Our Ref: 08/294

Professor Roy Green
Reviewer, TCF Review
c/- The Manager, TCF Review Secretariat
Department of Innovation, Industry, Science and Research
GPO Box 9839

CANBERRA ACT 2601

23 May 2008

Dear Professor Green,

Re: CSIRO's Submission to the Review of the Australian Textile, Footwear and Clothing Industry.

We thank you for the opportunity to provide a submission to the Review of the Australian Textile, Footwear and Clothing (TCF) Industry by the Department of Innovation, Industry, Science and Research. Our attached comments are written with an understanding that CSIRO is actively undertaking research of particular relevance to the Australian TCF Industry.

Australia's TCF industry can only remain globally competitive through innovation and adaptation. CSIRO strongly supports the development of an integrated network of TCF innovation clusters to develop technology platforms which will provide the basis for a range of globally competitive products.

CSIRO can assist the sector by carrying out research and development, help transfer and adapt overseas technology, facilitate access to intellectual property, identify emerging opportunities that relate to the sector and provide specialist training. CSIRO is uniquely positioned to address issues on a national scale and incorporate research from wide ranging disciplines into a single research program, such as the Niche Manufacturing Flagship. As Australia's largest public R&D provider, CSIRO sees itself as an integral innovation partner of the Australian TCF industry. Our specific comments are attached.

Declaration of interest:

The CSIRO is a statutory authority under the Science and Industry Research Act 1949. The CSIRO is the recipient of Australian Government funding. Individuals associated with the Organisation are members of the Technical Textiles and Nonwovens Association Board and the Australian TCF Technology Network Steering Committee.

Please do not hesitate to contact me or the main submission contact should you require any further information.

Yours sincerely

Stephen Morton

Dr Steve Morton
Group Executive, CSIRO Manufacturing, Materials & Minerals

CSIRO Submission 08/294

To the Commonwealth Government's Review of the TCF Industries

May 2008

Enquiries should be addressed to:

Dr Bill Humphries

Acting Chief

CSIRO Textile and Fibre Technology

Cnr Colac Rd and Henry St

Belmont Vic 3216

Ph: (03) 5246 40000

Email: Bill.Humphries@csiro.au

Table of Contents

Executive Summary

Australia's TCF industry has remained competitive through innovation and adaptation. However, the industry has steadily been declining over the last decade and needs to re-evaluate its approach towards developing the technological advances required to allow the industry to survive and prosper.

Changing Nature of TCF Industries

Traditionally TCF products are considered low-tech manufactures. Labour costs tend to be a major element of cost, and the products tend to be undifferentiated, at least at the mass-produced (non-fashion) end of the scale. Barriers to entry are relatively low; competitive advantages in these products come from price rather than quality or brand names. It is generally accepted that Australia, along with other developed countries, cannot compete in this market.

Technology and global challenges, however, are opening up a vast array of new applications for textiles including textile composites for aerospace, automotive and marine applications, medical textiles including tissue engineering scaffolds, textiles for protection and improved human performance, filtration textiles for water and energy applications, fibrous materials as components of batteries, solar cells and organic light emitting diodes, large scale applications in agriculture, aquaculture and horticulture and many more. The markets for these textiles may be smaller than the traditional commodity textiles but growth rates are higher and quality and performance characteristics are key attributes rather than simply price making barriers to market entry much higher.

It is in these segments of the market where Australia's TCF industry can potentially be competitive if the industry is able and willing to embrace radical innovation. Success can only be achieved by increasing innovation intensity in material science, process engineering, supply chain management and product design and by moving away from the notion that textiles are only about clothing. Many future materials will be based on fibres, and by strategic focusing of effort, Australian TCF businesses can find niches where they can be competitive. The TCF industry must see itself increasingly as a manufacturer of advanced materials and take advantage of the explosion in new knowledge in material science and process engineering.

To meet the global energy and water challenges the future TCF Industry must make greater use of materials from renewable resources, and employ non-polluting processes which use little water.

Not all parts of our past TCF sector will be able to make the transition to be globally competitive and new types of companies may form based on new technology to replace companies which cannot make the necessary changes.

The Scope for the Industry to Take Advantage of R&D

The key question is: how can innovation intensity be increased? The main barrier is that industrial innovation is very high risk particularly radical innovation. Most Australian TCF companies are SMEs and therefore, individually, lack financial, technical and managerial resources to take on and manage the risks associated with radical innovation. To overcome this, groups of companies and researchers need to come together in innovation clusters to identify and develop technology platforms which will provide the basis for a range of globally competitive products in particular market segments where

Australia can have comparative advantage. One way to facilitate this may be to provide incentives that go some way in reducing the risks associated with radical innovation for industry and researchers alike. It is important to note that, to be competitive, critical mass is required to develop these platforms. They will require transformational and pre-competitive research activities which will be beyond the capacity of any one of the SMEs involved in the TCF industries. Therefore cooperative arrangements and Government support will be required.

The collaboration model could be established through a body operating in a similar fashion to the Australian TCF Technology Network. A Government program which supports a TCF network with the aim of establishing innovation clusters with incentives for collaborative research including the necessary market research could be effective in increasing innovation intensity and is worthy of consideration. The incentives must bring together a critical mass of researchers and industry to prosecute research aimed at the development of pre-competitive technology platforms. This is where market failure exists.

Future Skills

As the industry moves to a higher knowledge and innovation intensity, clearly this will result in changes to the skills required by the TCF workforce and in particular lead to an increase in the need for graduate engineers and technologists. The industry must attract process, chemical and mechatronic engineers but this will require the industry to improve its image as a knowledge-based industry with a genuine future in Australia, but this is part of the transformation that is necessary if it is to survive. Hiring staff from these disciplines means that they are not confined by traditional thinking and may bring new ideas and perspectives to the industry. They will also have the background to apply the new emerging sciences and technologies upon which the future textiles industry will be built.

Recommendations

- *Australia should look to identify and exploit new opportunities to develop TCF businesses based on the rapidly developing ability of fibres and fibrous structures, including nanofibres, to find application in an ever-increasing range of applications. (Section 2.1 page 10).*

- *TCF companies, researchers and end users should seek to form innovation clusters to identify and develop key technology platforms which will underpin the manufacture of globally competitive products in their market segment which have comparative advantage. (Section 2.2 page 15).*

- *Consideration should be given to the provision of targeted incentives for the formation of a TCF innovation network consisting of pre-competitive innovation clusters. The incentives must bring a critical mass of researchers and industry together in the clusters to undertake radical innovation activities. (Section 2.3 page 18).*

- *Any Government program which assists the bringing together of researchers and industry must have clear and workable guidelines for the ownership of intellectual property which arises from the collaboration. (Section 2.3 page 18).*

- *The TCF industry should seek to recruit skills in mechatronic, process and chemical engineering to help transform the industry into a modern material processing industry and underpin the development and production of world class products. (Section 2.4 page 20).*

1. Introduction

On the 8 March 2008 the Minister for Innovation, Industry, Science and Research, Senator Kim Carr announced a comprehensive review of the Australian Textile, Clothing and Footwear (TCF) industries to be conducted by Professor Roy Green in consultation with an industry reference group. The review will take into account the changing nature of the industries in the TCF sector and assess their current performance and prospects. It will seek to ensure that TCF industries are able to take advantage of new technologies and new research and have the skills and strategies that are needed to compete in the global market place.

CSIRO has been involved in textile and fibre research for more than 50 years and has an international reputation in this field. Historically much of its research has been in support of the wool growing industry, however, in the last 10 years textile research in CSIRO has diversified into a broad range of activities including wool product development, cotton processing, technical textiles and nanotechnology relevant to fibres and textiles. Case studies showing the benefits to the local TCF industries of this research are attached as Appendix 1.

CSIRO conducts strategic research that could transform elements of the existing and/or create new elements in Australia's TCF sector. It also carries out contract research and development for the current Australian TCF industry as well as providing specialised testing and commission processing activities on a fee for service basis.

A CSIRO officer is a member of the Technical Textiles and Nonwovens Association Board and another officer is a member of the Australian TCF Technology Network Steering Committee.

A paper titled *The Future is Fibres* has recently been developed by CSIRO in conjunction with Deakin and RMIT Universities and major industry players under the auspices of the Australian TCF Technology Network. This paper proposes a new vision for the TCF industries based on advances in material science and new textile applications and is attached as Appendix 2. It provides a clear strategy for creating a new TCF sector which is globally competitive based on innovation and comparative advantage.

This submission to the Review draws heavily from *The Future is Fibres* paper. Discussion is focussed on issues related to the changing nature of the TCF industries and how innovation can shape the future of this sector of the Australian economy.

2. Terms of Reference

2.1 The changing nature of the industries in the TCF sector and their current performance and prospects

Key points:

- The Australian TCF industry overall is in decline although some segments are globally competitive.
- Traditionally TCF products are considered low-tech manufactures.
- Technology and global challenges are however opening up a vast array of new applications for textiles.
- Development of products in these new segments require extensive knowledge of material science, process technology and end user application knowledge making barriers to market entry much higher.

It is well documented that in the face of global competition from low wage economies the size of the Australian TCF manufacturing industry has declined over the last decade. Imports now outstrip exports by a factor of more than 5 to1 and industry value-add has halved in the last decade[1]. China, the global giant of the textile industry, is the main country of origin for imports into Australia, particularly for clothing[2]. Production of yarn, fabric and clothing have all declined in the last 5 years but surprisingly clothing less than the other categories due to a strong specialist clothing sector. A strong sector of the TCF industry is technical textiles and nonwovens with a turnover of around $1.9 billion and a strong export focus[3].

Traditionally TCF products are considered low-tech manufactures. Products tend to have stable, well-diffused technologies largely embodied in capital equipment, with low R&D expenditures and skill requirements. Labour costs tend to be a major element of cost, and the products tend to be undifferentiated, at least at the mass-produced (non-fashion) end of the scale. Barriers to entry are relatively low; competitive advantages in these products come from price rather than quality or brand names.

Technology and global challenges are however opening up a vast array of new applications for textiles including textile composites for aerospace, automotive and marine applications, medical textiles including tissue engineering scaffolds, textiles for protection and improved human performance, filtration textiles for water and energy applications, fibrous materials as components of batteries, solar cells and organic light emitting diodes, large scale applications in agriculture, aquaculture and horticulture and many more. The markets for these textiles may be smaller than the traditional commodity textiles but growth rates are higher and quality and performance characteristics are key attributes rather than simply price. Development of products in these segments require extensive knowledge of material science, process technology and end user application knowledge making barriers to market entry much higher.

