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Senate Standing Committees on Economics
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Dear Secretariat,

Re.: ANFF submission to the Parliamentary Inquiry into Australia's Innovation System

The Australian National Fabrication Facility (ANFF) welcomes the opportunity to contribute to the inquiry into Australia's innovation system.

ANFF has been funded under the National Collaborative Research Infrastructure Scheme (NCRIS) to provide access to state-of-the-art micro and nanofabrication facilities. ANFF, with its focus on the fabrication of new materials and devices, is a highly relevant organisation for fostering innovation in the Australian manufacturing industry.

Key recommendations are:

- a) Investments to support innovation should be focused on areas in which Australia has comparative advantage.
- b) Access to world-class research infrastructure is essential for innovation to flourish.
- c) Education is critical to ensure technology uptake, reduce skill shortages and enable informed public discussion.
- d) Access to research infrastructure is essential for innovation in manufacturing.
- e) Cross-sector collaboration is needed to tackle the society's biggest challenges. Public sector innovation should be better recognised and rewarded.
- f) The ANFF governance model, a company limited by guarantee, has been highly successful.
- g) NCRIS provides rapid, cost effective access to infrastructure for Early Career Researchers.
- h) Continuity of funding is essential to attract and retain Australia's research and innovation workforce.
- i) Strong international relationships are essential to operate in a global market. International collaborations should be encouraged and used as a KPI for NCRIS capabilities
- j) Voucher schemes for industry access of research infrastructure provide support for emerging industries.

Yours sincerely,

Rosie Hicks
CEO Australian National Fabrication Facility

Background

ANFF is one of the 12 capabilities funded in 2006 under the Australian Government's National Research Infrastructure Strategy (NCRIS). Headquartered at the Melbourne Centre for Nanofabrication in Clayton, it links 19 universities and CSIRO to form a national network of ~ 500 tools available for use by academic, public sector and industry researchers throughout Australia. The total investment is now ~\$275 million. During 2012/13 ANFF serviced the research infrastructure needs of 2,000 researchers, with nearly 20% of these coming from industry. ANFF employs 87 FTE highly specialised staff, many recruited with overseas training.

ANFF comprises eight complementary nodes, which are spread across Australia, each having specialist skills in fabricating different types of nano- and micro- moieties and structures to support the national effort in nanotechnology. For example, in South Australia the nodes have an emphasis on sensors and defence-related projects, whilst the Victorian node works closely with the local biomedical and scientific instrumentation companies. For each of these industries, innovations at the nano scale will open up new opportunities

Through ANFF's ability to carry research through to the prototype stage, new products and processes can be developed for Australia as they require little material, rely on high levels of technological expertise and can be shipped around the world at minimal cost.

Each node of ANFF consists of customised cleanrooms, specialised equipment used in a sequential fashion to fabricate nanostructures and highly experienced operators trained in producing high-precision end results. Australian industry uses ANFF facilities in collaborative research with universities and in prototype development. It provides Australian SMEs with the opportunity to develop prototypes of innovations without having to bear the high initial capital costs of entering the nanotechnology field.

ANFF is a service organisation, dedicated to providing efficient and effective support ranging across materials development, design advice, prototype construction and novel fabrication technologies. ANFF is engaged by industry clients to use facilities to make a prototype device or engineer a process for its manufacture. While some industry users are trained to use ANFF facilities directly, many contract ANFF staff to perform work on their behalf. ANFF also supplies advanced materials (e.g. nanotubes, specialist polymers) or devices (such as optic fibres or microfluidic chips) that are otherwise not commercially available.

ANFF is governed by a Board heavily drawn from senior experts from Australian industry, with members of the company being the participant universities and CSIRO. An international advisory committee with members from leading similar facilities in the USA and UK provides strategic input. ANFF has a small head-office group led by an experienced CEO who ensures that good collaboration continues, milestones for equipment installation are met, facilities are well maintained and access to facilities is provided on the basis of quality of the research. Since its inception, ANFF has provided the support for its users to publish world-leading science in outlets such as Nature and other "A" ranked journals and has attracted the attention of the leading US military laboratories that have subsequently developed collaborative research programs with Australian researchers. ANFF's web site (www.anff.org.au) provides case studies of major innovations having significant commercial potential that have been developed using ANFF facilities. Through its nodes ANFF regularly trains new users of nanofabrication equipment, ensuring that Australia will have the technological capability to participate in a world market for nanotechnology-based products that is estimated to be worth \$3 trillion in 2020¹.

