NCRIS Roadmap Review – Submission by the Australian Academy of Technological Sciences and Engineering

The Australian Academy of Technological Sciences and Engineering[1] (ATSE) strongly supports NCRIS. To be world competitive, Australia's research system must ensure that our researchers have access to state-of-the art infrastructure, facilities and databases. Australia's highly dispersed population makes the sharing of expensive research infrastructure a necessity. Such sharing not only makes economic sense — it also builds clusters of research excellence and creates new opportunities for cooperation between researchers. NCRIS is helping to build such cooperation, not only between public sector researchers but between *all* those involved in the research sector, including government agencies and the private sector. ATSE strongly supports efforts to build such cooperation.

Summary of ATSE's Comments

ATSE:

- strongly supports the concept of NCRIS and believes that sharing research facilities and infrastructure not only makes good economic sense but also promotes cooperation between researchers.
- believes that the current balance of funding for university infrastructure between NCRIS and other sources is appropriate.
- urges NCRIS to take a lead in promoting best practice in the management of research facilities and infrastructure in Australia.
- considers that remote access to instrumentation, databanks and computing facilities is of increasing importance.
- sees value in locating NCRIS facilities in research precincts, subject to a commitment to genuine collaboration on the part of precinct researchers (and to develop potential commercial applications where applicable).
- notes that the Discussion Paper has included the needs of the Humanities and Social Sciences and urges NCRIS to examine the needs of other areas that are also not explicitly covered in the NRPs (for example, wireless sensor networks).
- sees a need for NCRIS investment in relation to mitigation of greenhouse gases, and energy production, storage, conversion, efficiency and so on (that is, more extensively than just low-emission large scale energy processes).
- has provided a number of other specific comments on the contributions of each of the Working Groups to the Discussion Paper as well as on aspects of the provision of information and communications technology (ICT) facilities and services.

[1] ATSE was established in 1975 with the mission to promote the application of scientific and engineering knowledge to the future benefit of Australia. ATSE is one of four learned national Academies, which have complementary roles and work together both nationally and internationally. ATSE has about 750 elected Fellows who are the leaders of applied science and engineering across the country. ATSE is comprised of experts from a diversity of professions many of whom have been consulted on this submission.

ATSE recognises that there are other sources of funding for infrastructure in priority areas such as water and climate change. In taking decisions on funding, NCRIS needs to take these other sources into account. In relation to the funding of research infrastructure in Australia's universities, ATSE believes that the current balance of support between NCRIS and other funding sources is appropriate.

ATSE believes that it would be timely for NCRIS to promote world's best practice in the governance of all major research facilities in Australia. This could take the form of an annual conference that brings together managers and users. ATSE notes the success of the Cooperative Research Centres (CRC) Association annual conference in promoting best practice.

ATSE believes NCRIS has made a significant contribution to research performance in Australia and compliments the Committee on its initiative to review the 2006 Roadmap to ensure that its priorities are correct and it is meeting its objectives. ATSE is broadly supportive of the NCRIS Roadmap and the refinements suggested by the Expert Working Groups.

Broader Themes

ATSE welcomes the broader approach to supporting infrastructure that NCRIS has adopted. ATSE supports the adoption of broad themes identified by the Expert Working Groups, subject to them being consistent with NCRIS principles. The need for ICT requirements to form an integral part of planning of any new facilities is essential and where appropriate this needs to include remote access to instrumentation, databanks and computing facilities.

ATSE understands that any submission for NCRIS funding must identify how facilities will be operated and maintained and where the requisite skills are to be obtained. Where there are concerns that skill shortages might impair optimum performance of a new facility, suitable provision must be made in the initial budget for skills development, even to the extent of recruiting research teams from overseas for the initial period of operation.

ATSE is keen to see the concept of developing research precincts taken into account in NCRIS evaluations, particularly when the new facility plans (or could be encouraged) to work in areas where there are potential commercial applications for the research undertaken. The concept of precincts could then be expanded to co-location with potential users of the research. This would be a powerful factor in ensuring that programs remain focused on practical outcomes and support the national innovation agenda. In seeking NCRIS funding, it is essential that precinct members demonstrate a commitment to genuine collaboration, as opposed to mere geographic proximity. The location of new facilities must also take into account other issues such as user access and the willingness of host institutions to contribute to facility costs.

The Discussion Paper notes that the needs of the Humanities, Arts and Social Sciences (HASS) may not be explicitly covered by the National Research Priorities and are not covered by the current Roadmap. There may be other areas that fall into this category — including emerging areas of research. NCRIS needs to watch for such areas and take appropriate action.