[1] TCF Review background paper 2008
[2] TFIA Submission to House of Representatives Standing Committee on Economics, Finance and Public Administration Inquiry into the state of Australia's manufactured export and import competing base now and beyond the resources boom
[3] TTNA Submission to the Productivity Commission Inquiry into Post 2005 TCF Assistance Arrangements 2003

It was concluded in the Productivity Commission Post 2005 Inquiry that the Australian TCF industry could not compete in the mass-produced, commodity segment of the industry. Other developed countries have come to similar conclusions, in particular European Union countries[4], and developed strategies for the development of a new differentiated TCF sector based on specialty products, new textile applications and customisation.

Box 1: Case Study - Nanofibre Innovation in Europe - Elmarco

Based on a radical innovation of the Technical University of Liberec, Czech Republic, in a short time (since 2004) Elmarco has become a world leader in the nanofibre industry. They are the first and still the only company in the world that produces machines for the mass industrial production of electrospun nanofibres.

Elmarco is working with a cluster of companies to develop products based on nanofibre technology. They have formed a joint venture with Alltracel of Ireland, (Nanopeutics) to operate in the field of nanofibre technologies for the wound-care market. They are also working with Cummins Filtration, the Nattick Soldier Centre, Clarcor Inc, Neumag, and many other companies and Universities to develop world class innovative products based on nanofibres in fields such as filtration, acoustic insulation, protective garments and energy applications.

At the beginning of 2006 Elmarco engaged 60 new employees, bringing the current total workforce to approximately 160, 45 of whom are engaged in R&D. The mean age of their staff is 32 years.

It was also pointed out by the Productivity Commission that segments of the Australian TCF industries had already adjusted to the new global environment and were finding competitive niches. In a major study of Australia's manufacturing sector, CSIRO's Manufacturing Roadmap identified the technical textiles sector as an area worthy of research and innovation investment on the basis of sustainability, R&D sensitivity and significance, rating it in the top 10 of the categories examined. CSIRO through its research and development and testing services has worked with companies who are producing competitive speciality products in filtration, geotextiles, acoustic fabrics, protective clothing, shade cloth, hygiene, surf and sportswear.

Although there are some segments of the industry which are already very competitive in global terms the prospects for turning the more general declining industry into a vibrant growth sector depend on the industry becoming more broadly globally competitive, and not all parts of our past TCF sector will be able to make that transition. New types of companies may form based on new technology (see Box 1) to replace companies which cannot make the necessary changes. The difficulty of making the transition should not be underestimated as it cannot be assumed that countries like China will remain solely a supplier of commodity textiles. In all sectors of the economy China is increasing its R&D expenditure[5] and it can be assumed that their textile industry will benefit from this investment and move into higher value products to mitigate the effects of the increases in labour costs which are already occurring. Therefore competition is going to intensify and there is no "silver bullet" solution that will lead to a transformed TCF industry. Success can only be achieved by increasing innovation intensity in material science, process engineering, supply chain management and product design and by moving away from the notion that textiles are only about clothing. Many future materials will be based on fibres

[4] Euratex Strategic Research Agenda June 2006
[5] Global R&D Report R&D magazine 2007

and will replace existing metal and plastic products in a range of industries, and by strategic focusing of effort, Australian TCF businesses can find niches where they can be competitive. It is also crucial to develop the skills base of the industry. Without the necessary highly skilled workforce, the industry will still struggle (see section 2.4).

It should be noted that the arguments presented here for the TCF sector are relevant to any industry sector in Australia but particularly in manufacturing. Jobs in manufacturing in a high wage economy must be underpinned by science and technology. A recent United States report[6] by the National Academies provides considerable evidence to support this view. A quote from this report which is particularly relevant to the TCF industries is:

> "Civilization is on the brink of a new industrial order. The big winners in the increasingly fierce global scramble for supremacy will not be those who simply make commodities faster and cheaper than the competition. They will be those who develop talent, techniques and tools so advanced that there is no competition."

There is no future for the TCF industries in trying to simply produce the same products as those produced in China or India, or the same products that Australia produced 30 years ago in a protected market. Australian TCF industries must strive to "develop talent, techniques and tools so advanced that there is no competition."

Recommendation:
Australia should look to identify and exploit new opportunities to develop TCF businesses based on the rapidly developing ability of fibres and fibrous structures, including nanofibres, to find application in an ever-increasing range of applications.

[6] Rising Above The Gathering Storm: Energizing and Employing America for a Brighter Economic Future Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology, National Academy of Sciences, National Academy of Engineering, Institute of Medicine ISBN: 978-0-309-10039-7

2.2 The scope for the industry to take advantage of research and development, new technologies and innovation in textiles and design, to build on its existing strengths and move into new areas where the sector can be competitive

Key points:

- Most Australian TCF companies are SMEs and therefore lack financial, technical and managerial resources to take on radical innovation activities.
- Cooperative structures are required to bring together innovative textile companies, leading edge end users and research institutions to identify and develop key technology platforms which will underpin the manufacture of globally competitive products in their market segment.
- Some technology developed by these clusters may not fit into the conventional manufacturing processes currently used in the TCF industry. These technologies may give rise to new spin-off, niche manufacturing companies which will form a new segment of the TCF industry.

The key question is: how can innovation intensity be increased? The main barrier is that industrial innovation is very high risk particularly radical innovation. Most Australian TCF companies are SMEs and therefore lack financial, technical and managerial resources to take on radical innovation.

This is not to say that Australian companies do not risk capital on the development of innovative processes. CSIRO has been involved in projects with TCF companies (see Box 2) that are high risk (and successful) and SME interaction with CSIRO has been made simpler by the recent establishment of an SME Engagement Centre which provides for a single point of entry for Australian Small to Medium Sized Enterprises to interact with the whole of CSIRO and especially Flagship programs.

However, the industry as a whole has limited capacity to carry out transformational research on a broad scale. Globally it is estimated that $1 trillion[5] is spent annually on scientific research across all sectors of endeavour. The Australian Bureau of Statistics estimated[7] that in 2003/04 the Australian manufacturing industry spent $3.3 billion on research and development and the TCF sector contributed $41 million to this total (approximately 0.0041% of global R&D expenditure). Obviously the Australian TCF industry will always be a relatively small player in the

Box 2: Innovation in On-Line Measurement Leads to Improved Hygiene Products

CSIRO Textile and Fibre Technology developed an on-line instrument for the measurement of the quality of nonwoven products being produced by Textor Pty Ltd. This opto-electronic device gives on-line information on the presence of unacceptable dark spots as well as the width of the fabric which is a critical production parameter.

This custom-designed quality control system gave Textor a critical advantage and helped retain crucial contracts with multi-national companies as well as gain export markets in South East Asia in the fast growing hygiene market.

[7] Australian Bureau of Statistics, Research and Experimental Development, Businesses, Australia, 2003-04 (8104.0).

global R&D market but many overseas companies are taking an "open innovation"[8] approach and trying to connect into the burgeoning knowledge base being created by R&D around the world. The TCF industry must see itself increasingly as a manufacturer of advanced materials and take advantage of the explosion in new knowledge in material science and process engineering. CSIRO has many international linkages and knowledge of developments throughout the world and can play an important role in connecting the industry to global developments. But the local industry must be able to further develop and adapt this knowledge as well as carry out its own unique R&D to ensure that it can establish globally competitive niches. It is unlikely to be able to do this effectively on a company by company basis. Co-operative structures are therefore likely to be required to allow the industry to identify, develop and implement technology platforms on which it can build a future industry.

Cooperative structures should bring together innovative textile companies, leading edge end users and research institutions. Australia is fortunate in having one of the world's largest specialised fibre research facilities at CSIRO Textile and Fibre Technology, backed up by the Centre for Material and Fibre Innovation at Deakin University and the textile, design, research and education delivery at RMIT.

In addition, CSIRO takes a long term perspective of global science trends and national research priorities, and considers its investment priorities in this context. Key global science drivers/trends have been identified and advanced materials, amongst others, has been identified as a platform capability around which it wants to build large-scale programs that combine physics, engineering, chemistry and biology to develop the materials of the future. This will provide an important source of knowledge from which the TCF industries can draw.

Industry will require innovations that will lead to successful commercialisation and it will be important to ensure that innovative projects are supported by sound market analysis i.e. it is vital that the commercial opportunities are real.

The cooperative structures or "innovation clusters" would identify key technology platforms which will underpin the manufacture of globally competitive products in their market segment. Possible areas to build cluster platform technologies that have been discussed in various industry forums are:

- Military, sportswear, workwear and protective clothing – based on the R&D expertise within CSIRO, Defence Science and Technology Organisation and the Australian Institute of Sport who are already building a collaborative cluster in textiles for improving human performance.
- Medical and hygiene textiles based on Australia's strengths in medical research, clinical practice and textile research.
- Water and Energy – many of the issues facing Australia are related to water and energy. Textile materials can play a future role in water management, desalination, filtration for advanced power generation systems, energy scavenging devices, flexible solar cells etc.
- Automotive, aerospace, marine – textiles and fibre reinforced composites are crucial components for these industries, which have a strong and in some cases

[8] Open Innovation by Henry Chesburgh Harvard Business School Press ISBN 1-57851-837-7

growing base in Australia. Innovation in the fibrous component of composites can give these related Australian manufacturing sectors a competitive advantage.

- Mining – Australia is home to the biggest mining companies in the world and is acknowledged as the world leader in mining services. Textiles are used in mining operations, refining and smelting. Partnerships between the mining and mining services sector, textile companies and researchers will provide world class products for this industry.

Technology developed by these clusters may not fit into the conventional manufacturing processes currently used in the TCF industry. These technologies may give rise to new spin-off, niche manufacturing companies. Examples of these technologies are the carbon nanotube yarn, web and fabric technology being developed within CSIRO Textile and Fibre Technology and the Niche Manufacturing Flagship and nanofibre tissue engineering scaffolds under development by CSIRO Textile and Fibre Technology and CSIRO Molecular and Health Technologies.

The cluster model is depicted in the Figure 1. The key points are:

- Researchers, TCF companies and leading edge end users form clusters to identify technology platforms which should be developed which will underpin the development of globally competitive products.
- The clusters should be applications focussed, built around industry segments where Australia can have comparative advantage and there is leading edge Australian end users.
- Critical mass should be deployed to ensure that the technology platforms are at the forefront of knowledge and give the clusters intellectual property that leads to commercial advantage.

Box 3: Bionic Technologies Australia – A Cluster Developing World Class Medical Textile Implants

Bionic Technologies Australia is a consortium originally formed through a Victorian STI Grant consisting of Polynovo Biomaterials (a CSIRO spin-off company) CSIRO, the Bionic Ear Institute, St Vincent's Hospital, and The University of Wollongong.

As part of its activities it is developing neural repair guides for implantation into patients for the repair of severed peripheral nerves.

