescopes are the key capabilities underpinning the ability of Australian researchers to produce world-class research and innovation.

The next generation of earth-bound optical telescopes (dubbed extremely large telescopes or ELTs) are currently in the planning/development phase and will begin to come on stream in around 10-15 years. Similar planning is underway in relation to radio wavelength observing, with international efforts appearing to coalesce around the proposed Square Kilometre Array (SKA) project which, if it proceeds, would be operational in its full form in around 2020 (see Section 7 for a discussion on these requirements).

The current generation of 8-metre optical and infrared wavelengths telescopes (include the two 8-metre telescopes that comprise the Gemini Observatory) will remain the primary earth-bound optical instruments for the next decade. Australia, one of seven partners, joined Gemini in 1998. Gemini North in Hawaii began observations in 2000 followed by Gemini South in the Chilean Andes in 2002.

### Rationale

Astronomy is one of Australia's highest impact sciences. Australian astronomers have played leading roles in recent major discoveries, including the acceleration of the universe, the existence of dark energy, a new type of galaxy, a unique double pulsar, and planets orbiting other stars. Our high international standing in astronomy helps support public interest in science and provides powerful evidence to the rest of the world of Australia's scientific and technological capacity. Astronomy is a rapidly evolving field in which continued investment is essential in order to keep pace with global developments.

Development of infrastructure for astronomy involves significant collaboration with industry and generates technological spin-offs. Early investment in new projects is crucial to securing the most valuable elements of these technology development programs and maximising the spin-off benefits for Australia.

### Infrastructure/support requirements

For Australia to remain a major international contributor to astronomy it is essential that we continue to have a strong presence in leading-edge international infrastructure, both the current and next generations. Australia also needs to maintain the domestic infrastructure which constitutes the bulk of observing capacity for Australian astronomers.

The Australian astronomy community has identified its priorities for infrastructure investment in the *Australian Astronomy Decadal Plan 2006-2015*. Consistent with that plan, the Committee considers that the priority areas for NCRIS investment in optical and radio astronomy should be:

- Continued support for existing national facilities, namely the *Anglo-Australian Observatory* (AAT optical/infrared telescope) and the *Australia Telescope National Facility* (ATCA and Parkes radio telescopes);
- Delivery of the Square Kilometre Array (SKA) *Pathfinder* radio telescope facility (also see Section 7; and
- Access to 20% equivalent of the 8m-class Gemini optical telescope and instrument program.

## DRAFT

It is expected that major instrumentation upgrades to *Gemini* and the development of the *SKA Pathfinder* (with Australia in both cases playing a role in technology development) will deliver an order of magnitude improvement over existing capabilities in optical and radio astronomy worldwide. Australian participation in *Gemini* and *SKA Pathfinder* would keep Australian astronomers at the forefront of astrophysical research for at least the next decade.

Although also a high priority, the total cost of participation in next generation infrastructures: an ELT and the full SKA, fall outside the NCRIS funding envelope and should be considered 'landmark' in this context of NCRIS (see [Section 7](#)). It should be noted, however, that any decision to fund these projects is likely to mean that funding for existing facilities could eventually be phased out and their operating costs transferred.

### Conclusion/issues

The Committee welcomes views on:

- how the needs listed above might be further prioritised;
- the impact the anticipated SKA siting decision would have on the prioritisation; and
- the process for considering Australia's involvement in next generation infrastructures (see [Section 7](#)).

## 6.11 Terrestrial ecosystem research network

### Description

The ability to effectively monitor environmental parameters and interpret the associated data holistically is essential to understanding the key components of our landscape and how they function in an integrated manner. The challenge is to develop relevant and reliable datasets on the key components of our terrestrial ecosystems, i.e. our water resources, biodiversity and soils, which capture accurately their evolution and health over time.

### Rationale

Soil and water are fundamental to the wealth we generate from our lands, while our unique biodiversity is adapted to our variable climatic patterns and holds the key to sustainable living on our continent. Our landscape is under threat from problems such as salinity, land degradation, serious degradation of water resources and loss of biodiversity, as well as from the often-negative impacts of pests, fire and climate change.

Landscapes need to be understood and managed in an integrated way. Understanding how the landscape functions is the key to living sustainably in it. The health of a landscape is determined by the quantity and quality of water it receives. The quantity and quality of water that a landscape receives is in turn affected by parameters such as topography and soils, vegetation cover, land use and depth of groundwater. When we alter the vegetation in a catchment we change the habitat of its remaining biodiversity, the quantity and quality of water running off, and the volume and timing of flow pulses received by the river, leading to impacts on plants and animals of the floodplain, river and estuary. Understanding and managing these interrelationships and their impacts requires integrated, coherent data sets on a national scale providing accurate, reliable, measures of the state of key environmental parameters and how these are changing through time.

Currently, while significant investment has been made in terrestrial data collection efforts, the available data is poorly integrated and often inconsistent, limiting its value for both research and environmental management. Development of this capability would build upon learning from the National Land and Water Resources Audit and various State of the Environment reports that have pointed to the need for Australia to move beyond patchy and *ad hoc* data collection exercises and make initial steps towards more coherent and nationally consistent approaches to terrestrial data collection and management.

### Infrastructure/support requirements

There is an opportunity for additional investment to catalyse development of a co-ordinated system, providing an internationally significant research capability while at the same timing meeting a major national land management need and leveraging existing State and Australian Government investments in data systems.

To meet this need, investment could be directed to the development of a *terrestrial ecosystem research network*.

Such a network would deliver an urgently needed upgrading of the information base that underpins Australia's environmental research and environmental management efforts. It should be national in scope, comprising geographically distributed sensors providing real time, or almost real time, data streams using state-of-the-art communications technology. Monitoring

## DRAFT

could be undertaken both spatially and temporally to build understanding of how the environment is changing (and is likely to change in the future) both across regions and through time.

The data streams could flow into three hubs, focusing respectively on the areas of water, soils and biodiversity. The hubs would provide data repositories and state-of-the-art modelling capacity, delivering both data and value-added analysis for research teams and natural resources management agencies across the country.

In the case of water, for example, data aggregated and modelled in the hubs could relate to key parameters including stream flow, groundwater depth, evaporation rates, the flux of nutrients (phosphorus and nitrogen) driving downstream plant responses, levels of suspended solids (driving turbidity that affects how we use water as well as ecological processes), salt, carbon, agricultural chemicals and the consequent ecosystem responses.

While the envisaged network would provide for the development of these individual hubs, a desirable outcome and an important focus of any NCRIS investment would be their integration into a meaningful holistic picture of Australia's terrestrial ecosystems. As a first step towards this, the establishment of a series of more intensive long-term ecological research sites across Australia is suggested, encompassing both agricultural and natural areas and linked to the three key national hubs. Such research sites would help us to understand how different ecosystems are changing over time and in response to external factors and conditions such as climate change and differing land use.

Developing the outlined network would be complementary to the interests of other government programs such as the Commonwealth Environmental Research Facilities (CERF) program of the Commonwealth Department of Environment and Heritage, oriented to filling operational research gaps in environmental research, and the developing programs of the National Water Commission such as its water resources benchmark and accounting projects. The network should attract co-investment from other agencies.

Strong leadership and collaboration would be required to develop the network. Australia has excellent scientific skills among many scientists in hydrology, soil science and ecology, along with well-developed capacity in remote sensing and information technology that now allows this network to be developed in an integrated and cost-effective way. Developing it effectively, however, will require willingness on the part of management agencies to pool resources and expertise.

### Conclusions/issues

The Committee welcomes views on the desirability of developing a Terrestrial Ecosystem Research Network along the lines outlined above.

The Committee notes that developing such a network would require substantial planning at the agency, government and inter-government levels. A mechanism for providing the necessary direction and coordination would be needed to bring the concept to fruition, with further consideration needed as to what that mechanism might be.