ATSE is concerned that the Discussion Paper tends to reflect the views of groups within current areas of research strength. This is not necessarily going to provide a focussed approach to national needs. ATSE would have been more comfortable with an approach that started with an analysis of the needs of the various research areas. It is to be hoped that the present Review will draw inputs from outside the areas that NCRIS has supported to date.

Capabilities in Current NCRIS Roadmap

The current list of capabilities is appropriate although ATSE is concerned that what the Australian community currently sees as two of the most critical scientific issues, climate change and water, are not specifically listed. While recognising that some infrastructure in these areas may be funded from other sources, the prominence that climate, water and energy have received has meant there has been an acceleration of research activity in these areas in recent times.

The related matter of energy is covered only in terms of low emission, large-scale energy processes. ATSE is concerned that this undervalues work on energy storage, energy efficiency, alternative fuels and the like. ATSE would like to see the current capability broadened and would also like to see the area of low-emission, large-scale energy processes funded, which has not happened under the current Program.

It is gratifying that the Environmentally Sustainable Australia Expert Working Group has identified some of these items in their list of focus areas where gaps exist, but activity already taking place should warrant consideration of these fields for inclusion in the list of Capabilities. While the needs of research in these areas may not always be appropriate for NCRIS investment, the communities involved should be given the opportunity to put forward any needs that are consistent with NCRIS objectives.

Environmentally Sustainable Australia Working Group

Capabilities

The need to identify climate change, water and energy as capabilities has already been identified above but it needs to be emphasised that these do not relate only to environmental sustainability. They are also relevant to the Frontier Technologies National Research Priority.

ATSE notes the comment regarding a lack of capability in regard to the built environment. This is an area where an NCRIS investment could well act as a catalyst to encourage more research. The built environment is responsible, directly or indirectly, for over 30 per cent of energy related greenhouse gas emissions in Australia. A major national facility directed towards characterising the thermal efficiency of various building materials and systems might encourage more work in this critical area. Such a facility could also consider aspects of recyclability of materials and embodied energy, important areas not at present addressed in building regulations or environmental practice guidelines.

Current NCRIS Investments

In general ATSE is highly supportive of the investments already made. It is hoped that the adequacy of the existing investment is periodically reviewed, as is the case in some areas such as earth observations. While there has been significant progress, much more needs to be done. Provision for second and later stage investments in key areas needs to build on the experience derived from early stage research work.

ATSE believes that the Terrestrial Ecosystem Research Network (TERN) has great, but as yet unrealised potential. The fragmentation of effort in this area, and data collection that appears to lack well-defined goals and outcomes continue to provide good reasons for investing in TERN. ATSE notes that Dr Trevor Powell's 2008 report on TERN urges NCRIS to put in place "a governance system that undertakes long term planning and research coordination..." This point needs to be addressed in the revised Roadmap. Our comments on wireless sensor networks in the next section of this submission are also relevant to the monitoring of terrestrial ecosystems. The prospect of further funds should be an enticement for progress towards making TERN a useful mechanism for researchers.

Other Current Developments

ATSE strongly supports the need for a coordinated remote sensing research facility. This has become an underpinning technology for a broad range of research work. ATSE is exploring opportunities for collaboration in this area with the Chinese Academy for Science and, as has been the case in some water and energy research, opportunities might emerge to develop some facilities jointly.

Future Directions

One major challenge for NCRIS is to identify what major research facilities can be developed to respond to the significant threat which climate change poses for Australia. Mitigation of greenhouse gas emissions and adaptation to what potential climate change will occur must be addressed. Australia urgently needs research infrastructure to meet a likely emissions reduction target in the range 60-90 per cent of present levels, which will require participation and development of all possible solutions with a much greater emphasis on conservation, renewables and integrated energy systems. ATSE urges a strategic approach in facilities investment that ensures that the relationships between energy production, greenhouse gas emission, mitigation and adaptation options, water resource management, biodiversity conservation and food production systems are addressed as an integrated whole, rather than as single isolated investments.

While reducing our dependence on fossil fuels is a priority, there may be a case for a national geosequestration facility possibly located adjacent to one of the existing developments but open to researchers interested in projects in new areas. A national geothermal energy facility might also be considered. Such national facilities could cost-effectively develop the specifications for new pilot facilities or test new equipment. A co-located carbon storage facility might encourage more work on coal- and gas-derived liquid fuels and accelerate progress towards a hydrogen economy.

Work currently being undertaken by ATSE has revealed the opportunities for the development of a range of biofuels based on non-food biomass grown in areas not suitable for conventional agriculture or on algae and wastes. Continuing NCRIS

support for work on biofuels should allow a range of feedstocks to be tested, allowing small-scale research verified on something approximating a commercial scale operation.