These guides are made from a novel biodegradable polymer which is extruded into a filament which is then fabricated into a micro-knitted tube with a special fibre coating. This technology is currently undergoing animal trials.

This is an example of bringing a cluster together with world class expertise in material science, textile technology, medical science and clinical practice to produce an innovative high value product.

- Some clusters will commence without an existing TCF company where an appropriate and willing company does not yet exist (e.g. the Bionic Technologies Australia cluster developing neural repair guides - see Box 3 and the Niche Manufacturing Flagship development of CNT yarns and their applications).

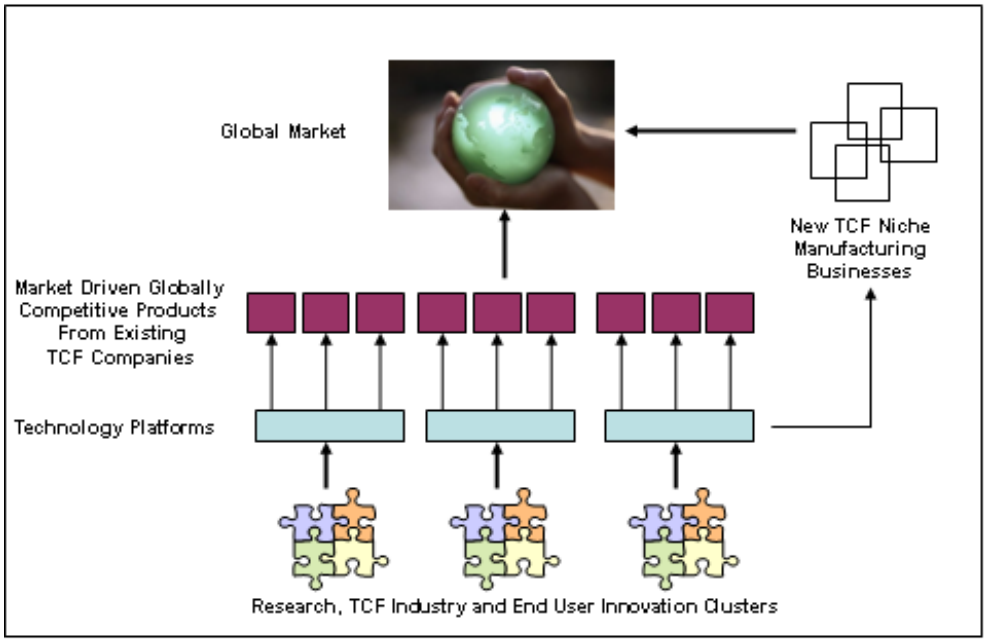


Figure 1: Innovation Cluster Model

The work in all clusters should be predicated on the underlying need to move to the use of materials from renewable resources, near zero water use and non polluting textile processes. In the renewable resources area CSIRO and the Grains R&D Corporation are working together in an initiative to develop a lucrative crop bioindustry in Australia which could result in new sources of biomaterials as an input material to the TCF industry. Potentially this will help the environmental sustainability of the industry by replacing petrochemical feedstocks with renewable plant resources. Crop biofactories are inherently suited to Australia because of our progressive agriculture and downstream processing capabilities, diversity of crops and growing seasons and strong R&D and regulatory infrastructure. If this initiative is successful it could link the Australian TCF industry into the emerging bioeconomy and help give the industry another comparative advantage.

Although the innovation cluster model has many attractions there is, however, an issue of market failure related to the TCF industry carrying out radical innovation either on an individual or cluster basis. In CSIRO's experience it has been difficult to engage with TCF companies to carry out transformational research. The SMEs involved in this sector have limited funds available for R&D and therefore industry projects are usually limited to around the $200,000 scale. CTFT has tried to form cluster activities in the past through a proposal for a CRC for Technical Textiles and a Technology Development Fund proposal in the area of smart fire-fighter ensembles. The CRC bid was not successful despite a commitment of over $1 million per year from the industry participants (mainly due to the concern that the industry would be "double dipping" as it already had access to the TCF SIP scheme) and the Technology Development Fund was withdrawn before our proposal was assessed. These proposals showed the willingness of the industry to cooperate in R&D activities but without Government assistance the proposals did not progress. Government incentives for the establishment of the innovation clusters proposed in this submission would therefore be in response to this demonstrable market failure.

A cluster model has been discussed within the Australian TCF Technology Network and has received support in principle; however more resources are required to turn this idea into reality The collaboration model reduces both technical and commercial risk but increasing innovation intensity within this cluster framework is still likely to require Government policies which provide an incentive for industrial risk-taking in the innovation field. This issue is addressed in the next section.

Recommendation:

TCF companies, researchers and end users should seek to form innovation clusters to identify and develop key technology platforms which will underpin the manufacture of globally competitive products in their market segment which have comparative advantage.

2.3 The sector's access to and use of government programs aimed at promoting innovation and productivity

Key points:

- With the help of the SIP scheme some companies have successfully transitioned into brand/design/supply chain specialists and manufacturers and have found successful niches.
- SIP grants are often used for capital equipment or minor product development rather than radical innovation, which merely prolongs business as usual.
- To achieve the desired transformation of the industry, consideration should be given to more precisely targeted incentives for innovation, particularly radical innovation, which will lead to differentiated globally competitive products.
- This can best be done by providing incentive for the formation of pre-competitive innovation clusters.
- Researchers and industry must have clear and workable guidelines for the ownership of intellectual property which arises from cluster activities.

The current TCF industry has many strengths, and that segment of industry still surviving has consolidated its position by exploiting these strengths, including:

- Design capability;
- Fashion orientation;
- Effective sourcing;
- Brand management and global supply chain management;
- Testing facilities and accreditation systems;
- Technical knowledge; and
- Innovative and entrepreneurial attitude

The industry has restructured to take advantage of these strengths, assisted by the benefits of the TCF Strategic Investment Program (SIP). Some companies have successfully transitioned into brand/design/supply chain specialists and manufacturers have found successful niches - eg. in technical textiles, defence and health applications and protective textiles, and we have a textile design and fashion sector that has high profile due to its innovative design, niche marketing and, its connectivity with global supply chains.

The SIP scheme gives companies access to grants for both capital equipment and research and development but to a cap based on the company's turnover. From feedback from a number of companies, grants are sought more often for capital equipment than R&D. This reflects the comparative risks of achieving a return from these two different investments. Capital expenditure on equipment is perceived to be much less risky than investment in R&D, on average. However, the capital equipment that can be purchased in Australia can be purchased anywhere in the world and therefore in itself does not give Australian companies a competitive advantage. What gives competitive advantage is the processing of innovative materials (including from new renewable sources), knowledge based flexible/adaptive manufacturing processes, digital manufacturing, process integration and online quality inspection systems, new process combinations and near

wasteless, non-polluting textile production processes[9]. All of these require on-going innovation to ensure a competitive advantage. Of course innovation is not enough on its own. It must be linked to the general expertise required to manage a business including marketing and financial expertise. Where companies have used the SIP scheme for genuine innovation, too often it has been for incremental development or modification of existing processes and products which are really part of the normal business processes. In such cases, the government funding therefore was only prolonging the life of business-as-usual (effectively a subsidy), rather than achieving the intended purpose of enabling TCF companies to transform their businesses by developing genuinely new products and markets. The exclusion from the SIP scheme of companies in the technical textiles sector left out many of those with the attitudes and abilities to drive the changes needed in the TCF sector that the scheme was trying to achieve.

The desired transformation of the industry could be accelerated significantly if precisely targeted incentives are in place for innovation, particularly radical innovation, which will lead to differentiated globally competitive products. The industry requires assistance to aggressively pursue innovation to stimulate the existing TCF industry to build on existing strengths (similar to the European strategies) as well as nurture new strengths of an emerging major fibres based sector.

The collaboration model described in the previous section could be established through a body operating in a similar fashion to the Australian TCF Technology Network. This Network has been successful in bringing researchers and industry together; however it has very limited resources. A Government program which supports a TCF network with the aim of establishing the innovation clusters with incentives for collaborative research including the necessary market research could be effective in increasing innovation intensity and is worthy of consideration. The incentives must bring together a critical mass of researchers and industry to prosecute research aimed at the development of pre-competitive technology platforms. This is where market failure exists.

The issue of how intellectual property rights are handled within these clusters must be addressed as this is often a barrier to collaboration. Perceptions about the value of existing or potential IP can increase the difficulty of developing collaborative arrangements and add significantly to the effort necessary to proceed. Unfortunately, organisations playing different roles in the clusters may have a different appreciation of IP rights, manage them in different ways (including the assignment of ownership) and take different approaches to negotiating collaborative arrangements involving the development of IP or the use of background IP. In many cases the costs involved in overcoming these differences are excessive. Any Government program which assists the bringing together of researchers and industry must have clear and workable guidelines for the ownership of intellectual property which arises from the collaboration.

[9] Manutex Research Roadmap Joint Research Strategy Initiative for the Future of the European Textile, Clothing and Machinery Industries May 2007

.

Recommendations:

Consideration should be given to the provision of targeted incentives for the formation of a TCF innovation network consisting of pre-competitive innovation clusters. The incentives must bring a critical mass of researchers and industry together in the clusters to undertake radical innovation activities.

Any Government program which assists the bringing together of researchers and industry must have clear and workable guidelines for the ownership of intellectual property which arises from the collaboration.

2.4 The future skills needs of the industries, current skill shortages and the availability and appropriateness of education, training and professional skills development opportunities within and for the sector

Key points:

- Australia has limited undergraduate courses in textiles whereas China and other countries are still producing large numbers of textile graduates.
- To compete, Australia either has to recruit from overseas or attract other disciplines such as mechatronic, process and chemical engineers who can adapt but also change the thinking related to how fibres are processed.

As the industry moves to a higher knowledge and innovation intensity, clearly this will result in changes to the skills required by the TCF workforce and in particular lead to an increase in the need for graduate engineers and technologists. Specialist undergraduate courses in textile technology have closed at the University of New South Wales and Deakin University. RMIT maintains courses in textile technology and design.

It is interesting to contrast this with China which has around 8 major Universities (such as DongHua University in Shanghai and Xi'an Polytechnic University) whose core activity is textile technology. France has two "Grande Ecoles" one in Roubaix the other in Mulhouse devoted to textiles, and these have driven the growth of a vibrant technical textiles sector in France which has transformed their traditional silk and wool industry into a 6 billion Euro technical textiles industry[10] (see Box 4). Even the United States has a major University activity in textiles through The National Textile Centre (NTC) which is a research consortium of eight universities: Auburn University, Clemson University, Cornell University, Georgia Institute of Technology, North Carolina State University, University of California - Davis, University of Massachusetts - Dartmouth, and

Box 4: French Technical Textiles Industry based on Training and Innovation

French production of functional and technical textiles:

- Number 2 manufacturer in Europe, after Germany
- 450 companies, primarily SMEs
- 6 billion Euros in turnover, accounting for 37% of the textiles industry

Top Universities and Training

The country's focus on quality education and producing top-calibre engineers and technicians has contributed to the evolution of the textile industry in France from clothing to the use of high-tech fabrics in the design of ultimate performance products. The multidisciplinarity of France's engineers is a key factor in this transformation. Internationally-renowned engineering schools include ENSAIT and ESTIT in Northern France, ENSITM in Northeastern France and ITECH in Lyon.