# DRAFT

## 6.12 Integrated marine observing system

### Description

Underpinning our ability to understand and ensure the long-term health and productivity of Australia's marine estate and related industries is the capacity to deliver timely and accurate detection and prediction of changes in the ocean environment, coastal ecosystems and marine living resources. This requires capabilities in: collecting data (both remotely and via research vessels); storing, managing and making accessible the data that is collected; and modelling to support the interpretation of data and inform predictions. It is important that these capabilities are coordinated in a nationally consistent and coherent manner.

### Rationale

Under the United Nations Convention on the Law of the Sea (UNCLOS), the combination of our 200 nautical mile limit and extensive "claimable continental shelf" means that 70% of Australian territory will be ocean. Australia's marine jurisdiction is one the world's largest, and also one of the least explored and understood. To date, marine information needs have largely been addressed in piecemeal manner, on a sectoral or institutional basis, resulting in observations that are limited in scope, and fragmented in time and space.

Australia has excellent research capacity in ocean ecosystems and marine environments, but urgently needs research infrastructure to support an improved understanding of its marine environment and the influence it is having on the atmosphere and terrestrial environments. For example:

- More than 40% of the anthropogenic CO<sub>2</sub> is currently absorbed in the Southern Ocean. Understanding oceanic processes is critical to understanding the impact of the anthropogenic CO<sub>2</sub> in climate change.
- Climate variability is hugely affected by El Niño, a disruption of the ocean-atmosphere system in the tropical Pacific having important consequences for weather and climate around the globe.
- Sensible management of the marine environment requires accurate and timely information.

Upgrading our existing capability would also provide information about our massive store of biological and seabed resources and the unprecedented stresses to which our ocean ecosystems and marine environments are being subjected. More broadly, however, it would underpin applications across national security, marine safety, marine resources and related industries, coastal ecosystem management, and climate prediction, while at the same time ensuring that Australia meets its international obligations for marine management under UNCLOS.

### Infrastructure/support requirements

To meet this need, it is suggested that an *Australian Coastal and Ocean Observing System* be developed.

The system would integrate data from remote sensors (including satellite systems deployed by northern hemisphere nations) and automated *in situ* observing platforms with advanced modelling techniques. Such systems are becoming routine in the northern hemisphere with the development of cutting-edge technology that is revolutionising marine research and observation capacity. Integral to the system would be processes to store, quality control and make readily accessible its data and associated information.

## DRAFT

The system would comprise two linked and interdependent components - blue-water and coastal - and include engagement in related international programmes (e.g. the Integrated Ocean Drilling Program (IODP)<sup>16</sup> and the Global Ocean Data Assimilation Experiment<sup>17</sup>). The blue-water component would primarily serve climate and ocean forecasting, but would be closely linked and integrated with the coastal component, which would focus on coastal and continental shelf ecosystems (note that an additional highly important and desirable outcome of any developments would be interaction and linkage with parallel terrestrial monitoring networks and associated data). The coastal component might initially include intensive observing systems in several regions, with lower level systems in other areas which could be upgraded as needs, resources and testing indicate.

The infrastructure most urgently needed for the system would include:

- Access to research vessels. (It is acknowledged that the cost of acquiring research vessels is likely to be outside the scope of NCRIS -see Section 7.1);
- Equipment to gather data (based on vessels or on automated *in situ* observing platforms); and
- Participation in IODP.

There is a strong case for early action. Australia has a large marine estate about which it has limited knowledge. Investments in instrumentation and sensor networks are being made by different agencies and universities but are not being well co-ordinated. International assessments indicate that benefits flowing from targeted investment in ocean observing systems can generally be expected to exceed costs by at least an order of magnitude.

The key challenge lies in building co-ordination and co-operation between the research, operational and educational agencies that would be key stakeholders in the system. This will require ongoing engagement and commitment from key stakeholders combined with strong leadership.

### Conclusions/issues

The Committee welcomes views on the desirability of developing an *Australian Coastal and Ocean Observing System* along the lines outlined above, and on how NCRIS investments might be most productively applied to deliver such a system.

The Committee favours Australia's participation in the IODP.

---

<sup>16</sup> IODP focuses on: (a) solid earth cycles and geodynamics; (b) environmental change, processes and effects; and (c) the deep biosphere and the sub-seafloor ocean

<sup>17</sup> Participation requires the capability to measure ocean profiles of temperature, salinity and other properties, ocean currents at key choke points and air-sea fluxes of momentum, heat, freshwater, CO<sub>2</sub> and other properties. A key component will be the deployment of an array of profiling Argo floats as the Argo array in the oceans near Australia is notably sparse compared with other regions.

# DRAFT

## 6.13 Structure and evolution of the Australian continent

### Description

The capacity to obtain accurate information on the geological structure of the Australian continent is an important capability supporting both our understanding of fundamental geological processes and structures and the manner in which they have evolved over time. Important elements contributing to this capability include:

- Geophysical imaging – (both seismic and non-seismic) providing detailed information on physical structure and processes
- Geochemical analysis – providing information on the chemical composition of geological materials (both solid and liquid)
- Geophysical modelling – providing advanced earth simulation from micro to global scales and facilitating the interpretation of data

### Rationale

From its ancient rocks and unique tectonic setting to its network of interdependent modern environments, the Australian continent is a natural laboratory for the study of processes that have shaped the modern world. Its evolution over long periods of time has determined its distribution of the abundant mineral and energy resources, and its vital supplies of soil and water upon which we depend. Detailed scientific knowledge of the Australian continent's geological structure and evolution makes a fundamental contribution to: understanding the emergence of the modern environment and the global changes that have shaped it; comprehending the complex interactions that control the stability or instability of modern earth systems upon which our lifestyle and habitat depend; locating the supplies of minerals and energy resources; and anticipating and responding to major natural disasters.

Research in this area is critical for the economy and wellbeing of Australian society, and will remain so for the foreseeable future. Australian researchers have world-class expertise, producing over 5% of the global output of geoscience publications and having a commensurately disproportionate influence in terms of citations, the highest for any branch of science in Australia. However, the effectiveness of research in this area is strongly dependent on the infrastructure available to geoscience researchers and the degree to which they are able to access it. Currently, Australian researchers are being constrained by significant gaps in major research infrastructure, arising largely from the lack of a coordinated approach to its development.

### Infrastructure/support requirements

Priority areas of infrastructure development to support this capability have been identified for both the short and long-term.

An important short-term opportunity exists for dramatically increasing the impact of existing national infrastructure in key areas of capability such as seismic imaging and computational modelling of earth processes, and for making them more accessible. This is likely to produce the most immediate benefits in the short term in the most cost-effective manner.

Longer-term options that will also considerably contribute to our understanding of the structure and evolution of the Australian continent include: a national geotransect; a National Geospatial Reference System; and a network of ocean-bottom seismometers. These would require planning and collaboration on a substantial (national) scale involving all relevant major groups.

### Conclusions/issues

## **DRAFT**

The Committee favours developing an integrated, broadly accessible national capability building on key major existing capabilities in seismic imaging and computational modelling of earth processes. Comments are sought on this proposal.

# DRAFT

## 6.14 Low-emission, large-scale energy processes

### Description

There is a need to develop and deploy low-emission, large-scale processes for fossil-fuel and biomass based energy production, both globally and in Australia. Within Australia it is particularly important to address this need in a manner that is suitable to our unique conditions and which enables scale-up and testing of research outcomes.

Coal provides a major source of energy in Australia and around the world, and will continue to do so over the coming decades. Given this reality, the Committee considers it critical that ways are found to minimise the adverse environmental consequences of coal usage, and views this as the highest priority area for immediate NCRIS investment relating directly to energy production.

The Committee recognises the longer-term potential of non-fossil fuel based energy technologies such as wind power, solar power (such as photovoltaics), tidal power and geothermal, together with the expertise relating to these technologies (and their underpinning science) that has been built up in the Australian research community. Usage of these technologies is growing rapidly, but from a low base, suggesting that they will become increasingly important over the longer term, with their rates of uptake influenced, at least in the short term, by the extent to which their costs can be brought down to levels which are competitive with fossil fuels. The Committee also recognises that infrastructure investments in other areas would, if implemented, provide platforms for developing and exploring technologies that could help bring down the costs of non-fossil fuel based energy (see, for example, sections 6.3.1, 6.4.1, 6.5).

