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Digital Steel

Report of the Steel Industry Research Mapping Project

Howard Partners, December 2012

ABSTRACT

This document is the Final Report of the Steel Industry Research Mapping Project undertaken by Howard Partners over the period September to December 2012. It is set out under headings and subheadings contained in the project brief. Some background and resource material is included in a separate Attachment document.

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Executive Summary

This Report has been prepared to provide information and advice on ways in which the steel fabrication sector can obtain greater access to knowledge generated through research in Australian universities and research organisations in order to drive innovation as the foundation for improved productivity, competitiveness, and energy efficiency.

The Report was prepared on the basis of over 100 interviews, discussions and conversations with people in universities, research organisations, professional associations and institutes, intermediary organisations and steel fabrication businesses. This was supported by background research and reference to primary source documents. A theme running through the project was that the industry is facing hard times. Cost pressures, import competition, and skills shortages were front of mind issues. Many businesses were considered to be in 'survival mode'.

These issues will not be resolved easily and openness to the adoption of new knowledge and practice is only one, albeit important, dimension. It is beyond the scope of this project to deliver a restructuring and modernisation strategy for the sector. But it is clear that businesses within the sector must be prepared to look for new ideas and opportunities, be open to setting new strategic directions, and be agile in relationship building around new business opportunities. Many companies identified in the project have followed this approach and are performing well.

This Report is intended to make a contribution by drawing attention to the role that research, education, and knowledge transfer can play in building a sustainable and robust steel fabrication industry.

Why "Digital" Steel?

The descriptor is used to convey the pervasive application of digital tools and techniques to integrate manufacturing activities across the value chain. Digital integration can encompass all functions necessary to translate customer/user needs into a final product. Many people involved in the steel fabrication supply chain raised this aspect as a key issue and as an enabler of innovation in process and project delivery.

Digital integration is one aspect of *advanced manufacturing* technologies and techniques – that is, the use of knowledge and technology to enhance the production, performance, and embedded value of manufactured products, as well as reconfiguring business processes, and transforming the way business is done.

Other aspects of advanced manufacturing include: metal injection moulding (MIM), laser machining, 3D printing, micro-electronics, use of automation and robotics, advanced coatings, nanotechnology, metal casting technology, high speed CNC machining technology, high volume ferrous casting technology, and composite moulding technologies. All of these make extensive use of digital technologies.

The Australian Steel Fabrication Industry is on a path towards advanced manufacturing, but has some way to go. This Report aims to identify and canvass opportunities for the development and growth of the steel fabrication sector through the transfer, translation, and application of knowledge developed in our universities and research organisations. This will require clear strategies, extensive collaboration, delivery programs, investment, and supporting institutional arrangements.

Findings

The following findings are based on the program of consultations and interviews, review of policy, university, research organisation and industry documentation, and library and web based sources.

1. There is not a great deal of research taking place in the areas specified in the brief. There is a substantial amount of research being undertaken in fields such as materials science and engineering, and in the metallurgical properties of steel, but very little specifically related to steel fabrication. The strongest research commitments are in coatings, supported strongly by BlueScope at the University of Wollongong, Deakin University and RMIT.

2. *Research follows the funding.* Public funding for steel related research is heavily oriented towards discovery projects in areas such as Materials Chemistry, Materials Science, Chemical Engineering, and Civil Engineering reflecting a strong science oriented, theory based, investigator initiated research culture.

3. There is very little research in more 'mundane' areas of manufacturing engineering and manufacturing technologies. This reflects limited funding for applicable research, which has an engineering, problem solving, and prescriptive orientation, and few avenues to fund and support longer term strategic (third horizon) research; this is a significant gap in research funding compared to the UK and European Frameworks.

4. Materials Science discoveries and inventions may be picked up in larger companies (nationally and internationally) and start-ups – but not by struggling SMEs without a strategic vision and strong entrepreneurial capability.

5. Fields of Research (FORs) and research focus do not align easily with the manufacturing capabilities identified in the project brief. Industry/user program and project needs might require knowledge drawn from several FORs, across different faculties and universities. Research organisations designated research centres or institutes are in the best position to address cross-disciplinary research, but at the end of the day academic researchers need to maintain their disciplinary orientation to secure research recognition, and funding, which counts.

6. There is strong capability for analysis and testing of steel properties, including surface and structural properties, welds and joints. But manufacturing process-engineering research, which links the science with the engineering, is not well funded or supported. This contrasts with Germany, the US and China.

7. It is important not to overlook the purpose of a university and the university system. Universities are not 'knowledge warehouses' merchandising 'knowledge products' that are generally available for sale to businesses. Universities and research agencies have 'capabilities' that are best accessed through collaborations and partnerships. Small, one-off research transactions (projects) are hard to sustain – unless they are part of a broader program. The following points are of note:

    a. Businesses access 'capabilities' rather than 'research'. Research outputs will generally not be in a form or format that is useful to business.

    b. Discovery research can be translated into capabilities if it is funded. Linkage grants with *businesses* can provide good outcomes.

    c. Capabilities can be developed jointly through *industry* collaborations in applied (applicable) research.

    d. There is very little appetite for short-term consultancy in Australian universities – unless it can build into research projects and programs. Consultancy, when priced at commercial rates, can underwrite the discovery research agenda.