ANFF's comments in response to the Terms of Reference of the Economics References Committee follow.

The challenges to Australian industries and jobs posed by increasing global competition in innovation, science, engineering, research and education, with particular reference to:

(a) The need to attract new investment in innovation to secure high skill, high wage jobs and industries in Australia, as well as the role of public policy in nurturing a culture of innovation and a healthy innovation ecosystem;

Investments to support innovation should be focused on areas in which Australia has comparative advantage.

Areas like nanotechnology are transformative in that they will bring the opportunity for the Australian manufacturing industry to move into areas that are high skill and high wage sectors of the economy. Nanomanufacturing has been described as a mega trend, with the potential to surpass the digital revolution's impact on society². Estimates of the world market for nanotechnology products range to \$3 trillion by 2020³, with Australia poised to take a significant part of this due to its research leadership in photovoltaics, quantum computing, infrared sensing, silicon-carbide memories, high-bandwidth photonics, and electro-active polymers. This leadership represents an opportunity for Australia; an area to be addressed in light of recent suggestions by the Business Council of Australia, which has identified highly differentiated manufacturing as an area of comparative advantage that should be nurtured⁴.

For Australia to secure access to this market, it must undertake cutting-edge R&D and be able to translate this into prototypes that form the basis of new industries. Scaling to build affordable products creates new industries and new jobs in new factories. The physical scale of nanotechnology products negates any "tyranny of distance" in world markets and there are already examples of highly successful Australian companies participating significantly in niche markets in the nanoelectronics and nanophotonics fields. We are truly operating in a global market.

(b) The Australian Government's approach to innovation, especially with respect to the funding of education and research, the allocation of investment in industries, and the maintenance of capabilities across the economy;

Access to world-class research infrastructure is essential for innovation to flourish.

The Australian Government can foster a climate of innovation in four ways:

- Firstly by supporting research and development in universities, CSIRO, and industry. Others will undoubtedly comment on the international levels of such support compared with country GDP. Under the NCRIS model, ANFF charges researchers for access to facilities. The charge forms a small component of the variable costs of operating the facilities. However, the contribution of user income (forecast to reach \$3.8 million in 2013/14) is important to the sustainability of the facility. Funding of research through the ARC and NHMRC must continue to provide financial support for researchers to access shared facilities.
- Secondly by ensuring that sufficient young Australians are encouraged to study STEM disciplines. Here Australia produces many fewer engineers and applied scientists per head of population than countries winning in the innovation stakes.
- Thirdly by ensuring that facilities for R&D that are world-class.
- Fourthly by requiring public sector research to be appropriately exploited for its impact, especially in the STEM disciplines, by making recognition of impact and opportunities for exploitation a key performance indicator for publicly supported research programs.

(c) The importance of translating research output into social and economic benefits for Australians, and mechanisms by which it can be promoted;

Education is critical to ensure technology uptake, reduce skill shortages and enable informed public discussion.

Whilst there are estimated to be 100 nanotechnology companies in Australia⁵, many of the commercial clients accessing ANFF do not fall into this category. For example, 3D printing capabilities for rapid prototyping have been accessed by companies ranging from dental & medical, to automotive, to aquaculture. Educating Australian industry regarding the possibilities of micro- and nanofabrication is essential to capturing the maximum benefit from the ANFF investment. ANFF has

appointed a Business Development Manager whose role it is to foster this. Having government policy that encourages the uptake of technologies like nanotechnology is vital for Australia's long-term economic success.

To ensure continued public support for public-sector R&D the long-term importance to the economy of such R&D needs to be much better promoted by government and the university sector. Through appropriate programs in schools in science and civics, illustrations of successful innovations should be publicised, national innovators recognised and the role of innovation in keeping Australian industry internationally competitive better highlighted. Activities like choosing national research priorities should be intensified and industry and business people should be involved in decisions about public sector R&D expenditure.

(d) The relationship between advanced manufacturing and a dynamic innovation culture;

Access to research infrastructure is essential for innovation in manufacturing.

Innovation requires not just the development of new products but also the ability to manufacture those products in sufficient quantities at an affordable price.

Overseas countries that have a vibrant innovation culture have developed advanced manufacturing sectors. Examples include the USA, the Scandinavian countries and Israel. For some of these countries it is the ready availability of venture capital that drives the nexus; in others it is the close collaboration that has been developed between the private and public sectors. Advanced manufacturing can be as much a result of the application of new technologies to existing processes as it can to application of transformative technologies like nanotechnology and additive engineering. As an example, the success of the medical device industry in Australia owes much to the entrepreneurial founders of the successful companies quickly adopting what is new. By contrast, the science industry (a \$3 billion turnover per annum sector) having successfully exploited early CSIRO inventions, is now facing extreme international competition because of the lack of an adequate innovation pipeline.