R&D and Innovation

In addition to research at France's top schools and the Institut Français du Textile et de l'Habillement (a large industry-focussed textile R&D organisation), partnerships with other branches of activity have guaranteed continued development in functional & technical textiles: civil engineering (LIRIGM), agronomy (INRA), micro and nano-electronics (CEA Minatec),medical (INSERM), materials & sensors (INSA); National Center for Scientific Research n Lille, Lyon, Mulhouse and Troyes.

[10] http://www.invest-in-france.org/uploads/files-en/07-06-25_150146_pub_20050512_en_functional_and_technical_textiles_in_france_proven_expertise_success.pdf

Philadelphia University. The institutions share human resources, equipment and facilities. Although this is mainly a research consortium one of its missions is: “To train personnel, establish industrial partnerships and create transfer mechanisms to ensure the utilization of technologies developed.” North Carolina State University has a large undergraduate program in textile technology.

Due to a lack of demand for places it is unlikely that any Australian university will establish a new undergraduate course in textile technology. This leaves the industry two options to augment the local supply of textile technology graduates. The first, an immediate more short term option, is to attract textile graduates from overseas. CSIRO Textile and Fibre Technology regularly provides internships for undergraduate and Masters students from France, Germany, China and India who come to Australia for up to 12 months. Without exception these students enjoy their experience in Australia and could form a pool of talent that could be recruited by the industry in the future. The second option is to attract process, chemical and mechatronic engineers into the TCF industry. This could provide a longer term, sustainable solution, but will require the industry to improve its image as a knowledge-based industry with a genuine future in Australia, but this is part of the transformation that is necessary if it is to survive. Hiring staff from these disciplines means that they are not confined by traditional thinking and may bring new ideas and perspectives to the industry. They will also have the background to apply the new emerging sciences and technologies upon which the future textiles industry will be built.

It should be noted that CSIRO Textile and Fibre Technology, with the support of the International Fibre Centre, presents specialist courses on various aspects of textile technology. These have been very well attended and with industry support will continue. These courses do not replace undergraduate courses but are complimentary as they provide specialist professional development and can be used to train graduates from other disciplines in the specialisations of the TCF sector.

Recommendation:
The TCF industry should seek to recruit skills in mechatronic, process and chemical engineering to help transform the industry into a modern material processing industry and underpin the development and production of world class products.

3. Summary

Australia's TCF industry has remained competitive through innovation and adaptation. However, the industry has steadily been declining over the last decade and needs to re-evaluate its approach towards developing the technological advances required to allow the industry to survive and prosper.

Many opportunities will arise as materials based on fibres increasingly find applications in textile composites for aerospace, automotive and marine applications, medical textiles including tissue engineering scaffolds, textiles for protection and improved human performance, filtration textiles for water and energy applications, fibrous materials as components of batteries, solar cells and organic light emitting diodes, large scale applications in agriculture, aquaculture and horticulture and many more. The industry should increasingly see itself as a manufacturer of advanced materials and take advantage of global as well as Australian research in fibre, textile and material science. It is important that the industry also takes into account the long term need to move to the use of materials from renewable resources, near-zero water use and non polluting textile processes.

Industry and researchers need to come together to identify and develop technology platforms which will provide the basis for a range of globally competitive products. One way to facilitate this may be to provide incentives that go some way in reducing the risks associated with radical innovation for industry and researchers alike. It is important to note that, to be competitive, critical mass is required to develop these platforms. They will require transformational and pre-competitive research activities which will be beyond the capacity of any one of the SMEs involved in the TCF industries. Therefore cooperative arrangements and Government support will be required.

CSIRO can assist the sector by carrying out research and development, help transfer and adapt overseas technology, facilitate access to intellectual property, identify emerging opportunities that relate to the sector and provide specialist training. The TCF industry is largely made up of SMEs and SME interaction with CSIRO has been made simpler by the recent establishment of an SME Engagement Centre which provides for a single point of entry for Australian Small to Medium Sized Enterprises to interact with the whole of CSIRO and especially Flagship programs. The Niche Manufacturing Flagship as well as the activities of CSIRO Textile and Fibre Technology are particularly relevant to the TCF industries but many parts of CSIRO have activities which may in some way be relevant to this sector, in particular CSIRO Material Science and Engineering and CSIRO Molecular and Health Technologies, both of whom have strong material science capabilities. In addition, the Minerals Down Under Flagship can provide a vehicle for developing textile solutions of value to the mining sector. Increasingly research for the TCF industry will require a multi-disciplinary approach and CSIRO can assemble teams from across the organisation as well as the University sector to meet these multidisciplinary challenges

As described in the body of the submission, progress is most likely to be made through the establishment of a network of innovation clusters which allow critical mass to be deployed to establish leading edge platform technologies which will underpin a world class industry. Government can provide incentives and support for the establishment of such clusters.

Appendix 1 – Case Studies: R&D helping the TCF Industries

These examples highlight the benefits of properly funding major transformational research to overcome market failure. While the value of this research to Australia and the Australian TCF industry is now clear, no individual company within the Australian TCF industry could have supported these major research projects.

Electrostatic Filters

With funds from Australian Wool Innovation, CSIRO Textile and Fibre Technology recently developed a filter material from a special blend of fibres which results in the material having a high level of electrostatic charge which has a very long lifetime (greater than 3 years). This charge results in the material having high efficiency but low pressure drop, making it ideal for respirator and air-conditioning filters. The researchers optimised the blend ratio, and developed manufacturing procedures to produce the filter material.

Several commercial partners assisted at various points in the project, one of them the Adelaide-based wool technology company Michell Pty Ltd, financially supported fibre selection trials by CSIRO.

These trials were followed by an independent overseas evaluation of CSIRO's process by consultants engaged by Michell. These trials confirmed that the filter medium performed well compared to the currently available filters.

An international global leader in the manufacture of respirators, approached CSIRO about its filter manufacturing process, and was put in touch with Michell.

This company had rigorous quality and performance requirements for its products, which are sold in leading trade and retail outlets across Australia. Negotiations between the parties reached a successful conclusion, with the result that Michell now has a commercial supplier relationship to produce half a million personal respirators and refill cartridges over the next twelve months.

Sportwool™

During the mid 1990's a shift began to occur within the Australian Football League (AFL) from solid shade or colour blocked vertical or horizontal striped or harlequin style garment designs knitted from dyed yarn to sublistatic heat transfer printed polyester products. This was driven by the need for easy application of sponsor logos/player numbers, ability to create more sophisticated designs at much lighter fabric/garment weights and at greater garment tensile strengths.

CSIRO Textile and Fibre Technology (CTFT) (then Division of Textile Physics) had a history of working in the area of clothing physiology and a major supplier of apparel to the AFL, Perth manufacturer Burley-Sekem contacted this division to discuss the development of a sublistatically printable wool football guernsey fabric as a higher performing, more comfortable to wear alternative to the recently emerging 100% polyester products.

During the same period the Australian Wool Research and Promotion Organisation (AWRAP) had been responding to a request from Melbourne cycle-wear manufacturer

Giramondo Cycles for a heat transfer printable wool containing fabric for cycling tops. Cyclists had largely moved to printed polyester garments but had historically worn wool.

CTFT, with funding from the wool research body of the time, initiated a project to develop a heat transfer printable wool containing fabric as an alternative to 100% polyester for use in Australian sport. During the project yarn counts and fabric structures were optimised for a range of sporting activities from a very light weight 120 g/m² fabric quality for cycling wear to a robust 250 g/m² quality for physical contact sports. Specialist fabric finishes maximising moisture management, minimising the emission of odour, protecting from yellowing during high temperature printing and to preserve fabric strength during dyeing/printing were developed. Significant product performance testing in the laboratory and on athletes backs in a climate chamber were also undertaken to objectively measure the performance enhancing benefits of the product. The products were named "Sportwool™".

In the ten years which have passed since the completion of the Sportwool™ R&D project the annual turnover from the manufacture of Sportwool™ fabric in Australia is $2 million. Licensed Sportwool™ fabric is manufactured by Victorian textile manufacturers Melba Textiles Pty Ltd and ABMT Textiles Pty Ltd. Licensed Sportwool manufacturers are also operating in the UK, Italy, Japan and South Korea. A Sportwool™ licence fee ensures a revenue stream back to Australian. A number of non-licensed fabric ranges are also offered using Sportwool™ generated IP.

CSIRO developed Sportwool™ products have been worn by Australian athletes at Commonwealth and Olympic games, and at a professional sporting level in cycling, squash, football and cricket and is increasing being worn in industry as a protective garment to protect from exposure to heat and ultra violet radiation under the sub-brand WoolScience™.

Next-to-Skin Wool Garments

Many consumers have traditionally felt that wool was not suitable for next-to-skin apparel as it is 'prickly or itchy' and indeed a common belief, even amongst the medical/dermatological communities was that wool was a common cause of an allergic reaction. A major research program at CSIRO combining both textile science and physiology led to the transformational understanding that fine wool is indeed very suitable for next-to-skin wear and that the unpleasant reactions that sometimes occur are related to the use of an inappropriate coarse wool quality which then mechanically irritates the skin. In marketing terms this major finding has 'opened the doors' on new opportunities for wool next-to-skin garments. This knowledge has been a key foundation stone for several Australian SMEs in the TCF sector. Examples include:

(a) Tastex: Tastex is a small knitwear manufacturer based in Hobart and their business is centred on 'Premium woollen wear for schools, government and private business that is comfortable, long lasting and easy to care for.' (http://www.tastex.com.au/). Tastex was an early adopter of the results of the CSIRO research and quickly moved to offer a range of school garments with a finer wool quality in line with the outcomes of the CSIRO research. (School garments were traditional made from coarse wool to both meet a particular price point and were well known to be particularly 'prickly'.) This proved to be a major marketing success giving them a significant market advantage. Within a short time Tastex's whole production of schoolwear had moved to the new quality.