The Committee also recognises the long-term potential of nuclear fusion as an abundant, relatively more environmentally friendly source of energy, together with Australia's strong background and expertise in fusion physics<sup>18</sup>. At this stage, Australia is not a participant in the critical next stage of the development of fusion energy, the International Thermonuclear Experimental Reactor (ITER)<sup>19</sup>, which seeks to demonstrate the scientific and technical feasibility of generating and using fusion energy. The Committee does not view Australian participation in ITER as an immediate priority for NCRIS funding, in part because of uncertainties relating to the scale and nature of the commitment required and in part because of the very long-term nature and uncertain outcomes of the research itself.

### Rationale

While Australia has benefited for decades from its rich coal resources, the adverse climatic consequences of ever-growing greenhouse gas emissions from coal-based electricity generation extend to and affect Australia's water resources, biodiversity and natural treasures such as the Great Barrier Reef, while national and international policy responses to climate change threaten our continued use and national economic contribution of these low-cost resources.

Australia's public and private sector researchers have a well-deserved reputation for development of innovative technologies to support Australia's mining and minerals industries, as well as supporting Australia's electricity generators. However, we lack the capacity to undertake the further research needed to move beyond the laboratory scale. There are Australian technologies in these areas that are innovative (indeed step-change – for example in

---

<sup>18</sup> Including pioneering work by Sir Mark Oliphant on fusion reactions and magnetic confinement research

<sup>19</sup> For further information on ITER see: <http://www.iter.org/>

## DRAFT

CO<sub>2</sub> capture, mineral sands processing and coal/biomass gasification) but need progression to a meaningful scale to reduce technology risk sufficiently for commercialisation. Currently, most research into next-generation, large-scale, low-emission electricity generation and minerals processing is being conducted in the USA, Europe and Japan by large equipment and utility companies, with government support. While Australia could simply import its technology in this area, to do so would be to forgo the prospects for commercialisation of Australian technologies in this very important area as well as to incur risks arising from the fact that imported technology will not have been developed for the particular types of coal found in Australia. Local research support will continue to be needed to avoid major loss of capacity due to fuel-related problems (as has happened and continues to happen for all Australian black and brown coal power stations) and to enable us to be “informed buyers” of plant that is imported.

Providing this capability would fill a major gap in Australia between laboratory bench-scale and pre-commercial scale facilities (including opening up for collaborative use some existing facilities). The government has recently opened for business the Low Emissions Technology Demonstration Fund (LETDF). This funding is expected to provide a relatively small number of large grants for the demonstration stages of pre-commercial scale facilities. The objective of the LETDF is to demonstrate the commercial viability of new technologies or processes or the application of international technologies or processes to Australian circumstances. NCRIS funding could complement LETDF projects by supporting earlier stage, more basic research on energy processes.

### Infrastructure/support requirements

To meet this need, it is suggested that a capability be developed to:

- Adapt next-generation combustion and gasification processes for Australia's broad range of black and brown coals and ambient conditions;
- Demonstrate the operation at meaningful mid-scale level of locally-developed, step-change technologies for processing of our coal and mineral resources and capture of combustion emissions (particularly CO<sub>2</sub>);
- Support meaningful interaction in international research programs and projects relevant to exploitation of our Australian energy and minerals resources.

It is proposed that the capabilities developed be flexible enough to also allow demonstration of mid-scale processes for the utilisation and gasification of biomass resources.

A public-private partnership through joint funding of the capability proposed here would enable the current skill base in the area to support the transition of Australia's electricity and minerals processing industries to next-generation plants, while supporting the development of the next generation of local research personnel. There is considerable potential to leverage existing infrastructure in Victoria, New South Wales and Queensland (in particular) that complements or should become part of (with suitable upgrading) the proposed research infrastructure. International funding support has been provided in the past into Australian research projects in these areas, and likely would be available again to support the proposed capability.

### Conclusions/Issues

As noted above, the Committee considers that the highest priority for NCRIS investment relating to energy production is the development of low-emission, large-scale processes for fossil-fuel and biomass based energy production. The Committee notes that it would expect a high level of support from other sources to accompany any NCRIS investments. The Committee welcomes views on how NCRIS funding might most productively be applied to deliver a national, collaborative response in this area.

# DRAFT

## 6.15 Next generation solutions to counter crime and terrorism

### Description

Solutions and research capabilities in the forensic sciences are required that contribute to reducing the threat and impact of crime and terrorism.

Key capacities that are needed relate to the ability to:

- accurately and rapidly detect, in the field, chemical, biological, radiological, nuclear and explosives (CBRNE) agents;
- detect CBRNE agents at a distance or covertly;
- vastly improve the rapid identification of suspects in property or volume crime cases through the delivery of forensic science solutions in the field;
- sustain traditional forensic sciences and develop new solutions to meet emerging threats; and
- improve information and intelligence through enhanced data management and data mining.

### Rationale

On a global scale, Australia remains a relatively safe and crime free society, but this is being challenged by the emergence of a new form of terrorism and a continuing high level of domestic property crime. Crime and terrorism have the potential to undermine society at all levels, cause major economic havoc and to have a severe impact on tourism.

The Australian Government has invested in a number of recent initiatives to coordinate and support R&D with a focus on security and terrorism. These include the establishment of a Science, Engineering and Technology Unit to coordinate research and developments and the soon-to-be-established CBRN Data Centre under the Australian Federal Police. The National Institute of Forensic Services, working together with industry, has also been successful in attracting funding from the Australian Government for several pilot research projects as part of a broader innovation strategy.

Notwithstanding several recent investments in the forensic sciences, the inherent weakness is that the industry by necessity deals with the day-to-day practical case work issues. It is not a research industry, and relies on its 'future solutions' coming from the traditional research providers in academic institutions. If the forensic sciences are to be able to meet the operational challenges of the future, the next generation scientific and technological solutions must come from the research sector and that sector must give appropriate priority and emphasis to developing solutions to meet these emerging needs. There is a current significant capability gap in this area that compromises technologies and the management of information.

### Infrastructure/support requirements

The key challenge is to ensure that the solutions developed are targeted in a practical way so that they meet the needs of industry and assist it in overcoming major impediments. For example, forensic laboratories are not able to process samples collected at property crime scenes in a timely manner, which results in repeat offending and delays in our criminal justice system.

Better assessment of potential evidence at the scene (in the field), with the ability to analyse samples such as DNA, drugs and fingerprints and to then search suitable databases remotely, has the potential to deliver more effective and quicker justice, to make people feel safer and with the added bonus that forensic laboratories would have the resources to better service serious and more complex crime.

## DRAFT

Terrorism is an increasingly significant component of the work of forensic laboratories. New scientific and technological solutions will be needed to meet the rapidly evolving analytical challenges confronting forensic providers. Solutions will be needed that help anticipate, prevent, protect, respond and recover from such incidents.

### Conclusions/issues

The Committee considers that targeted and focused funding of infrastructure is necessary to enable researchers to conduct specific R&D that focuses on the areas of immediate need listed above. It is suggested that next generation S&T solutions should:

- leverage off existing national assets;
- enhance industry–university partnerships;
- have a public interest focus but be run in a business like way;
- encourage a virtual centre approach and not be about ‘bricks and mortar’;
- develop specific research nodes to meet specific needs but with an overall governance/leadership structure;
- focus on the creation, extension and adaptation of S&T solutions;
- have a 3–5 year time focus but not exclude shorter-term deliverables.

There is potential overlap of the some of this capability in relation to bioterrorism and the capability described under Section 6.8 - Networked PC3 containment and biomolecular facilities for emerging infectious disease, bioterrorism and forensics.

The Committee welcomes views on whether both capabilities could be gainfully addressed with a combined solution, and if so, how the specific needs of this capability could be accommodated, particularly the non-bio related aspects.