8. Universities are, nonetheless, hard to connect with. Many have poorly developed websites, gatekeeper barriers, and limited resources for industry engagement. Institutional commitment to building relationships in research <u>and</u> teaching that are initiated and negotiated by senior executives in business and universities, and supported at the CEO/Vice

Chancellor level, yield the best results. Successful interactions occur within a framework of trust and commitment.

9. There is actually quite a lot of industry-linked research in Australian universities. Most connections are with large companies, and the strongest linkages are with international/global corporations. Research is globally oriented, and there are potential flow on benefits for Australian companies. Australian researchers have strong linkages with overseas universities in China, North America and Europe. Australian industrial research generally can benefit from this.

10. BlueScope and Arrium have extensive linkages with several universities in Australia and overseas. This follows from the winding down of BHP research laboratories and the subsequent employment of staff in universities and research centres. There is a commitment to building and maintaining this capability. Overseas steel producers are implementing similar strategies. Baosteel recently committed support for an Australian university research consortium.

11. Applicable and integrative research that is relevant to industry is not well funded in Australia. This is a major strength of programs like the CRC program. CRC involvement with industry connected PhD and Masters programs have also been important. This is an often-overlooked aspect of knowledge transfer from universities to industry. Many CRCs supported industry problem solving, involving short term projects under a longer-term program.

12. There are some existing and newly formed research centres that may be able to develop this model that requires a balance in the research portfolio between discovery research, commissioned research, and postgraduate education. The new ARC Industrial Research Transformation Program may address this issue, but the amounts available are very small.

13. It is generally recognised that the most effective form of knowledge transfer is through the employment of skilled and knowledgeable graduates (Howard Partners 2005a). Larger companies have postdoctoral positions, graduate recruitment programs and offer cadetships for promising students. SMEs tend to have a shorter time frame, are cash flow constrained, and are therefore unwilling to take on new graduates and/or support a PhD program for a staff member that may cover 3 years.

14. Several universities are adopting an integrated approach to research, education and training, as advocated in the Bradley review of higher education environment (Bradley et al. 2008). RMIT is a leader in this approach. The newly formed alliance between the University of Canberra and Holmesglen TAFE indicates the potential to leverage the strong VET capability in manufacturing engineering at the TAFE into a research context.

15. There is very little SME engagement in research, although there have been strong interactions through the CRC infrastructure, including for example the CAST CRC. Research is seen to be too expensive in Australia for SME and ME engagement. Smaller companies are less likely to have staff with a degree qualification or a connection with a university/research organisation, although there can be strong trades/VET linkages. The best companies have both VET and university qualified staff and strategic management capability.

16. The Researchers in Business (RIB) program is well regarded, particularly for getting relationships started. It is used extensively by CSIRO, but no RIBs have gone into the steel fabrication sector. The disadvantage is that funding is generally only available for a single project.

17. Mechanisms are being implemented and advocated to cover the costs of universities and research organisations working with SMEs. A voucher system has been introduced in

Victoria and is canvassed in the non Government members' report of the Prime Minister's Manufacturing Taskforce (Prime Minister's Manufacturing Taskforce 2012).

18. The "Pittsburgh" perception of the steel industry needs to be dispelled (large factories, smoke stacks, large workforces, company towns). The industry is disaggregating and internationalising with differences in ownership and control along the supply chain. The fabrication sector is, in its own right, a significant component of the economy where there is a large number of SMEs, predominantly family owned. There are, however, many successful corporately structured fabrication businesses with strong export reach.

19. Australia will not be able to produce all the different varieties of steel needed by a robust and sustainable fabrication sector. Fabricators source globally, and not only on the basis of price. It is critical, however, that imports meet quality standards and certification requirements. Australia should play to its strengths around products, which is currently reflected in the BlueScope strategy. Countries import and export steel of different grades – of which there are many. For example, Sweden exports 80 per cent of its production and imports 85 per cent of its requirements.

20. From an international perspective, steel fabrication is 'high tech' and makes extensive use of digital technologies (CAD/CAM/CNC), automation, robotics, 3D visualisation and printing, etc. ICT is embedded in machinery, robots, etc., but does not integrate well with factory automation systems. Opportunities exist to achieve greater integration in the sector through the adoption and application of ICT – including building information management (BIM).

21. The steel fabrication sector is generally fragmented, conservative, and unsophisticated. This is reflected in:

    a. the low take up of technology

    b. an approach to marketing and business development based on orders and tenders rather than relationship strategies

    c. a strong trades/guild culture rather than a knowledge and innovation culture.

    Application and adoption of new technologies and manufacturing processes requires new knowledge and skills; the traditional trades approach may not be applicable in the new digitised, automated and knowledge based manufacturing environment.

    Fabricators *can* build businesses around agility, flexibility, and responsiveness to changing circumstances and opportunities. This requires a strategic approach – playing to competitive advantage and distinctive capabilities, being involved in networks and building relationships. Several examples emerged during the consultations.