(b) iZWool: Quoting from their website: 'iZWool International P/L has developed and marketed fabrics to suit many different sporting applications, including mountaineering, motor cross, equestrian, sailing, cycling and many other sporting disciplines. Feedback on the performance of the wool based fabrics has been excellent.' (http://www.bbec.asn.au/izwool2001.pdf) iZWool is based in Western Australia and in the development of their product range sought detailed specific information from CSIRO on wool qualities suitable for next-to-skin wear. iZwool's successes have included managing a supply chain, manufacturing and supplying a major international airline with a range of wool undergarments for their flight crew.

(c) Hedrina Textiles: 'Hedrena became reality in 1992…. Within months of registering the brand 'Hedrena' a unique pure wool knitted fabric was being developed under the guidance of the CSIRO and the Australian Wool Corporation. Years later, Hedrena garments are proudly worn by people throughout the world. The 'Hedrena Wool' logo has become an international symbol of quality and classic style. Often overseas visitors have Hedrena garments at the top of their shopping lists.' (http://www.hedrena.com.au/). As stated in the quote, Hedrina Textiles utilised the outcomes of the CSIRO research to develop its core product: men's and women's 100% wool underwear and base layer fabrics including a lingerie range. CSIRO worked closely with Hedrina including undertaking specific technical trials as part of the original product development. Excellent next-to-skin comfort was and is critical for this product range. Hedrina has grown steadily from its beginnings and now has seven retail outlets in three states as well as selling their products in most major Department stores around Australia. It is interesting to note that the original concept fabrics and products based on the company's interaction with CSIRO have stood the test of time and remain as their 'signature' products.

(d) In a broader sense the outcomes of this transformational CSIRO research have now been absorbed widely by the industry with all manufacturers of next-to-skin wool fabrics and garments being aware of the critical need to carefully choose wool quality to meet this key market requirement for comfort. Other Australian SMEs who would use this information virtually daily include The Merino Company and DPK.

Acoustic Modelling Software

CSIRO developed a software simulation package for I.N.C. Corporation Pty Ltd (a medium-size private company based in the eastern suburbs of Melbourne, that produces high-performance, environmentally-sound engineered materials, for Original Equipment Manufacturers) to routinely use to assist with product development. The package implements state of the art mathematical models of the acoustic energy absorption given basic parameters of the fibrous material. This software has enabled I.N.C. to shorten their product development cycle by reducing the number of experimental samples required to iterate to the specified design.

Easycare Wool/Cotton Knitwear

Bleaching and dyeing procedures to provide a wide range of solid shades were developed and commercialised for circular knit fabrics manufactured from a blend (30/70) of shrink proofed wool and cotton. The dyed fabrics met specified criteria for easycare, appearance after machine wash/tumble dry, colourfastness and resistance to pilling. The

technology was scaled up and proven in industry in collaboration with Rocklea Spinning Mills. The product developed was used in Sheridan's Elite Manchester collection and Bonds underwear in Australia and exported to the Hong Kong manufacturer Fountainset to be made into apparel for women and young people and available through the Lands End catalogue, one of the biggest distribution outlets in the US. Woven product retailed in Polo Ralph Lauren's premier store in New York in the form of "Sportsmans Flannel" a casual shirt.

Easycare Suits

Easycare describes garments that retain their appearance after repeated machine washing and tumble drying. They can be worn immediately without having to spend a considerable amount of time restoring the garment to a pristine or "just pressed" appearance. The seams must remain flat and without pucker, the fabric must remain smooth without wrinkles and any creases or pleats must remain in place. Suits are complex garments, assembled from as many as 50 separate components and accessories. A suite of easycare technologies to meet specified performance requirements were developed by CSIRO in order to achieve the desired outcome. The processes developed were commercialised by Berkeley Apparel (Melbourne) with the release of a machine washable, 60/40 wool/polyester suit through David Jones retail stores.

Optim Technology

The Optim fibre treatment developed by CSIRO gives wool a silk like quality for extremely fine, soft and lightweight fabrics. The Optim manufacturing process stretches fibres 40 to 50% in a specially designed machine, making each fibre 3 to 3.5 micrometres finer. The reduced diameter fibre is then chemically set in this softer form. Optim fibres have increased length and strength, as well as a silk-like lustre, but retain many of the desirable properties of fine wool such as drape, handle moisture absorbency and comfort. This technology was adopted in Australia, initially by Port Phillip Mills (Melbourne) and later by Michell (Adelaide) with Optim fibre exported to international markets. The commercial design for the Optim machine was developed by Invetech (Melbourne) in collaboration with CSIRO.

Improved Bleaching Technology for Wool and Wool Blend Products

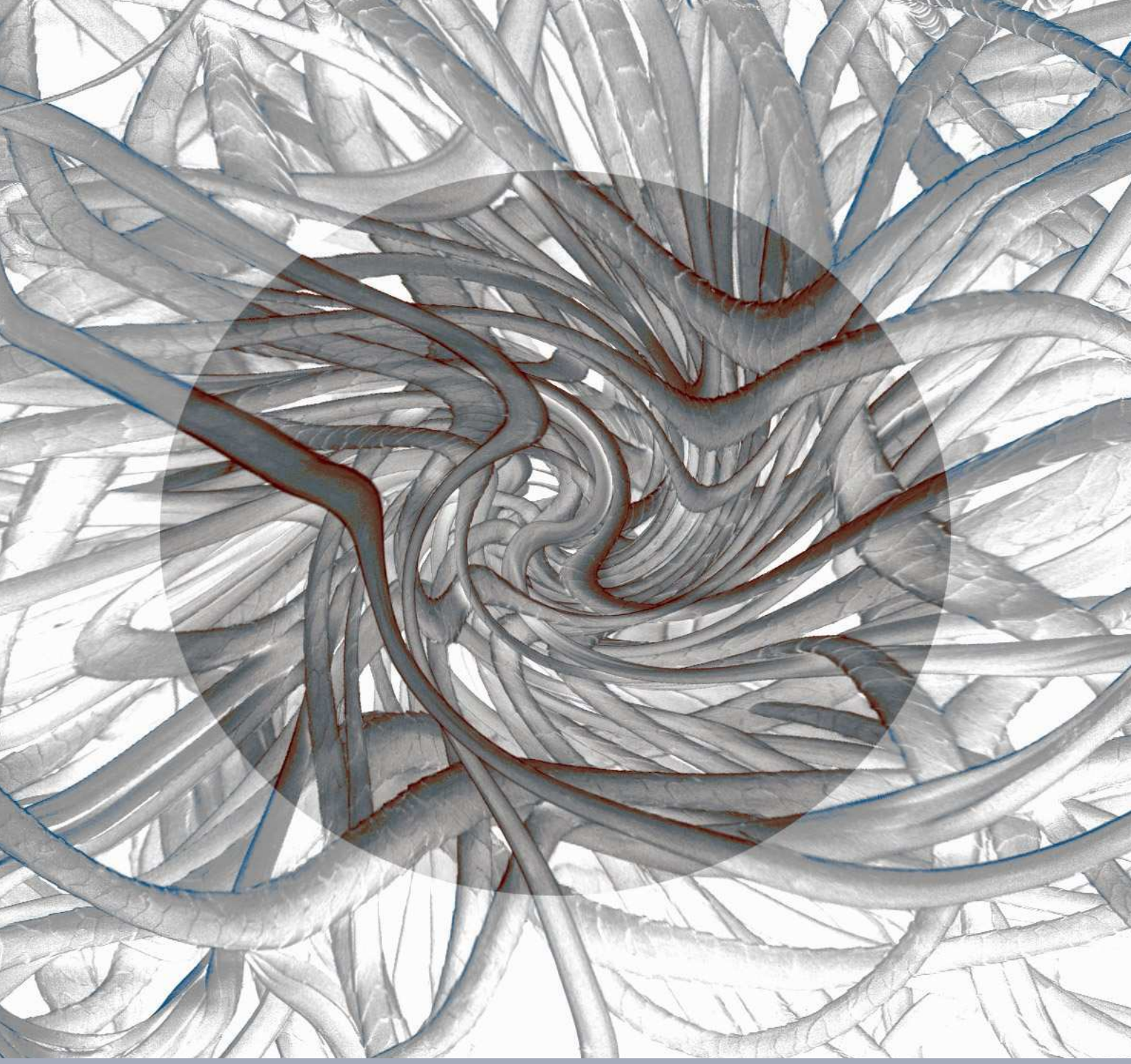
ColorClear™ WB Technology is a new reductive bleaching method for wool and wool blend whitening. The technology uses sodium borohydride chemistry to produce the active reductive bleaching species, hydrosulphite, in situ. It was originally developed by the Rohm and Haas Company and has been applied in the textile industry for use in dyestuff stripping, decolorisation of effluents and whitening of fibres. CSIRO has further developed/optimised the technology for wool textiles, and this wool specific technology has been benchmarked against the current industry standards for both whiteness and fibre damage. This technology was adopted by DPK Australia, a supplier of high quality circular knit fabrics and Australian Country Spinners to achieve superior whiteness and brightness.

Fibre Innovation for Nonwovens

Melbourne manufacturer Melded Fabrics are suppliers of nonwoven fabrics to the automotive industry and also supply nonwoven wall coverings to the exhibition industry, much of it exported. They use specialty bicomponent fibres to produce their unique products but their supplier, Dupont, had decided to exit that particular market and advised them of their intention approximately 12 months in advance. In trying to find alternative suppliers the company discovered that the Dupont product had unusual

properties that they did not understand and when they manufactured fabrics from other suppliers' fibres they could not reproduce the original fabrics' unique attributes which were providing them with their market edge. CSIRO TFT was engaged to understand the problem and to help to provide a solution. After several months of detailed investigations into the fibre and fabric properties and manufacturing processes it was discovered that the Dupont fibre's properties were partially due to the antiquated equipment being used, which was producing an unusual structure not produced by the new supplier’s machines. Melded's chosen alternative supplier was informed of this and they were able to simulate it through modifications to their manufacturing equipment and they now supply Melded Fabrics with a satisfactory product. This allowed Melded to continue operating through very difficult circumstances and maintain their product differentiation and market edge.