# DRAFT

## 6.16 Systemic Information Infrastructure

The Committee views systemic information infrastructure as a high priority as it underpins an effective research system and specifically supports many of the capabilities identified in this Exposure Draft (for example informatics, sensor networks). This section scopes the issues involved in providing a comprehensive systemic information infrastructure but in general does not identify the specific infrastructure/support requirements. The Committee will continue to be advised by the e-Research Coordinating Committee, the Australian Research Information Infrastructure Committee (ARIIC) and the Australian Research, Education Network Advisory Committee (ARENAC) and stakeholder consultations.

Many of the capabilities identified in this Exposure Draft have common themes and dependence upon systemic information infrastructure (for example informatics, sensor networks). The needs and opportunities driving the strengthening of systemic infrastructure include:

- The requirements of new technologies, such as computer simulations, synchrotrons and sensor networks;
- The expanding size of the datasets upon which research is based;
- The increasing volumes and greater complexity of information generated through research;
- The need to work across traditional disciplinary, institutional and national borders;
- Changing research practices that are intensely collaborative;
- Dependence upon high quality network access; and
- The increasingly data and computationally intensive nature of research.

While the need for this information infrastructure is directly identifiable with the specific supporting requirements of the capabilities outlined in this report, this infrastructure is also highly important to a much broader range of research activity ranging from areas of early adoption such as high-energy physics, astronomy, science and engineering, through to evolving areas in the biological sciences, social sciences and humanities. It is not only highly important to sustaining the standing of researchers in these fields, it is critical to the development of collaborative approaches to nationally focused research. It requires the provision of a national system of facilities and services that support both individuals and groups of researchers in their various fields and that maximise our research effectiveness by interfacing with the international research community.

In all of these fields there is a high level of commonality in both needs and their implementation. Investment in this infrastructure therefore needs to be approached on a systematic basis in order to maximise its utility and impact on research activity across many specialisations, rather than providing uniquely tailored solutions for each.

Systemic Information Infrastructure (SII) includes the following sets of inter-related components:

- **Data storage management, access, discovery and curation** to improve interaction and collaboration;
- **Grid enabled technologies and infrastructure** to enable seamless access to the facilities and services required in various research fields;
- **Support skills** to assist researchers in developing and using this infrastructure effectively;
- **High performance computing** to allow analysis, modelling and simulation; and
- **High quality network access through high capacity bandwidth** to permit interaction with diverse data and computing resources.

Research practice will be increasingly dependent upon SII. These components are briefly discussed in the following sections.

# DRAFT

## 6.16.1 Data access and discovery, storage and management

Many of the capabilities identified in this Exposure Draft will produce (for example through instruments such as synchrotrons or sensor networks) or depend upon large sets of data.

In addition to new sets of data, some identified capabilities will depend for their utility and success upon curation of and access to large collections of existing information resources, in a variety of formats e.g. print publications, databases, sound recordings, images, (photographs, paintings, x-rays) and repositories of non-bibliographic information.

Ideally, investment in SII should provide researchers with the ability to: gain access to information relevant to their field from a variety of sources seamlessly; exchange information collaboratively with colleagues, to annotate their datasets or publication; and to manage and disseminate the results of their research through supported repositories.

Repositories have the potential to move beyond the traditional approaches, e.g. just for storing publications, to support innovative new forms of research data, collections and research output. Some possibilities include:

- Life cycle management of research and research results;
- Smart publications that link experiments, results and a range of documents that shorten and change the “publication cycle” (time to release new research);
- The ability to validate not only research conclusions but also research results; and
- The ability to allow other researchers access to original raw data – even for different purposes – or to provide stronger support for authenticity, authority and integrity of research.

In order to manage research outputs, many elements need to be in place. These include: appropriate hardware and software (the technology); supporting workflows, policy and regulatory frameworks and administrative arrangements; and resources, especially staff resources. In addition, there are copyright and other legal considerations, and technical standards issues, including sustainability, that need to be considered.

In order to be exploited by search engines and data mining software tools much of the data, including experimental data, that will be exposed through the linkage of databases, needs to be annotated with relevant metadata providing information on provenance, content, conditions of use and so on.

Much of the work around data access has focussed on removing barriers to access, through technical mechanisms of software tools and hardware. Seamless access to information and other resources can be impeded however, particularly in a networked environment, if researchers are not mindful of intellectual property law. In many cases, there is no certainty. A key issue for the future is to establish legal protocols that can allow access to, or downloading of, research to be clarified and simplified.

To enhance researcher effectiveness and facilitate easier access to research results and outcomes, it is also essential that electronic storage of research is done with the appropriate application of internationally agreed technical standards.

### Data discovery and access

SII investment is required to provide ready and collaborative discovery and access to new and existing information; this is the key to the future of research in the electronic environment in which much research is conducted today. The objective is to enable researchers and readers to search, browse and discover resources within a repository and access them, either under controlled conditions or in an unrestricted way.

## DRAFT

To elements that need to be addressed in this capability, in order to provide maximum commonality and utility to researchers across many disciplines and to best facilitate collaboration and accessibility, are those that provide the ability to:

- Identify, integrate, curate and where necessary, translate existing, distributed, and often disparate data collections / sets stored in different institutions;
- Provide seamless search interfaces across distributed archives i.e. develop data grids;
- Archive existing and future data for integration and reuse;
- Develop federated digital data libraries and where appropriate to link these with computational resources; and
- Convert data into compatible formats.

These are complex and difficult tasks that need to harness extensive resources in a strategic and sustainable manner, to pull together teams of people and leverage new technologies such as distributed computing, for the benefit of the groups concerned. These archives may need to be organised to provide interoperability across heterogeneous metadata schemas. In some instances services will need to be built to allow simulation data to be retrieved from repositories or regenerated dynamically using computational services.

Australian researchers have been involved in developing some of these capabilities at both national and international levels, and this experience should be built upon in developing further and more integrated capabilities. For example, **BlueNet: The Australian Marine Science Data Network** is building infrastructure to enable the discovery, access and online integration of multi-disciplinary marine science data on a very large scale to support current and future marine science and climate change research, ecosystem management and government decision making. **BlueNet** will link the vast data repositories and marine resources that reside in eight universities with governmental institutions both in Australia and overseas. The **BlueNet** infrastructure will provide secure, long-term data archiving facilities, a platform for deploying novel data exploitation tools as well as the governance and institutional arrangements necessary to maintain an on-going, interoperable, accessible and flexible network.

### Data storage

SII investment needs to address the issue of reliable, efficient and accessible storage of research data, in order to achieve the required effectiveness and collaborative outcomes for the capabilities identified in this exposure draft. Currently extensive holdings of research data are stored within personal archives, either on researcher desktops or on departmental/institutional servers. In these locations it is largely inaccessible, and inhibits collaborative research activity. A substantial subset of this type of data needs to be archived and curated for long-term preservation. The data in many cases is a complex mix of numeric, textual and image data and therefore the mechanisms for curation and access are necessarily complex. Furthermore it should be noted that such digital preservation requires the preservation not only of the data but also of the programs that are required to manipulate and visualise it.

With the increased production of data through modern research activity and the use of new research infrastructure, and with the outputs from simulations and the various instruments and sensors among the various research communities, very large storage infrastructure is required to store and make accessible key research data.

This infrastructure will need to be built using hierarchical storage management for high speed online access. In many instances this will also require the linkage between disparate databases to build a sophisticated federation of databases. In others, there will be a need to ensure that there is high capacity storage, such as that provided presently through APAC.

# DRAFT

## Data management

SII investment is needed to address the challenge of management of data of diverse size, complexity and location. Presently there are a myriad of haphazard efforts to store and manage data, largely based around institutions and, within institutions, around departments and individuals.

In all cases the provision and maintenance of institutional repositories – the software, hardware and services required to accept, store, make available online and manage a wide range of digital content, including the research output – are fundamental. Repositories will provide much greater functionality and support for collaboration, as well as exposing research activity in ways that have not been possible before, further increasing the return on investment in publicly funded research.