National research infrastructure must enable researchers to take ideas from proof-of-concept through to developing the manufacturing processes and access to this infrastructure is essential for innovation in manufacturing. For example, SMEs cannot afford to fund cleanrooms. Even mature companies with substantial facilities cannot afford to vary the tightly controlled process used for day-to-day production to pursue innovation. Companies use state-of-the-art tooling to build standard products. Universities offer the ability to use non-standard or older tools (e.g., smaller wafer sizes) to create new products. Most OECD countries have developed or are developing capabilities similar to ANFF. These form an "industrial commons," a foundation of capabilities and knowledge that is shared within an industry sector.

(e) Current policies, funding and procedures of Australia's publicly-funded research agencies, universities, and other actors in the innovation system;

Cross-sector collaboration is needed to tackle the society's biggest challenges;
Public sector innovation should be better recognised and rewarded.

Australia desperately needs a culture in publicly funded research agencies and universities where taking good science and technology through to beneficial output is recognised and rewarded. In universities in particular, the application of ERA has pushed the pendulum too far towards publications as the acme of success and the arbiter of promotions. It is acknowledged that it more difficult to measure the innovative output of publicly funded research but this is a direction that the UK is exploring⁶. Perhaps a new direction from Australia in this regard should be piloted on the STEM disciplines. Assessment should involve representatives from industry and business, charged with making judgements on whether an innovation has significant economic benefit.

It is of note that nanotechnology research currently comprises above 10% of the funds expended by the Australian Research Council on project grants. Being able to do this research and capturing its benefits relies on the facilities that ANFF offers. Taking the research through to prototype innovations and achieving proof-of-concept is reliant on the private sector having access to state-of-art fabrication facilities without having to endure the capital expense, risk and time delays of setting these up.

Maintaining ANFF by the provision of Commonwealth funding is essential if Australia is to capture the benefits of its nanotechnology research. The remit of NCRIS capabilities like ANFF needs to be clearly extended to facilitating interaction between public and private sector researchers in collaborative ventures. Cross-sector collaboration is needed to tackle the big challenges, for example, in healthy aging, water and energy.

(f) Potential governance and funding models for Australia's research infrastructure and agencies, and policy options to diversify science and research financing;

The ANFF governance model a company limited by guarantee has been highly successful.

The ANFF has been formed as a company limited by guarantee. This has enabled the appointment of a non-representative Board, with members drawn from business and industry on State Government recommendations. As a result, any inter-institutional rivalry has been suppressed and strategic issues addressed. Collaboration between the public and private sectors has been able to be encouraged.

ANFF has found that the governance practice it has adopted has worked very effectively. We would commend this model for national facilities.

Although nodes have steadily increased their usage by industry and require industry to pay access costs that are much higher than those for public sector researchers, full cost recovery (including amortisation for capital equipment) would render use of the fabrication capability out of reach by Australian SMEs.

(g) The effectiveness of mechanisms within Australian universities and industry for developing research pathways, particularly in regards to early and mid-career researchers;

NCRIS provides rapid, cost effective access to infrastructure for ECRs.

National research infrastructures provide a pathway for early and mid-career researchers to advance their research because they no longer have to secure large grants to have access to major capital equipment. Further, the time taken to order, install and commission equipment is removed providing researchers with the ability to make rapid progress. The access policy applied ensures that quality research is supported, whilst providing early-career researchers with access at a cost level that can be supported by individual universities. ANFF makes no claim on intellectual property developed, leaving this with the researcher/home institution. Because ANFF trains researchers and publicises their activities, improved recognition follows, with collaborative opportunities arising.

However, it is critical that research funding continues to provide adequate support for access to national research facilities. Recent cuts to the Australian Research Council, if carried through to the size of project grants, will make it increasingly difficult for researchers to afford even modest access costs.

(h) Policy actions to attract, train and retain a healthy research and innovation workforce;

Continuity of funding is essential to attract and retain Australia's research and innovation workforce.

NCRIS provides access to world class facilities, including technical staff, to create a highly accessible research ecosystem. Schemes to promote the retention of top researchers in Australia, such as Australian Research Council Federation Fellows, and many Centres of Excellence are highly dependent on access to shared infrastructure.