Appendix 2 – The Future is Fibres: Industry Discussion Paper



The Future is …**FIBRES**

Vision and Strategy

Creating a Vibrant Fibre Sector in the Future Australian Economy

AUSTRALIAN TCF TECHNOLOGY NETWORK

RMIT UNIVERSITY

DEAKIN UNIVERSITY

CSIRO

CONTRIBUTING AUTHORS

Nigel Johnson	*Chief, CSIRO Textile and Fibre Technology*
Keith Cowlishaw	*Head of School, Textiles & Fashion, RMIT*
Xungai Wang	*Alfred Deakin Professor, Centre for Material and Fibre Innovation Deakin University*
Peter Kreitals	*Manager, Australian TCF Technology Network*
Lachlan Caddy	*Network Officer, Australian TCF Technology Network*

ACKNOWLEDGEMENT

The authors would like to thank all the various parties that have contributed to the development of this paper, particularly the participants at the TCF Technology Network's 2007 Strategy Workshop on 23 August and most notably the collective members of the Network's Advisory Committee and Strategy Group, all of whom have generously contributed their thoughts, efforts and time:

- *Paul Cacioli, Gale Pacific*
- *Sam Cassarino, Yakka*
- *Robert Bell, Madison Filter*
- *Steve McMillan, Melba Industries*
- *Darren O'Loghlin, Bruck Textiles*
- *Thomas Seeger, Bruck Textiles*
- *Sarah Beilby, ADA*
- *Phillip Butler, Textor*
- *Bill Humphries, CSIRO*
- *Peter Cookson, Deakin University*

1. THE EVOLVING SOPHISTICATION OF THE FIBRES SECTOR

Fibres are integral to all living things, from the twisted strands of our DNA to the complex fibrous structures that make up our largest mammals and trees. Life on earth has evolved by assembling fibres and fibrous composites into complex materials with a wide range of sophisticated properties.

To date, humankind has taken macro-fibres and developed textile materials, and these have become ubiquitous in our human-made world.

But we are nowhere near reproducing what nature does with fibres. The emerging sciences that are enabling new nanotechnologies and biotechnologies are driving a revolution in new materials, and fibres are poised to be at the centre of that revolution. Many future materials will be based on fibres, including:

- Nanofibres
- Fibres from biopolymers (natural or bio-derived)
- New nanofibrous composites (copying natural material structures)
- Complex hierarchical structures engineered from fibre components at nano, micro and macro scales.

There are endless new applications and fibre developments underway, that will create new business opportunities based on fibres. For example:

- Functional and protective apparel
- Biomedical materials including replacement and/or regeneration of mammalian body parts
- lightweight fibre composites replacing metal and concrete structures
- flexible consumer products replacing hard plastic
- Intelligent materials from functional fibres (eg conductive, sensory, responsive).

Thus, the multitude of applications for fibres in today's modern economy are reflected below:

2. FUTURE VISION FOR THE AUSTRALIAN FIBRES SECTOR

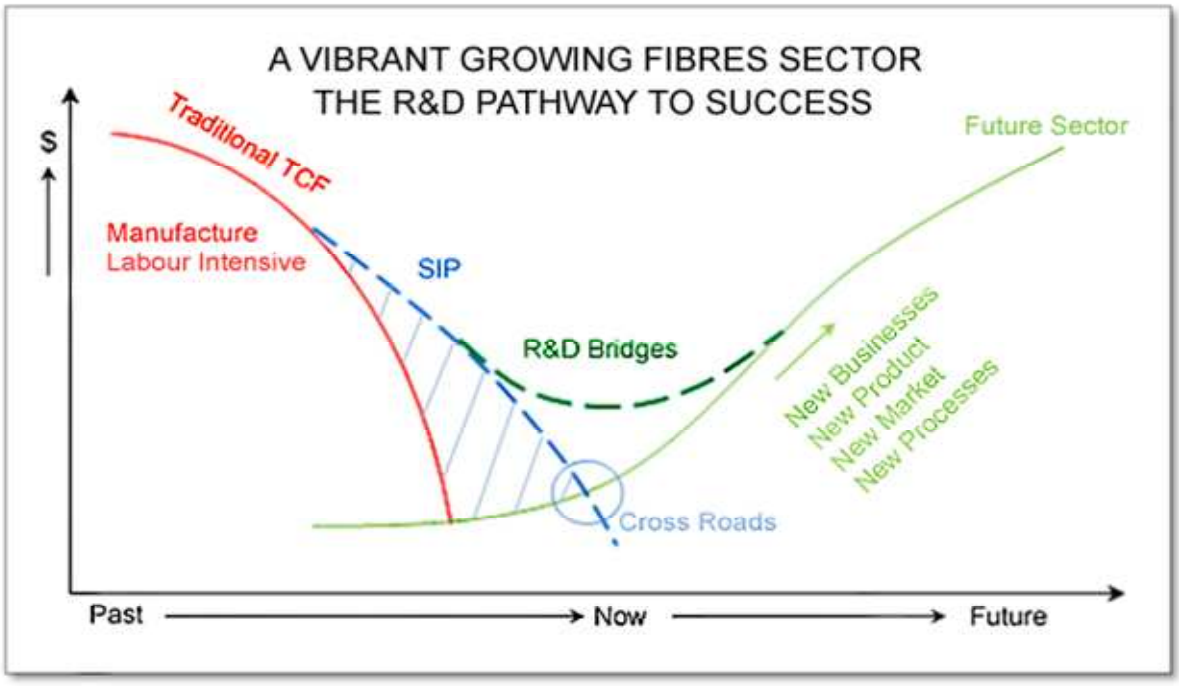
2.1. Global Activities

Around the world, new fibre businesses are emerging, through the efforts of entrepreneurs exploiting scientific progress. However, stimulated by these opportunities and the pressures on their textile manufacturing sectors, some first-world countries have already realised the emerging trends for a more sophisticated and technologically advanced fibres sector, and are already taking steps to establish their positions in a more strategic manner.

The USA has established a National Textiles Centre (NTC) that directs and supports fibre and textile research at a network of research institutions. Europe has developed a Strategic Research Agenda, including 5 key Technology Platforms for textiles and clothing.

Australia also needs to take action. Such actions must be lead by a vision of the future.

- Manufacturers of bio-derived fibres from natural feed-stocks, using biotechnology.
- Niche manufacturers of specific nano-fibres and nano-composites, creating high value materials and devices for export
- Manufacturers of several world-leading textile technologies developed as innovative solutions to Australia's major challenges (eg in water resources, energy, climate adaptation, transport, sustainable agriculture) and subsequently exported to the world.
- Specialist manufacturers that have adapted overseas fibre and textile advances for application to specific Australian issues, keeping various sectors of Australian endeavour in touch with global advances.



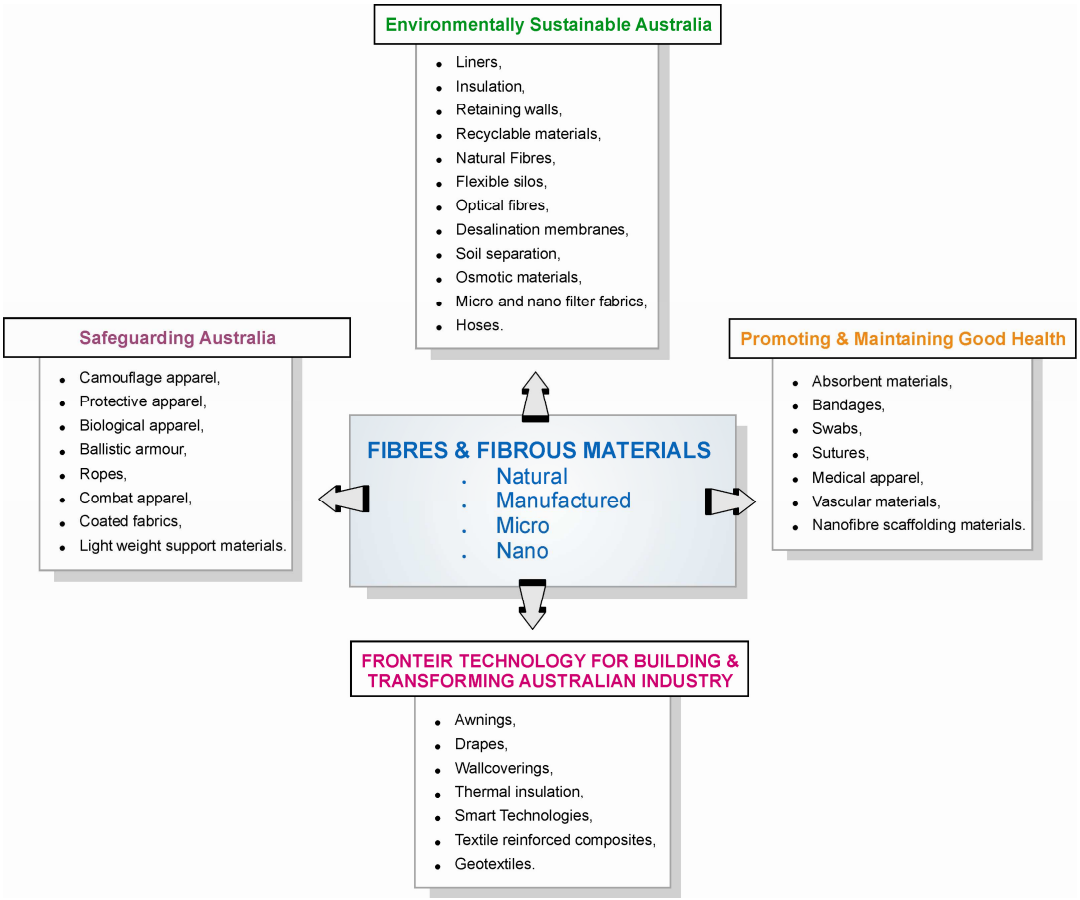
2.2. A Vision of Australia's Future Fibres Sector

Australia has the potential to benefit from an exciting fibre future that could see Australian enterprises as:

- Producers of sustainable natural fibres for global markets.

The opportunities and benefits to the Australian economy through such a future fibre and fibre materials sector are profound. These are consistent with the four National Research Priorities as shown in the diagram. (see over)

Fibres – Contributing Solutions to National Research Priorities



2.3 Australia's Comparative Advantage

In broad terms, the authors believe that Australia's relative advantages will come from three main drivers as highlighted below:

(1) **Exploiting our Natural Resources**

Australia has a sophisticated agricultural sector that can provide raw materials to feed a fibres sector. For example, Australia has a:

- Demonstrable record as a world leader in wool and cotton fibre production
- Proven potential to be a producer of next generation of sustainable fibres
- Capacity to successfully implement demanding sustainability/"green" policies
- Unique flora and fauna which can provide new fibrous polymers
- Extensive experience as an early adopter of biotechnologies for synthesis of bio-derived fibre-forming polymers.

(2) **Innovating to Meet Local and Regional Needs**

Developing applications for specific Australian needs, which can become world-class solutions that can subsequently be exported, eg:

- Water management solutions
- Climate adaptation tools
- Biomedical materials linked to our national health needs and world-leading medical researchers.
- Fibre and textile pre-forms to create innovative composite materials for our mining, aerospace, marine security and sports technology sectors.