ATSE is concerned at the apparent lack of arrangements to maintain Australia's blue water research vessel capability. The Discussion Paper envisages a hiatus in marine studies which could have serious consequences for the continuity of blue water marine science in Australia. ATSE believes that this matter requires urgent action.

Frontier Technologies Working Group

Current Capabilities

ATSE agrees with the Working Group's assessment of current capabilities and applauds the progress already made in Characterisation and Fabrication.

Whatever the outcome of the current Review of the Innovation System, there is no doubt that there will be ongoing interest in improving the implementation of the results of publicly-funded research. As most of the research done in NCRIS facilities is publicly funded, more overt consideration of how the outcomes might be used, in terms of management structure, programs and location could be merited.

The lack of any investment to date in research infrastructure in the energy area is disappointing. Part of the problem is illustrated in the way the National Research Priorities have been formulated and the NCRIS Discussion Paper structured. Energy is a key component of both Environmental Sustainability and Frontier Technologies. Both aspects need to be considered simultaneously.

The key finding of a recent report by ATSE on energy and nanotechnologies is that nanotechnologies are a growing group of enabling technologies dealing with engineering at the molecular level which can make a substantial impact on all areas of energy conversion, storage and distribution. The report identifies a number of promising areas in the short term which are below critical mass in Australia, namely organic photovoltaics, dye sensitised photovoltaics, energy catalysts and energy conservation using nanomaterials and sensors. Longer term there will be a need to support hydrogen production and use. Some of ATSE's views on other Frontier Technology issues that need attention have already been set out in previous sections of this submission.

Current Investments

ATSE agrees with the Working Group's assessment of the investments made to date by NCRIS.

Current Developments

The development of nanotechnologies in Australia will have an impact across many branches of science, industry and technology. Like any new technology there are likely to be benefits and disbenefits. In a recent report for the National Academies Forum ATSE examined the risks associated with nanotechnologies. Many applications of nanotechnologies introduce no new health, environmental or safety risks — for example in nanophotonics and nanoelectronics where the new technology builds on to the established microelectronics industry. Others such as

nanobiotechnology and nanomedicine raise concerns because of the intentional release of engineered nanoparticles into humans and into the environment. Free particles in the nanometre range raise particular health and safety issues because their toxicology cannot be deduced from the same material at the macroscale.

Currently the knowledge base in Australia on toxicity of nanoparticles is small. Nanotechnology research is broadly based and application specific. Few nanotechnology researchers have the capacity to undertake the tests needed to verify the safety of the particles they are using. The establishment of a national interdisciplinary centre in nanotoxicology, and its application to regulations, would ensure that Australia is not economically disadvantaged in the safe applications of nanotechnologies, and would assist in allaying societal fears about nanotechnologies.

Future Directions

The concept of converging technologies has recently become a topic of study in Europe and North America. Converging technologies are enabling technologies and knowledge systems that enable each other in pursuit of a common goal. Thus combinations of nanotechnology, biotechnology, information technology and cognitive science are being used to provide new approaches to topics such as emerging infectious diseases, security from man-made and natural disasters, sustainable development and coping with an ageing population. ATSE recently held a very successful workshop on converging technologies to combat emerging infectious diseases in Asia-Pacific and is starting a project on converging technologies for wellness and illness. NCRIS needs to be aware of these developments and be ready to support new interdisciplinary thrusts.

One area of infrastructure that may require attention is sold state nuclear magnetic resonance (NMR) spectroscopy. This important adjunct tool for structural work appears to be currently underprovided in Australia.

ATSE also recommends that the NCRIS Roadmap pay more attention to wireless sensor networks for sensing and actuation, together with network, processing, and storage infrastructure. Wireless sensor networks are collections of tiny nodes which communicate their location, identity, and local measurements of their environment wirelessly over low-power computer networks. A simple form, namely RFID, is beginning to be used in supply chain management in the retail sector. Richer forms are being planned for factory management, agriculture, mine safety, environmental monitoring, energy exploration, and defence.

Battery life and cost are two key design parameters of the tiny nodes, often called motes, since researchers will want to “sprinkle” thousands of them over their domain of interest, and let them gather data unattended for long periods. Research in the USA and at CSIRO’s ICT Centre gives us a glimpse of the near future. Recent work has shown that power management and circuit design can extend battery life to ten years, advanced chip design can get notes to coin size and cost less than ten dollars. On the other hand, there has been little progress on actuation, where commands will be sent to motes equipped to change the environment in which they sit, for example, by adjusting a flow valve. MEMS (Microelectromechanical systems) will play a role in the fabrication of actuators. A closed loop system will sense, determine appropriate

responses through models in high-performance computing facilities, and transmit commands to actuators sitting alongside the sensors.