ANFF employs, through its member organisations, 87 FTE of highly trained technical staff. These people provide both design and operating support for researchers to transform good research into inventions and subsequently innovations. Providing ongoing support for this cohort has meant that top flight researchers have been attracted to Australia and leading researchers with international reputations have stayed in Australia. The nanotechnology community, through ANFF and its biennial ICONN conference, has strongly fostered an innovative culture.

However, continuity of funding is critical to ensuring that the technical staff and researchers are retained. Funding schemes announced in October 2012, May 2013 and the recent May 2014 budget have extended operations of these facilities in increments of 12 – 18 months. Current funding now

runs for less than 12 months. The uncertainties in future funding continue to place a heavy burden on the ANFF Node Directors as they strive to maintain a highly skilled scientific workforce.

(i) Policy actions to ensure strategic international engagement in science, research and innovation; and

Strong international relationships are essential to operate in a global market;
International collaborations should be encouraged and used as a KPI for NCRIS capabilities

The US-Australia Joint Commission Meeting (JCM) in Science and Technology⁷ has been a valuable pathway for the development of significant international relationships. However, funding is needed to ensure the subsequent bottom-up growth of new collaborations. In the case of ANFF, the NCRIS investment provided significant leverage during the development of a strategic relationship with the US defense agencies. During 2014, representatives of the US defense laboratories will again visit exploring opportunities. It is noted that these agencies support 50% of the fundamental research in science and engineering at US universities and seek no ownership of the IP developed in collaborative projects. They are already supporting a number of significant Australian R&D projects under the ANFF umbrella.

ANFF has also developed close relationships through its international advisory committee with international facilities such as Cornell University, the London Centre for Nanotechnology, and EUMINAFab in Europe. By these links Australian researchers are kept abreast of what is happening overseas and are able to make their R&D known to a large international audience.

From a policy viewpoint, the government is encouraged to further promote these types of activities by NCRIS capabilities and include them as a KPI of the capabilities.

(j) Policy options to create a seamless innovation pipeline, including support for emerging industries, with a view to identifying key areas of future competitive advantage.

Voucher schemes for industry access of research infrastructure provide support for emerging industries.

To ensure the translation of invention from the laboratory to the market place, support for companies via voucher schemes such as the Victorian State Government's Technology Voucher Program and its predecessor the Small Technologies Industry Uptake Program (STiUP) has been very valuable. The funding enables the construction of the prototypes necessary to secure further capital. The vouchers are large enough to be meaningful, with a low administrative overhead and, in the case of the STiUP, did not require industry investment.

Internationally, the US Technology and Research Accelerating National Security and Future Economic Resiliency (TRANSFER) Act 2013 seeks to address the same issue.

In Conclusion

ANFF believes that it is important for government to identify areas likely to be of importance for emerging industries like it already has for nanotechnology. Supporting capabilities like ANFF is an effective way of promoting innovation. Making it a significant role of ANFF to foster innovation is seen as a worthy policy initiative.

The NCRIS program has been a significant positive factor in improving the innovative potential of Australia. ANFF would encourage the government to broaden its remit to encourage the facilities now developed to be made more readily available to Australian industry for innovation and for ANFF to be a hub for encouraging research collaboration and prototype development. State Governments should be actively included in this initiative.

As an enabling platform, investment in nanotechnology is essential for competitiveness of Australian research and manufacturing sectors.

¹ *Nanotechnology Research Directions for Societal needs in 2020*, Roco et al., Springer, Berlin and Boston,

September 2010

² *Nanomanufacturing – Emergence and Implications for U.S. Competitiveness, the Environment and Human Health*, United States Government Accountability Office, GAO-14-181SP

³ *Nanotechnology Research Directions for Societal needs in 2020*, Roco et al., Springer, Berlin and Boston, September 2010

⁴ <http://www.bca.com.au/newsroom/actions-needed-to-build-australias-comparative-advantages> accessed 29/07/2014

⁵ *Nanotechnology, Australian Capability Report Fourth Edition*, Australian Government Department of Innovation, Industry, Science and Research, January 2011

⁶ *A comparative methodology for estimating the economic value of innovation in nanotechnologies, A Report for DEFRA*, Oakdene Hollins Research, November 2010

⁷ Following the *Agreement Relating to Scientific and Technical Cooperation between the Government of the United States and the Government of Australia* (2007), Joint Commission Meetings (Feb. 2011, March 2013) were held to establish an overarching strategic dialogue between the two countries.