(3) **Focussing and Redirecting our Existing Capabilities**

There is a real and significant role for a strong fibres industry in Australia, as:

- Australia retains a comparative/competitive

advantage in R&D in fibre developments

- It is needed to service local needs
- There is scope to forge mutually advantageous international partnerships
- The resource base exists (human, scientific and natural resources)
- There is a strong existing knowledge and skills base.
- High design element
- Protective and performance apparel
- Industrial textiles

3. AUSTRALIA'S POSITIONING IN THE "NEW WORLD OF FIBRES"

This section highlights the potential for Australia to achieve this vision of an emerging and significant fibres sector, by building on the existing industry and research structure and capabilities.

3.1. Existing Industry Capability

The existing textiles/textiles product sector provides a strong base from which to build the new fibres sector. While the traditional activities of this sector are expected to ultimately only constitute a relatively small component of the future fibres sector, it is the very inherent entrepreneurial nature and market astuteness of these traditional players that will help enhance the technological benefits of the future fibres industry.

The current TCF industry has many strengths, and that segment of industry still surviving has consolidated its position by exploiting these strengths, including:

- Design capability
- Fashion orientation
- Effective sourcing
- Brand management and global supply chain management
- Testing facilities and accreditation systems
- Technical knowledge
- Innovative and entrepreneurial attitude

The industry has restructured to take advantage of these strengths, assisted in no small part by the benefits of the TCF Strategic Investment Program (SIP). Companies have successfully transitioned into brand/design/supply chain specialists and manufacturers have found successful niches - eg. in technical textiles, defence and health applications and protective textiles, and we have a textile design and fashion sector that has high profile due to its innovative design, niche marketing and, its connectivity with global supply chains.

But for the companies in this sector to bridge the gap and form part of the high potential fibres sector of the future, a much greater focus will be required on innovation, R&D and commercialisation (see Figure).

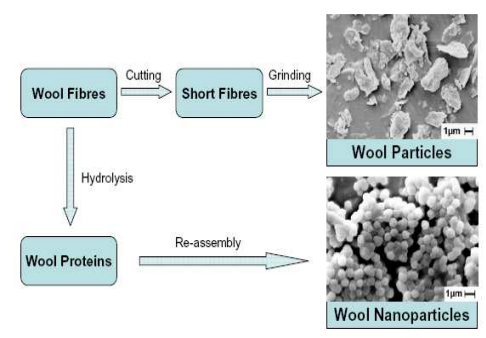
A clear vision of a future fibre sector will provide new direction and opportunities for this creative business energy, as well as attract new investors and entrepreneurs.

The new direction needs to be sufficiently aggressive to make use of the Research and Innovation capability within Australia to stimulate the existing TCF industry to build on existing strengths (similar to the European strategies) as well as nurture new strengths of an emerging major Fibres based sector (as offered by the NTC in the USA). This Vision extols a framework within which both potential new entrants and existing parties can participate, pursuing those opportunities which are of greatest relevance to them, leading to renewed growth of Australia's future fibre industry.

Super-hydrophobic textile surfaces out-perform the lotus leaf

The lotus leaf has an amazing capacity to keep its surface clean and dry. By mimicking the nano-structured surface morphology of the lotus leaf, researchers at Deakin University have been able to develop a range of super-hydrophobic textiles. These textiles have a water contact angle of over 170 degrees, which is much higher than that of a lotus leaf. Super-hydrophobic textiles can be used for both apparel and outdoor applications. The method developed at Deakin is a simple one-step process that may be incorporated into an existing fabric treatment process used in the textile industry. Functionalising the surface of conventional textiles adds significant value to the products.

Not all of the existing industry will have the capability or desire to follow up on the market and research developments – but we need to pursue a "knowledge industry" approach and recognise that it will be a different industry.



New ways of processing and using wool

The traditional ways of processing and using wool have not changed much for well over a century. To revitalise the wool industry, new ways of value adding to this unique fibre must be found.
Researchers at Deakin University and their partners have been exploring different means of converting wool and other natural fibres into micro and nano particles. These fine particles are much more reactive than the 'parent' fibres and can be used in a range of advanced applications.

3.2. Research Capability

Australia is fortunate in having one of the world's largest specialised fibre research facilities at CSIRO Textile and Fibre Technology, backed up by the Centre for Material and Fibre Innovation at Deakin University and the textile, design, research and education delivery at RMIT. In addition other Australian research institutions have been developing specialist research capabilities that involve the application of fibre technology. A key feature will be these fibre-focussed groups collaborating with researchers and users in other fields to build new fibres, complex fibre composites, and specialised applications.

Some examples of the activities of this research capability that are relevant to this paper are highlighted in the feature boxes.

3.3. Education & Training Network

The TCF sector has an effective established network of education and training providers, from vocational to undergraduate to post graduate, who can adapt their training and education programmes to create the intellectual capital and skilled personnel to populate this new industry.

Cotton fibre measurement breakthrough

Scientists at CSIRO have developed an instrument that more precisely measures the 'fineness' of ginned cotton fibres.

The development of the 'Cottonscan' technology brings the Australian and international cotton industry significantly closer to meeting a longstanding commercial challenge.

Fine fibres are needed to make high-premium lightweight fabrics but the industry's ability to accurately grade fibre in a cost-efficient way has presented a major problem.

Cottonscan benefits both cotton growers and the textile industry by enabling high quality fine Australian cotton to be correctly graded and valued by the market.
A series of comparative tests and international validation trials have demonstrated that the Cottonscan instrument can quickly and routinely measure the fineness and maturity of cotton with high precision.

4. STRATEGY FOR ACHIEVING THE VISION

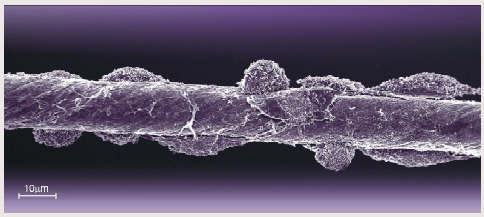
This section has been compiled from feedback and ideas generated through industry workshops and meetings of the Advisory Committee and Strategy Group.

Australia is well placed to capitalise on the vibrant new fibre-based developments, building on many existing and prospective elements of comparative and competitive advantage.

However, it is also important to appreciate that Australia is in a global marketplace. To be competitive, our future fibre innovations will need to be relevant to global markets to achieve the economies of scale to be price competitive in both local and international markets. Since most other countries are also looking at many of the broad opportunities identified in this paper, Australia's focus must be in areas where we have a real edge/expertise and Australia can establish itself as a world leader. Action is now needed to pursue focussed partnership projects between industry and researchers to turn these research priorities into commercial reality.

To best capitalise on our strengths we should be seeking to pursue collaborative projects between key firms in the industry to ensure the appropriate research and development occurs. An effective way forward would be to establish consortia of companies that are "non-competing" to develop new strategies.

Industry will require innovations that will lead to a successful commercialisation and it will be important to ensure that innovative projects are supported by sound market analysis. ie it is vital that the commercial opportunities are real.



Textiles encourage tissue growth

Tissue engineering support structures known as scaffolds are artificial devices designed to encourage cell attachment, proliferation and migration through the porous structure. CSIRO is tailoring fibrous scaffolds for particular tissue types. Scaffolds act as templates for attached cells, where new tissue forms gradually and can be implanted into the body. For a tissue engineering scaffold to work effectively, its structural and mechanical properties must be suitable for the type of tissue being grown. Using knitting, weaving, nonwovens and electrospinning technologies, CSIRO is able to produce fibrous scaffolds that are tubular or flat for a variety of purposes.

This also means that we need to identify the key regional markets that we wish to pursue. For example, in general the Asian markets are easier for Australia to penetrate than say the US or European markets, although of course this will vary depending on the specific product.

Some specific market opportunities are discussed in relation to each of the three drivers.

4.1. Exploiting our Natural Resources

Australia should seek to position itself as a major source of unique and niche oriented natural fibre products, eg:

- Maintain our position as the world's leading supplier of apparel wool, and the most efficient cotton producer
- Build on success of introducing wool fibre into unique applications, notably protective and performance apparel and target Asia with these products as Australian products have a good reputation there (especially in fire fighting and protective wear)
- The US market is also receptive to Australian wool product – wool is an outstanding versatile fibre. (active wear/performance wear utilising wool fibres are potential areas for innovation).
- Explore scope for adding value to rare animal fibres such as alpaca, cashmere, and mohair. These are true high fashion, high value fibres, that are produced in Australia that offer some degree of comparative advantage.
- Develop innovative new fibres based on our natural resources, biodiversity, and biotechnology skills.

4.2. Innovating to Meet Local and Regional Needs

Sectors where Australia has an established expertise that has a need for fibre and textile innovations are:

- Medical devices and health
- mining industry
- automotive
- built environment and
- sustainability.

Significant R&D is already being undertaken in Medical applications. Greater TCF industry involvement/participation needs to be encouraged into this sector. Increasingly the

focus will shift to broader scale monitoring of health, the prevention of cross-infection and managing an ageing population. The development of textile materials through fibre technology and the application of surface coatings offer innovative solutions.

The mining and minerals processing sectors are also a significant market in Australia with all technical services divisions of the world's largest mineral processors being based here. Fibres and textiles applications can be found in mining operations/refineries/smelters from filters to conveyor belts to protective apparel.

Note: A number of firms have already indicated that they would be interested in collaborating on a joint project targeting the mining sector. In addition, the CSIRO flagship "Minerals Down Under" is seeking innovative solutions for this sector.

Automotive textiles are an important segment with OEM manufacturers prepared to look at innovative solutions. Textiles are used for upholstery, head lining, seats, seat belt webbing, acoustic materials and high performance pressure hoses. Composite textile and fibre materials are increasingly being used in auto manufacturing.

Built environment is a major fibre and textile segment that includes domestic textiles and industrial textiles. Advanced materials that make use of carbon fibres and aramids for superior strength are now common place. Australia has a carbon fibre and carbon nanotube research capability that can be utilised to develop innovative applications for the built environment, as well as in the broader composite materials sector.

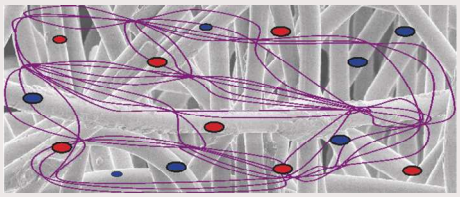
The development of products that will provide an environmentally sustainable outcome represents an important area where Australian industry can take global leadership. Fibre recycling, development of water filtration and conservation, conductive fibres for renewable energy, fibre composites for lower weight and wind turbines are some examples of sustainability end uses for Fibre innovations.