Furthermore, there are a range of issues to do with the management and sustainability of repositories in various domains, including e-sciences, grid computing and e-learning. There is increasing occurrence of cross-discipline and cross domain communication. With this there is an accompanying need for interoperability and integration between distributed systems and services to support inter- and intra-institutional and cross-domain communication.

A number of projects have been initiated in Australia to provide the platform and knowledge to evolve more comprehensive solutions.

For example, The **ARROW** project is specifically developing software, based on the open source FEDORA software, to manage the full range of universities' research outputs, to support the reports submitted annually to DEST and to provide easier access to the material. The software will support capture of content and its indexing in a research directory or directories, present a web version of the full directory, link from the directory level to full text and support once-only creation of metadata and other information needed to report correctly and manage the directory, the repository and a resource discovery service. The **ARROW** project is building a sustainable solution by involving a library systems supplier to provide software development, installation, maintenance and training for the ARROW repositories

### **6.16.2 Grid enabled technologies and infrastructure**

SII investment will need to include investment in the further development of grid technologies that enhance the capacity of e-Research capacity to provide researchers with pervasive and seamless access to high performance computing capabilities, large scale data collections, visualisation systems, sensors, instruments and technical support. Grid infrastructure is beginning to underpin the operation of dynamic, virtual organisations in research, government and business.

Collaborative access to resources needs to work at all levels, within and between research groups, and within and between institutions, nationally as well as internationally.

Middleware is a set of software and services designed to allow researchers to easily access these resources. To be effective, the middleware that supports collaborative access must conform to common standards, rely on a trust federation and, in many instances, use common software. While the general architecture of middleware has been defined for sometime, there is considerable work to be done to fill in the details as it needs to be tailored to specific requirements and the needs of various research fields. Work is already underway on the issues of access, authentication and authorisation identity management, for example, the **Meta Access Management System Project (MAMS)** is developing the software for creating better linkages between university information technology systems. The work is allowing researchers and students to access information more easily and seamlessly from different sources, both

## DRAFT

within Universities and between Universities. The work is attracting international attention due to successes in developing software for authentication, security and access.

### **6.16.3 Technical expertise**

As there are many technical challenges to be solved in developing the Systemic Information Infrastructure necessary to enable more collaborative research key investments need to be made in technical expertise and capability. In addition to the expertise required in the development and implementation phases, another significant issue is the skill sets required to support the researchers. It is clear that every researcher cannot be a top-flight programmer, or a digital librarian, in addition to meeting the extensive demands of their own particular professional discipline. It is therefore important to develop and reward the new and emerging occupations that can provide the necessary technical expertise to achieve the necessary developments in SII.

Computational science is one such emerging area. These people sit between the researchers and computer scientists to facilitate access, write the programs to support the research and link to other support personnel. Support services are a critical component of the necessary infrastructure.

In order to have the best chances of ensuring the highest quality content of research outputs at the earliest stage of the research process it may also be useful to seed research teams with information management professionals. Such professionals can assist researchers with their information management needs and also develop guidelines, tools etc for particular disciplines or particular needs.

### **6.16.4 High performance computing**

The demand for high performance computing systems with increased capacity and capabilities has been traditionally driven by the need to model and simulate complex natural systems and processes, for example in chemistry, physics, biology, geology and the environment. There is now an increasing number of users/ researchers for whom access to large-scale data is an essential requirement of their research. They are often concerned with data processing techniques such as searching, filtering, comparing, mining and pattern discovery. These techniques arise in many scientific areas such as bioinformatics, astronomy and cryptography and have applications in fraud detection, risk assessment, market information, intelligence gathering and security.

Users/researchers now need access to powerful high performance computing capacity, mass data storage systems, interactive visualisation systems and high capacity communication services. They are requiring services such as grid computing and federated databases that make increasingly more extensive use of high performance computing facilities in a collaborative environment. Consequently the demand for high performance computing can be expected to maintain the exponential growth pattern of previous years. It is important that this growth occurs in a cost effective manner that is consistent with the requirements of the research grids that will be progressively established.

### **6.16.5 High capacity communication networks**

The presence of a robust communications network is fundamental to research endeavour. Most developed countries are investing in upgrading their national research and education networks. In recent years the Australian Government has invested more than \$80 million in the Australian Research and Education network (AREN), a multiple gigabit per second optic fibre network

## DRAFT

connecting most university and research institutes within Australia and with substantial trans-Pacific connectivity.

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

### Conclusions/issues

The Committee views provision of systemic infrastructure as a high priority for ongoing NCRIS funding, building on investments made under the existing Systemic Infrastructure Initiative (which expires at the end of 2006). In recommending investments in this area, the Committee will be guided by the advice of existing committees such as the e-Research Consultation Committee, the Australian Research Information Infrastructure Committee (ARIIC) and the Australian Research and Education Network Advisory Committee (ARENAC). The Committee welcomes views on two particular investment propositions that have emerged in the course of its deliberations, relating respectively to:

- digital content and applications supporting research relevant to the creative industries (Attachment 1); and
- building an enhanced capacity to draw together data needed for research and analysis addressing geopolitical issues, thus addressing the National Research Priority Goal of *enhancing Australia's capacity to interpret and engage with its regional and global environment through a greater understanding of languages, societies, politics and cultures* (Attachment 2).

The Committee notes that Australia has a world-class research capacity in the area of *complex and intelligent systems*, with skills and knowledge that relate directly to the challenges of successfully introducing systemic infrastructure, both overall and in relation to the specific areas identified in this Exposure Draft (for example sections 6.4, 6.11, 6.12). There is an opportunity to take advantage of these skills in implementing specific projects (see Attachment 3).

## **Development of creative industries, digital content and applications**

### Description

The capacity to develop digital content and applications for the creative industries, and to bring together the disciplines which provide their R&D base, requires not only physical ICT infrastructure but also far better interoperability between existing technologies and content repositories and much better connections between research infrastructure and infrastructure of the various sectors of the creative industries. Developing this capacity requires:

- the establishment and population of federated institutional repositories for text and multimedia data, particularly with material that already exists in digital form but has not yet been curated, in order to achieve a critical mass of repository data and to provide the capacity to access and curate these resources collaboratively;
- the development of an infrastructure framework, including open access tools, approaches, processes and policies specifically enabled for the humanities, creative arts and social sciences but with expected applications for other discipline areas, particularly those requiring seamless access to text-based and image-based archives held in multiple institutional repositories; and the development of fine-grained rights management tools to reflect ethical agreements and protect intellectual property;
- the deployment and creation of Virtual Research Environment (VRE) tools and frameworks for communication, project management and design, access and rights management and other resources to support the underlying processes of research on both small and large scales; and
- the use of advanced technologies to pool research expertise, facilitate communication among researchers, research students and industry working in cognate areas, and to enhance the transmission of research skills (in particular, e-research skills).

There is an opportunity to use NCRIS investment to lift existing, excellent but partial, project-based infrastructure to a new level where:

- benefits of scale start to pay off both for researchers and the wider community
- there is seamless interoperability of databases and repositories, and
- collaborative interpretation – curation, not just digitised storage – of e-texts of all kinds is enabled.

NCRIS investment could be used to support a high level coordination function with the capacity to strategically connect existing research infrastructure – the databases and research communities - and existing communications and cultural infrastructure – the infrastructure providers and the institutions which hold much of the research resource. There is potential for partnering, including with national and state libraries and through public-private partnerships with industry, to develop this capability.

### Rationale

In developing creative industries, digital content and applications, Australia is enhancing a 'triple bottom line' sector of economy and society. The creative industries are high growth sectors which contribute to the knowledge-intensive, 'creative' economy but also are intensive users of human capital and thus provide high employment opportunity. Industry sectors benefiting from R&D in digital content and applications include:

## DRAFT

- the cultural institutions (national, state and regional museums, galleries, archives, libraries etc as well as private and third sector agencies),
- the established media and communications sector (print, broadcast, telcos) and
- new and emerging content sectors (games, web design, mobile devices, blogging and other commons-based peer-to-peer production and collaboration systems).