We expect that an ICT working group being formed by ATSE will project future workloads (sensing, processing, actuating) for systems of interest – in environmental monitoring, water management, energy management, computational biology, and different applications of computational fluid dynamics. The results could be useful in guiding NCRIS investment.

Humanities, Arts and Social Sciences Working Group

ATSE believes that greater use of digitisation would be applicable to science and engineering fields as well as in the HASS. Support for this should be aimed at generating national benefits, consistent with NCRIS principles.

ATSE is a strong supporter of the National Academies Forum (NAF), where all four of Australia's Learned Academies meet to discuss matters of mutual interest and also to undertake joint projects. This Forum recognises that the need for broad based involvement of the HASS disciplines in science and engineering, particularly in a community that can be highly sceptical about science in areas controversial areas.

The report by ATSE for the NAF on risks on nanotechnologies noted that the application of nanotechnologies will raise significant ethical, social and legal issues. Currently activity in these areas in Australia is scattered and limited in scale. The establishment of an interdisciplinary centre on social, ethical and legal aspects of nanotechnologies would ensure that Australia is not economically or socially disadvantaged by the applications of nanotechnologies. The study of community attitudes to development of nanotechnologies would be a vital component of its activities.

Promoting and Maintaining Good Health Working Group

ATSE believes the Working Group has identified the major issues in the medical and health related research areas. The application of converging technologies to healthcare is a growing area of activity requiring support.

One underlying concern in this area is the difficulty experienced in translating world-class research into commercial benefit. This is due in part to Australia's industry structure and the lack of large international pharmaceutical companies based here. It is also partly a result of the nature of the research undertaken, and in some instances to gaps in R&D capability. To the extent that the needs in this area can be addressed by NCRIS, the Program could assist in identifying where gaps exist and contribute to filling them. If this can be achieved, outstanding Australian laboratory research will not have to be taken elsewhere to be further worked on before a commercial company can take it up. A lack of a medical chemistry capability is an example of this problem and there may be others.

ATSE again recommends that NCRIS gives greater priority in its analysis to how funding applicants plan to capitalise on the outcomes of research undertaken in NCRIS-funded facilities.

Safeguarding Australia Working Group

ATSE supports the conclusions reached by the Safeguarding Australia Expert Working Group. ATSE believes that it is important that Australian research on quarantine issues, including any related environmental and health research, is provided with the necessary infrastructure so that potential problems can be identified and thoroughly examined in a timely manner. Maintaining capacity in nuclear technologies is also important for the Safeguarding Australia objective.

ICT Strategy

In relation to the section of the Discussion Paper provided by the ICT Strategy Group, ATSE would like a stronger focus on the 'users' and how they drive the development and operation of the research infrastructure. Australia could learn from the approaches taken to this kind of infrastructure in other comparable countries. Changing the roadmap on the basis of the achievements of researchers using the *current* Platforms for Collaboration (PfC) infrastructure and services could result in other important areas being overlooked.

The ICT Strategy should include a clear statement on the extent to which NCRIS PfC should focus on the other NCRIS capabilities as opposed to the needs of research groups more generally. ATSE believes that NCRIS PfC should focus on researchers (research groups) that are, or have the potential to be, world-class and should not be limited to supporting other NCRIS capabilities. Key research groups that are not adequately supported from the current PfC programs should be identified and their needs examined.

More generally, NCRIS PfC should have clear mechanisms by which the research groups to be supported are identified (especially in ARCS and ANDS). Hopefully the present review will result in input from these sources. Experience shows that effective ICT infrastructure and services depend on a strong focus on key user needs. NCRIS PfC also needs to have a clear statement on who is allowed to access infrastructure provided by the Program.

There needs to be a clear statement on the scope of what ICT can be funded by NCRIS — each of the PfC components needs a clear statement on the scope of its activities, such as the delivery of infrastructure and services, tools and techniques, and outreach (skills development, workshops, industry support etc). A common profile of activities for each component would help with the coordination of activities across the component programs.

The current six activities provide a broad framework for the eResearch infrastructure and services. It is not clear, however, that the current division into six components provides the best framework for an integrated national infrastructure. An alternative approach could be based on computing, communications, data and collaboration services for virtual organisations.

The NCRIS PfC components require sound governance, management and provide a coordinated service to key research groups. One way of achieving this would be

through the establishment of a PfC strategy group. Membership should include key researchers and the heads of the PfC component programs.