4.3. Focussing and Redirecting our Existing Capabilities

The fibres sector represents an opportunity for innovation through collaboration between the Research and Innovation institutions and the existing fibre and textile industry. An action plan to capitalise on the opportunities presented in this paper would need to address:

Cleaner water storage

A collaborative project between CSIRO, Gale Pacific, East Gippsland Water (EGW), and Superspan has demonstrated the benefits of textile covers for protecting potable water storages. In a two-year study, four drinking water basins were covered with suspended high-density polyethylene shade cloths, while two other basins were left uncovered as controls. The study showed that the semi-permeable covers successfully blocked light to prevent toxic algal blooms from photosynthesising and reduced evaporation by 90 percent. Other benefits included elimination of weed growth in the basins, saving labour costs and reduction in contamination from water birds and wind borne debris.



Easy-breathe air filters

CSIRO has developed an electrostatic filter that removes potentially hazardous particles from the air.

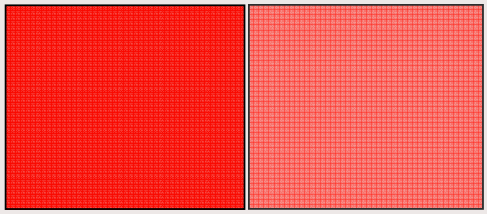
Intermediate size particles (those with diameters typically between 0.2 and 10 micrometers) can linger in the lungs for extended periods, during which they can cause poisoning (if the are toxic) or allergic reactions.

Electrostatic filters have an advantage over commonly used mechanical filters because of the low airflow resistance. With co-funding from Australian Wool Innovation Ltd, CSIRO has developed an electrostatically-charged wool filter medium, which consumes little energy, is highly efficient and makes breathing easier.
The material has a high dust-holding capacity and therefore a long life. It is suitable for use in air conditioning systems, personal respirators and many other industrial applications.

- an ongoing process to facilitate collaboration between the research and innovation institutions and industry. This process would probably best be served by an entity that could channel funding into innovation projects
- Identify what research is already happening, so this can be highlighted and promoted to industry
- Initiate market research to identify where there are commercial market opportunities. Industry needs to have confidence in innovation projects. eg:
    - A market research document on the industry sectors highlighted in section 4.2 would be highly valued.
    - Surface finishing – relevant to filter fabrics and to industrial fabrics
    - Looking for next polymer that will take over from existing synthetic polymers
    - An assessment of environmental opportunities – eg mulch mats are made out of polyethylene because of price factors, but it is not environmentally friendly.
- Identify innovation projects that could be developed and facilitate collaborative partnerships to implement an innovation project (eg The TFIA's CAPES Group provides a good base to develop a collaborative project in relation to Protective Apparel).

Virtually all of the innovative new fibres are developed outside Australia, and therefore we need to forge close links/partnerships with international fibre producers. Access to the right fibre is vital for our processors and global networking will be an essential component of a successful Fibres innovation strategy. Some issues that industry has stressed that need to be addressed in developing a successful fibre outcome are:

- The need for either a local pilot plant for developing new fibres or alternatively a Technology Agreement with a major international fibre producer
- Focus must be on producing fibres that address key Australian problems, where we have the recognised expertise. *The reality is that it will probably best to engage a yarn/fibre producer overseas, and then look to further processing and finishing in Australia.*
- Australia's strength lies in developing fibre derivations/new products and then collaborating on these. This is something that can also be accomplished with shorter lead times (eg in fabric finishing technology, Australia can achieve quick goals).
- Much of the industry infrastructure has disappeared over time, especially with the supply side – eg strong linkages will need to be re-established with the chemical sector



(Original fabric) (Faded fabric)

UV protection to keep colour in the fabric of life

Colour fading is a critical problem that continues to plague the textile industry, especially for products such as flags, awnings and car upholstery that are exposed directly to sunlight. Through an ARC Linkage project, Deakin University has established research partnership with Micronisers Pty Ltd and Bruck Textiles Pty Ltd to develop improved nano zinc oxide formulations that will give enhance protection of a range of fabrics against intensive UV radiation. This will significantly reduce the colour fading problems and hence add value to the fledging nano tech (as well as traditional textile) industries in Australia.

4.4 Research and Education Needs

Australia has an educational infrastructure in place that is well placed to meet industry needs and provide vocational and higher education graduates who can meet the requirements of a high technology fibres and materials industry. However, as the traditional textiles industry has declined, industry has focused on costs and maintenance of traditional skills and not invested in graduates. The educational institutions servicing the TCF industry have responded to industry restructuring positively with an emphasis on design and supply chains as a source of competitive advantage whilst continuing to provide vocational , undergraduate and post graduate programs in Textiles. To support a robust fibre sector the technological and

managerial base will need to be much more sophisticated.

This means the industry will need to attract new people, with new skill sets. Going forward the industry will need people that are well versed in:

- Biotechnology
- Nanotechnology
- Materials engineering
- Product design
- Supply chain management

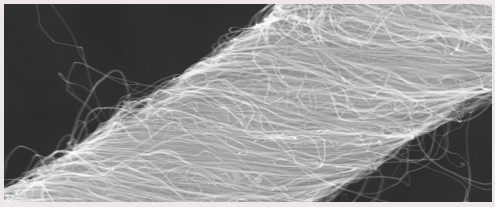
Much of this can be achieved through closer links with educators in other disciplines, by stimulating their interest in the exciting future for fibres in Australia, and by providing specialist fibre and textile training to build on their existing knowledge.

In the research area, Australia is fortunate to have had an extensive and world class textile research capability in CSIRO and at several Universities, developed largely to service the Australian woolgrowing industry. Although this has declined steadily over the last two decades, the remaining capacity is still world class, and the key groups have already re-aligned their activities to the vision outlined in this paper.

For Australia to fully realise the potential opportunities outlined above, these research groups will need to be rejuvenated and expanded.

A mechanism is also needed to bring CSIRO and University research groups more closely together, to further develop and promote synergistic effect in their research and development activities.

We have a solid foundation already for a vibrant new fibres sector in Australia. There is a lot more that fibres can offer to many existing industry sectors. With this vision and the right catalyst, the future is truly fibres!



Carbon nanotubes could go antiballistic

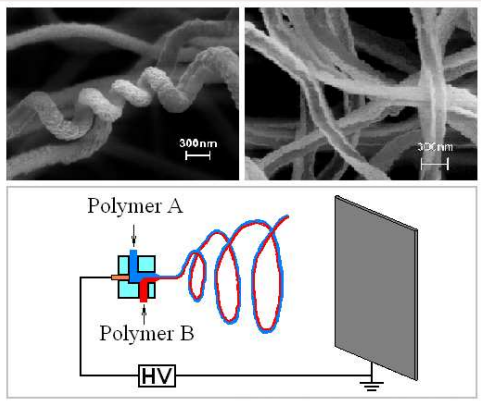
CSIRO has been granted funds under the Defence Capability and Technology Demonstrator Program* to demonstrate the capabilities of carbon nanotubes as strong, lightweight antiballistic materials.

Carbon nanotubes (CNTs) are amongst the first of the new wave of nano-structured materials and offer extraordinary properties of strength, stiffness and lightness.

The challenge is to capture the potential of these new materials at the macro level. CNTs are fibres of pure carbon that are only 1 to 100 nanometres in diameter but up to millimetres in length. Synthesising and manipulating these myriad tiny fibres into ordered structures requires a combination of novel processing skills coupled with a fundamental understanding of fibre behaviour.

CSIRO has established a capability to produce very highly specified CNTs with the unique characteristic of being able to be drawn directly into yarn. This in combination with other advanced materials will form the basis of the new antiballistic structures.

No single material has all of the properties required for ballistic protection, so a successful application of CNTs would see them as part of an integrated system with greater strength and flexibility and reduced weight.*



Functional bi-component nanofibres

Researchers at Deakin University have pioneered a technology for producing side-by-side bi-component nanofibres from different polymers (T. Lin &, HX Wang and XG Wang, *Advanced Materials*, **17**, 2699-2703, 2005). This technology further enhances the functionality of nanofibres for certain applications and also allows the production of the finest nanofibre materials by dissolving one of the polymer components.

*The Defence Capability and Technology Demonstrator Program, managed by the Defence Science and Technology Organisation, assists in the improvement of priority Defence capability by providing Australian industry with an opportunity to demonstrate their technology. This enables Defence to assess the potential of the technology to enhance military capability as well as the likely risks associated with acquiring the technology.

Hard Yakka

Nothing's Tougher

Yakka has recognized that heat stress is a major factor affecting workers and productivity during the summer months throughout Australia. Especially most in central and northern regions of the country. As a result, heat stress on the body can not only affect the ability for the body to concentrate and work for extended periods, but can also have serious personal health and OH&S implications.
Therefore, the Design Department at Yakka have engineered garments that assist in minimising heat stress. The range includes polo, trousers, shorts and shirts.
Figure 1, shows a typical affect to the body due to heat stress. There is evidence of rash on the arm. Rash sometimes occurs when regular reflective tape heats up from direct sun exposure. The tape is not breathable. Therefore allowing the skin to perspire and heat up under the tape area. When this happens the perspiration turns to heat which may cause the skin to rash.
Figure 2, is a picture of a Hard Yakka Koolgear polo which has been especially developed to help reduce heat stress.
It has ventilated sides. Wool blend fabrics. Mesh and segmented / perforated reflective tape.
Figure 3 is a cross section of part of the polo. WoolscienceTM is a high visibility pique knit fabric that was developed in Australia It offers the fastest moisture vapor absorption rate of any fabric. Perforated tape is also an exclusive Australian development. This tape is breathable and is a major contribution to moisture management of the body. Segmented tape also has the same benefits as the perforated tape, but flatter and stretchable. Both tapes are from 3M and comply to Australian high visibility standards. AS/NZS 1906.4:1997 for High Visibility Materials.

FIGURE 1

FIGURE 2

FIGURE 3

Bruck Bionic GEMINI™

Performance combined with durability and comfort

Bruck Bionic Gemini™ was developed using existing knowledge and adapting it to Australian conditions. In Europe, the main focus is to keep the body warm without overheating. In many parts of Australia, throughout most of the year, the main challenge is to keep the body cool. It is clear intelligent garment construction plays a very important role in meeting that challenge, but fabric also plays a very important role.

Bruck Bionic Gemini™ is an intelligent fabric construction with the following features:

- Fast drying
- Soil release
- Antimicrobial
- Anti odour
- High visibility

In addition to the selective use of chemicals it was crucial to test the functionality of these fabrics. Extensive tests in climate chambers and field tests conducted over several months have confirmed that Bruck Bionic Gemini™:

- Releases humidity 25% faster than a similar weight100% cotton fabric
- Dries 40% faster than a similar weight 100% cotton fabric
- Similar cooling properties compared to a similar weight cotton fabric

All of these improvements are most importantly achieved with chemicals, which have OEKOTEX STANDARD certification. Therefore Bruck Bionic Gemini™ in addition to being a high performance fabric is also environmentally friendly and a much healthier option for the Australian workforce.