Digital content and applications can also play a role in improving Australia's industry innovation and performance in such diverse sectors as financial services (user-friendly design interfaces for transforming provider-client interactions), education (online and export), defence systems (through eg., adoption of games technologies), health (telemedicine, diagnosis and support-at-a-distance) and government services and processes (e-government, e-democracy).

### Conclusions/issues

The Committee welcomes views on how, through investment in systemic infrastructure, NCRIS funding might be used to build Australia's capacity to undertake research supportive of the development of the creative industries, and in particular on the proposal outlined above.

**Collaborative and strategic data fusion and model interoperability**

Description

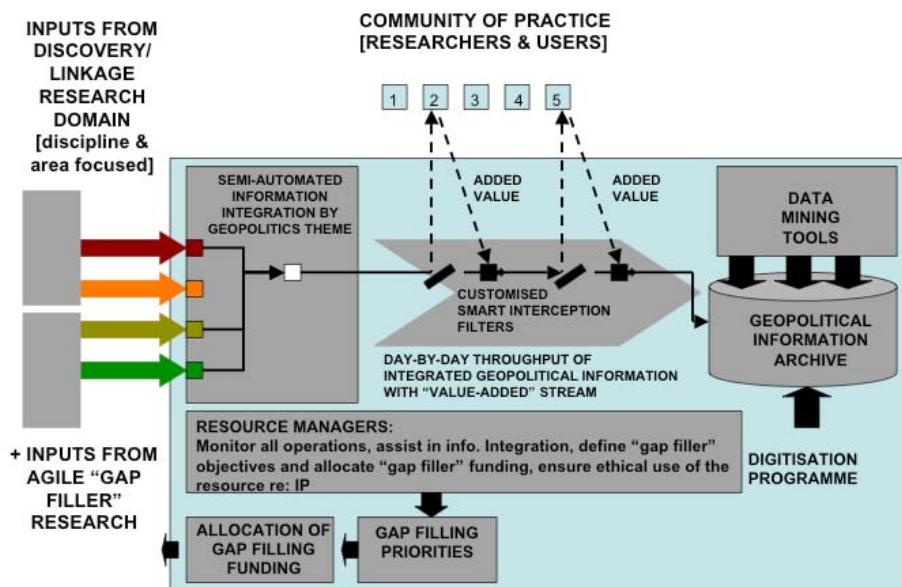
Australia’s ability to identify, and prepare for, a wide range of risks and threats rests in part upon our capacity to integrate diverse areas of knowledge and information in a timely and efficient manner. This would be supported by the development of an infrastructure capability that facilitates the fusion of data and insights from a diverse set of knowledge and information domains on a thematic basis, and which allows networks of relevant numerical models to be rapidly re-configured to address unfolding events.

The proposed infrastructure would consist of an interoperable set of data fusion and model interoperability protocols designed to make it far easier to identify, interpret and use the relevant but highly diverse set of information assets that Australia already possesses. These protocols and associated software tools would need to be able to mesh with those being developed by Australia’s strategic allies and principal research collaborators notably those in Europe, the United States and Japan.

Exhibit 1, which draws on work carried out by the NCRIS Safeguarding Australia expert sub-committee, illustrates aspects of this concept in specific relation to a “broad spectrum” geopolitics information resource. The wider concept described here would share many of these capabilities - but would be far more generic in application and scope.

**Exhibit 1**

**The Integrated Geopolitics Information Resource concept**



This collaborative strategic infrastructure would require compliance with agreed data exchange protocols. It would be created by a process of developing and agreeing these data fusion and model interoperability protocols with both day-to-day research users and the departments and agencies that would come into play to handle a national crisis.

# DRAFT

## Rationale

Knowledge relevant to our capacity to identify and prepare for risks and threats resides in experts in many different disciplines spanning science, engineering and technology, the social sciences and the humanities, and spread across a large number of organisations in the public, private and non-profit sectors. Findings pertinent to specific threats and risks are published in a wide range of journals. Relevant information, much of it proprietary, exists in numerous databases that currently cannot talk to each other.

There are also many formal numerical models that address specific aspects of risks and threats, relating to (for example) our critical infrastructure, protection against crime and terrorism, national security, population health, and plant and animal health and the natural environment. These models also cannot talk to each other. More broadly, Australia's capacity to perform leading edge research at the interfaces between disciplines and subject areas is constrained by the same set of data fusion and model interoperability challenges.

This fragmentation is limiting our capacity to apply our existing knowledge and analytical assets in an integrated problem-focused manner. This is a particular issue in areas such as counter-terrorism in which SET knowledge and social science and humanities knowledge must be integrated. Overcoming it is critical to making effective preparations based on "what if" assessments for national crises - and to handling these crises effectively should they occur. This capability is also important with regard to fostering research excellence.

## Conclusions/issues

The Committee welcomes views on the model for enhancing data integration as outlined above in regard to the specific application area of identifying and preparing for risks and threats. It welcomes views also on the applicability of the model to the wider challenge of building our capacity to synthesise and analyse information from diverse sources, on an "as needed" basis, to respond to research and wider social challenges.

**Australian research capacity in the area of *complex and intelligent systems***

Understanding, modelling and designing complex and intelligent systems is a substantial research challenge in a range of applications of national importance.

CIS, as a research community plays a critical role in a number of potential large-scale infrastructure projects. We highlight three of the most important of these:

- **Sensor Networks.** A number of the proposed capabilities involve the deployment of an array of sensors from which data is gathered (for example, the proposed Terrestrial Ecosystem Research Network (section 6.11); the Integrated Marine Observing System (section 6.12). Sensor networks can also play a key role in areas relevant to national security (for example, in early-warning systems) and industry (for example, in precision agriculture.) For the CIS research community these sensor networks are themselves the object of study; especially issues of communication, system design, and data fusion.
- **Large-Scale Informatics.** Major challenges for modern research relate to the acquisition, storage and manipulation of very large and varied data sets (two examples identified in this Exposure Draft are evolving bio-molecular platforms and informatics (section 6.1) and integrated biological systems (section 6.2). For the CIS community large-scale informatics raises numerous research issues in areas such as data-base architecture, data mining, contextual languages and machine learning. As such, infrastructure projects from across the whole research community offer a huge opportunity for CIS.
- **Manufacturing.** For the CIS community, manufacturing is a substantial research area which includes; the design of machines, sensing and control of processes, and automation of fabrication at different scales.

There is a world-class CIS research community in Australia including four ARC Centres, CSIRO ICT, and a number of very successful CRCs. Amongst these, Australia has leading strengths in the three key areas identified above. The CIS research community is able to play a vital role in many proposed infrastructure projects which in turn would act as essential “infrastructure” for CIS researchers. A second important consequence of actively engagement of the CIS research community in these infrastructure projects is the potential of securing a route to commercialisation and industrialisation of the systems required in their development.

“Complex and intelligent systems” (CIS), as a discipline, does not generally require access to dedicated or specific large-scale infrastructure. The most effective way for the CIS research community to benefit, and benefit from, the development of national research infrastructure is to be actively engaged in the many potential projects that substantially rely on CIS capabilities. It is proposed therefore that national research infrastructure projects which involve a substantial element of CIS domain knowledge, should actively engage collaborate and co-propose with established members of this research community.

# DRAFT

## 7. LANDMARK PROJECTS

The NCRIS Advisory Committee's advice included the recommendation that funding of "landmark" infrastructure (requiring investment above an upper-limit of approximately \$60 million) should be outside the scope of the NCRIS program, but that the Government should be advised on this infrastructure through the NCRIS process.

The Committee has not attempted to systematically scope Australia's landmark infrastructure needs. However, the following infrastructures have been identified as high priorities in the NCRIS process.

### 7.1. Blue-water research vessel

The Government's *Marine Science and Technology Plan* (1998), which was prepared to support the implementation of Australia's Oceans Policy, cites an upgrade of research vessel capacity as important to achieving objectives including sea bed and resource mapping, maintaining ecosystem health and function, understanding oceanographic processes and the role of the oceans in the climatic system, supporting regional marine planning and achieving sustainable industries.

Whilst the availability of satellites, new observational technologies, high performance computing and enhanced data management techniques has created a global revolution in marine science, researchers need to go to sea to conduct research. Australia's involvement in a number of international treaties and conventions requires blue water research to underpin their implementation. The area of research interest includes not only Australia's Exclusive Economic Zone (EEZ) but also other areas in the region that are of importance to Australia. Investment in a blue water research vessel is expected to leverage significant international investment in areas strategically beneficial to Australia through participation in international research programs focussed on our oceans.

Australia's blue water research vessels (*RV Southern Surveyor* and *RV Aurora Australis*) play an essential role in underpinning marine research. Both are nearing the end of their useful lives. To implement the proposed marine observing system (see Section 6.12) Australia would need to have at least one operating blue water research vessel in commission. The build cost of a replacement would be in the order of \$100m, although leasing there may be cheaper and more practical option. Ongoing operating costs would be approximately \$15-16 million per year.

### 7.2 Square Kilometre Array

The proposed SKA is a next generation radio telescope being developed by the International SKA Steering Group (ISSG) which draws together astronomers from 15 countries. Australia's involvement in the ISSG is being organised through the Australian SKA Consortium (ASKAC), supported by the Australian SKA Project Office within CSIRO's ATNF. The SKA would have an effective collecting area more than 30 times greater than the largest radio telescope built to date and would enable astronomers to see the formation of the early universe, including the emergence of the first stars, galaxies and other structures.

Australia is one of four contenders for the SKA site. It offers a very attractive location with radio quietness, coupled with a strong scientific and engineering base. In September 2006 the ISSG is expected to rank the candidate sites on science, technical and infrastructure cost grounds. Although Australia's candidature for siting is likely to rank very highly in terms of the scientific and other criteria, it is possible that political and financing factors may also influence any eventual decision.

## DRAFT

The opportunity to host the SKA in Australia has the potential to provide significant benefits to Australia, both in scientific and economic terms, and would enable Australia to exploit its naturally advantages to make a major contribution to international research infrastructure. In addition to the facility itself, astronomers would need high-capacity communication/data networks and high-performance computing resources. There would be a particular requirement for a high-bandwidth communication network for the full SKA facility.

An interim phase of the SKA project, construction of SKA pathfinder (10% of the full SKA) on the site, will establish feasibility and be a world-class telescope in its own right. The Roadmap identifies funding for the SKA Pathfinder as a priority. Commitment of funding support through the NCRIS process may be influential in the Pathfinder, and ultimately the full SKA, siting decision. Similarly a decision to site the SKA Pathfinder, or full SKA elsewhere, would need to be considered in determining Australia's astronomy infrastructure funding priorities.

### 7.3 Extremely Large Telescope

The next generation of optical astronomy instruments are currently being planned. These instruments, known collectively as Extremely Large Telescopes or ELTs, would deliver an order of magnitude improvement in ground based observing. Several international consortia are currently developing proposals for ELTs to be built over the next 10 to 15 years.

The National Committee for Astronomy's (NCA) *Decadal Plan for Australian Astronomy 2006-2015* has recommended Australian participation in an ELT at a minimum level of 10 percent partner. There are substantial benefits to be gained from being an early joiner at a significant level in relation to influencing the scientific and technical direction and access to development and construction work.

The NCA, through the ELT Working Group, is participating as an observer in the consortium developing one of the proposals, the Giant Magellan Telescope (GMT). The GMT is regarded within the Australian astronomical community as:

- representing the lowest risk of the various ELT proposals in terms of cost and technical requirements yet sufficiently ambitious to be a major leap forward in capability. Partners sign up for each stage of the project, thus maintaining a high level of flexibility. ;
- offering Australia the chance to be a major partner at lesser cost than alternative projects; and
- providing a good fit with other Australian capabilities and proposed capabilities.

The GMT consortium is comprised of a number of prominent US universities. The GMT has a proposed light gathering capacity of 25.4 metres, about 4.5 times the collecting power of any existing telescope. The current plans would see the GMT completed in 2016. The estimated cost of Australian participation in the GMT project from 2006 to 2020, if there were a commitment to that project, would be around \$80 million, some of which would be reallocated from existing funding sources in the later years.

# DRAFT

## 8. RESPONDING TO THE STRATEGIC ROADMAP – EXPOSURE DRAFT

### 8.1 Invitation to respond in writing

The NCRIS Committee invites written submissions on the Roadmap exposure draft. Please note that material in submissions may be used to produce the final draft and may be incorporated in the final draft without attribution (however your material will not be referenced if you stipulate confidentiality - see below).

Stakeholders are invited to:

- comment on the scope of the prioritised capabilities and to provide any views or information that might help to further prioritise those capabilities;
- provide any comments that will assist the Committee in further articulating the strategic infrastructure and support requirements, together with any associated issues, relating to the capabilities identified in the exposure draft; and
- respond to any issues/questions posed in the “Conclusions/issues” section for each capability.

Important note: The NCRIS Committee is **not seeking funding proposals** from individuals or organisations interested in the delivery of the priority capabilities. Once the Roadmap has been finalised, a process to seek proposals, where relevant, will commence (see Appendix 3 for further information). In the process of finalising the Roadmap the Committee will not consider submissions which primarily put forward a proposal for NCRIS funding, although submissions might *briefly* foreshadow a possible proposal in the context of responding to the matters outlined above.

### 8.2 Guidelines for respondents

Respondents are asked to observe the following guidelines:

- Submissions should be kept as brief as practicable, with a maximum of five pages relating to any one capability, and at a high level in relation to detail. They should include a summary statement identifying which capabilities are being addressed;
- Electronic submissions, submitted by email, are preferred;
- The author’s name, phone number, email address and/or postal address should be provided so that the NCRIS Committee or DEST can seek further information or verify authorship.

#### Deadline and address for submissions

In order to be considered in developing the final draft of the Strategic Roadmap, feedback on the exposure draft must be provided to the NCRIS Committee by **close of business (5.00 pm) Monday 5 December 2005. No late submissions will be accepted.**

Submissions should be addressed to:

NCRIS Committee  
c/o Department of Education, Science and Training  
Loc Code 726  
GPO Box 9880  
CANBERRA ACT 2601

Or emailed to: [NCRIS@innovation.gov.au](mailto:NCRIS@innovation.gov.au).

# DRAFT

## Important note on confidentiality

Submissions may be made publicly available on the DEST website unless you specifically request that your submission not be made publicly available. Authorship of submissions will be acknowledged. DEST reserves the right to withhold publication of submissions.

If you do not want your submission made publicly available, please say so clearly at the front of the submission, or in a covering note. If you do not want part of the submission to be made publicly available, please mark it clearly and put that part on separate pages or in separate documents.

While DEST will not make your submission publicly available as part of its work, you should be aware that it may be required to release your submission by the operation of law, a judicial or Parliamentary body or a government agency. DEST can therefore give no undertakings that your submission will never be made publicly available or ensure that you will be protected from future legal action. If you have any concerns about this, it is suggested that you seek your own legal advice.

# DRAFT

## APPENDIX 1 - NCRIS COMMITTEE TERMS OF REFERENCE AND MEMBERSHIP

### Terms of reference

The NCRIS Committee will advise the Government on the ongoing implementation, monitoring and review of NCRIS. The Committee's specific responsibilities will include:

- advising the Government on national research infrastructure strategy and priorities, including:
  - priority areas of research for major infrastructure investment within the scope of the NCRIS funding programme. The Committee will further develop the Strategic Roadmap, initiated by the interim NCRIS Advisory Committee, to give specific guidance on priority investment areas and implementation options;
  - infrastructure requirements for the national research and innovation system outside the scope of the NCRIS funding program, including the development of 'landmark' facilities and support for basic and institutional level infrastructure;
- advising on the coordination of infrastructure funding decisions with research funding agencies, across government and across levels of government;
- advising on NCRIS funding allocation processes, including the development of program guidelines, and the implementation of NCRIS funded projects;
- advising the Government on progress in implementing NCRIS, including any barriers to effective implementation; and
- advising the Government in relation to the review of NCRIS funded projects and NCRIS in general.

### Membership

Dr Mike Sargent (Chair)  
Director, MA Sargent & Associates Pty Ltd

Dr Evan Arthur  
Group Manager, Innovation and Research Systems, DEST

Professor David Beanland  
Emeritus Professor, RMIT University

Dr Roger Lough  
Chief Defence Scientist

Dr Phil McFadden  
Chief Scientist, GeoScience Australia

Professor Alan Pettigrew  
Chief Executive Officer, National Health and Medical Research Council

Dr Leanna Read  
Managing Director and CEO, TGR BioSciences Pty Ltd

Dr Stephen Walker  
Executive Director  
Engineering and Environmental Sciences, Australian Research Council

# DRAFT

## APPENDIX 2 - EXPERT ADVISORY ARRANGEMENTS

The NCRIS Committee was advised by four expert subcommittees tasked to advise and consult on infrastructure needs related to each of the four National Research Priorities. It was advised on e-research capabilities by the Government's e-Research Co-ordinating Committee, the Australian Research Information Infrastructure Committee (ARIIC) and the Australian Research and Education Network Advisory Committee (ARENAC).

The Committee acknowledges the valuable contribution made by all the expert advisers involved in developing the Strategic Roadmap and offers its thanks to all those involved.

**The Committee notes that the views expressed in the Roadmap are its alone and do not necessarily reflect the advice and views of the expert subcommittees or the individual members.**

The members of the four expert subcommittees were:

A/Professor Gary P Anderson  
Department of Pharmacology  
The University of Melbourne

Professor Tony Bacic  
Director, Plant Cell Biology Research Centre  
The University of Melbourne

Professor Judith Black  
Department of Pharmacology  
The University of Sydney

Dr Brian B Boyle  
Director, Australian Telescope National Facility  
CSIRO

Dr John Church  
CSIRO Marine Research and Antarctic Climate and Ecosystems CRC

Dr George Collins  
Chief of Research  
Australian Nuclear Science and Technology Organisation

Dr Wendy Craik  
Chief Executive  
Murray-Darling Basin Commission

Professor Peter Cullen  
University of Canberra

Professor Stuart Cunningham  
Acting Dean, Creative Industries Faculty  
Queensland University of Technology

Professor George Dracoulis  
Department of Nuclear Physics, R.S.Phys.S.E  
Australian National University

## DRAFT

Professor Calum J. Drummond  
Chief Research Scientist  
CSIRO Molecular and Health Technologies

Dr Annabelle Duncan  
Associate Director,  
Bio 21

Professor Hugh Durrant-Whyte  
Research Director  
ARC Centre of Excellence for Autonomous Systems, ACFR  
The University of Sydney

Professor Peter J. Fuller  
NHMRC Senior Principal Research Fellow  
Prince Henry's Institute of Medical Research

Dr Ian Fuss  
Chief Scientist (Information)  
Defence Science and Technology Organisation

Professor Helen Garnett  
Vice-Chancellor  
Charles Darwin University

Professor Andrew Gleadow  
School of Earth Sciences  
The University of Melbourne

Dr Bruce Godfrey  
Principal, Wyld Group Pty Ltd

Dr TJ Higgins  
CSIRO Plant Industry

Professor David J Hill  
Cancer Council Victoria

Dr Robert Hobbs  
formerly General Manager Research, BHP  
& Foundation Chairman, CRC for MicroTechnology

Dr Barry Inglis  
CEO and Chief Metrologist  
National Measurement Institute

Professor Anthony F Jorm  
ORYGEN Research Centre,  
The University of Melbourne

Professor Max Lu  
Director, ARC Centre for Functional Nanomaterials  
The University of Queensland

## DRAFT

Dr Mark Matthews  
General Manager, Howard Partners  
Visiting Fellow, Department of Engineering, Australian National University

Professor Tim McCormack  
Asia Pacific Centre for Military Law  
The University of Melbourne

Professor Caroline McMillen  
Research Centre for the Early Origins of Adult Health  
The University of Adelaide

Dr Steve Morton  
Group Executive  
CSIRO Environment and Natural Resources

Professor James A Piper  
Professor of Physics and Deputy Vice-Chancellor (Research)  
Macquarie University

Dr Ian Poiner  
CEO  
Australian Institute of Marine Science (AIMS)

Dr John Radcliffe  
Commissioner  
National Water Commission

Professor Tim Reeves  
Principal, Timothy G. Reeves and Assoc. Pty. Ltd

Dr Mike Rickard  
Post-retirement Fellow, CSIRO

Dr James Robertson  
Manager of Forensics and Technical Services, AFP

Vice-Admiral David Shackleton  
Shackleton Management Solutions (Chief of Navy Retd)

Mr David Templeman  
Director-General, Emergency Management Agency

Professor Matt Trau  
Centre for Nanotechnology and Biomaterials  
The University of Queensland

Dr Graeme Woodrow  
Chief, CSIRO Molecular and Health Technologies

# DRAFT

## APPENDIX 3 - NATIONAL COLLABORATIVE RESEARCH INFRASTRUCTURE STRATEGY (NCRIS) FORWARD PROCESS

### 1. Exposure draft of the Strategic Roadmap

The exposure draft will be open for public consideration from X November 2005 until 5 December 2005. The NCRIS Committee will also undertake a limited consultation process on the Exposure Draft in November, involving State and Territory Governments and university and research agencies.

### 2. Final draft and release of the first edition of the Roadmap

The NCRIS Committee will produce a final draft of the Strategic Roadmap during December 2005 after considering feedback on the exposure draft. By the end of December the final draft will be provided to the Minister for Education, Science and Training for his consideration and approval.

The finalised 'first edition' of the Roadmap will be released in early 2006 when approved by the Minister. The Roadmap will be available on the DEST website at [www.dest.gov.au.ncris](http://www.dest.gov.au.ncris) and made freely available for any legitimate use. In addition

### 3. 2006 NCRIS funding process

The approved Roadmap will provide a framework for allocating the first tranche of NCRIS funding. The process for allocating the first tranche will be undertaken during 2006, with funding agreements expected to be in place by the end of 2006. The NCRIS Committee expects to provide further detailed advice to the Minister on how the Roadmap should be implemented during the first quarter of 2006.

When the Minister has approved an implementation strategy, there will be public notification of those elements involving a requirement for first tranche NCRIS funding. Where appropriate, a 'statement of requirements' will be issued calling for proposals/funding bids to be developed by interested parties (anticipated timing around April 2006).

Funding proponents will then have several months to prepare proposals to address the first tranche requirements. As noted above there will be a heavy stress on the need to develop proposals that provide national, collaborative solutions. The length of time allowed to develop proposals will be adjusted to reflect the complexity of the requirement and operating environment.

During the second half of 2006, funding proposals will be assessed and agreements negotiated with a view to having funding arrangements in place by the end of 2006, though it is recognised that it may take longer to have complex project arrangements in place.

### 4. Subsequent work on the Roadmap

As noted above, the Committee regards the Strategic Roadmap that will emerge from this exposure draft as a first edition and has identified the need for it to be revised over time reflect changing priorities; the emergence of new opportunities and a better supporting information base.

In order to inform the allocation of NCRIS funding after the first tranche allocations, it will be necessary to begin the process of updating the Roadmap during 2006. The Committee will provide further advice to stakeholders in due course.

# DRAFT

## 5. Indicative NCRIS forward process timeline

<b>Date</b>	<b>Activity</b>
<b>2005</b>	
Early November	Exposure Draft finalised
November-5 December	Consultation on Exposure Draft
December	Strategic Roadmap finalised by NCRIS Committee and forwarded to Minister
<b>2006</b>	
By end February	Strategic Roadmap released
April	Statements of requirements for initial tranche of NCRIS funding released
May-July	Preparation of funding proposals
August-December	Proposals assessed, funding agreements and business plans negotiated and funding approved
September onwards	Project funding commences