22. The steel user community is conservative and over regulated. This is a significant issue as the potential for innovation is increasingly commencing with the end user – represented by architects, designers, and engineers. Low end user demand for steel translates into low demand for research. The architecture and design professions are not strongly engaged with steel. Exceptions include Cox Architecture. Architects are critical – but they do what they know.

23. In the construction industry digital integration leaves a significant responsibility with the developer to focus on outcomes rather than outputs (a structure) delivered at the lowest price. Public sector developers (including universities) have the opportunity to drive an outcomes focus and deliver great buildings.

24. The virtues of steel as a green material is not well promoted – or understood. Steel fabrication research is not well linked to research being undertaken in the built environment

– except at Wollongong. Opportunities exist to apply new technologies and materials to extend the service use-value of steel to users and consumers. This requires greater collaboration along the value chain.

25. The fabrication related professions do not work well together. There are also multiple industry organisations and professional bodies, but with gaps. The approach to government relations is generally lobbying and advocacy rather than workable solutions and evidence. There are good signs of collaboration in the academic sector with the creation of cross disciplinary schools and institutes that link engineering, design, architecture and the built environment – e.g. Swinburne, RMIT, QUT. This spirit of collaboration and common purpose may extend into the professional realm.

A way forward

On the basis of the material presented in this Report, there are three broad areas where universities, research organisations and businesses can work together to improve productivity and performance in steel fabrication. These relate to:

- Production and processing innovation
- Management capacity and capability
- Value chain integration

Production and processing innovations concern the adoption and application of new knowledge and technologies, skills to improve product performance and more effectively meet end user needs and requirements. Technology adoption also has the capacity to reduce costs, improve speed of delivery and enhance productivity. New digital technologies, as well as new materials have the potential to open up niche production areas. These are essentially 'factory' related issues.

Building management capacity and capability means creating sustainable businesses based on commitment to business development, marketing and relationships, partnerships and collaborations with related businesses and with universities and research organisations as a way to tap into new knowledge and business opportunities. Participation in local, national and international networks is a key aspect of this way forward.

Integration of the steel fabrication value chain using digital products and technologies has the greatest potential to reduce costs and improve business and industry performance. It is an approach that requires wide stakeholder commitment and learning from success through pilot projects. It also involves developing a high degree of trust among participants that comes from a culture of collaboration and partnership. It should be a strategy owned by all participants in the value chain, rather than being driven by one or two constituencies.

In all of these approaches strong industry leadership is an imperative. Government and the research sector can be partners, but not drivers of change.

Summary of research capabilities across universities and research organisations

An important aspect of the project was to develop a map of capabilities across institutions. This is represented in Figure 1.

Figure 1: Map of Steel Fabrication Research Capabilities at Australian Research Institutions

	Automation	Robotics	Additive Manufacture	Assembly	Coating	Casting	Cutting	Forming (Incl. Cold Forming)	Joining (Welding)	Joining (Riveting, Bolting)	Machining	Building Inform-ation Modelling	Energy Efficiency	Architecture & Design	B&C Management
Bond University*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Y
Curtin University*	-	-	-	-	-	-	-	-	Y	-	-	-	-	-	Y
Deakin University	Y	Y	Int.	Y	Y	Y	Y	Y	-	-	Y	Y	Y	Y	Y
Griffith University*	-	-	-	-	-	-	-	Y	-	-	-	Y	Y	-	-
James Cook University*	-	-	-	Y	-	-	-	-	-	-	-	-	-	-	-
Macquarie University*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Monash University	Y	-	-	-	Y	Y	-	Y	Y	-	Y	-	-	-	-
Murdoch University*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
QUT	Y	Y	-	Y	-	-	Y	Y	-	Y	-	-	-	Y	Y
RMIT University	Y	Y	Y	-	Y	-	Y	-	-	-	Y	-	-	Y	Y
Swinburne University	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
The ANU	Y	Y	-	Y	-	-	-	Y	Y	-	-	Y	-	Y	-
The University of Adelaide	-	Y	-	Y	-	-	-	-	-	-	-	Y	Y	-	-
The University of Melbourne	-	-	Y	Y	-	-	-	-	-	Y	-	-	-		Y
The University of NSW	-	Y	-	-	-	Y	Y	-	-	-	-	Y	Y	-	Y
The University of Queensland	Y	Y	Y	-	Y	Y	Y	Y	Y	Y	Y	-		Y	Y
The University of Sydney	Y	Y	-	Y	Y	-	-	Y	-	-	-	-	Y	Y	-
The University of WA*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
University of Canberra	-	-	-	-	-	-	-	-	-	-	-	-	-	Y	Y
University of Newcastle*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Y
University of South Australia	-	Y	-	-	-	-	-	Y	-	-	-	Y	Y	Y	Y
UTS	Y	Y	Int.	Y	Y	-	-	Y	Y	-	-	Y	Y	Y	Y
University of Western Sydney		Y	Int.	Y	-	-	-	Y	Y	-	-	Y	Y		Y
University of Wollongong	Y	Y	Y	-	Y	Y	-	Y	Y	Y	-	-	Y	Y	-
Total University Sector	**10**	**13**	**5**	**10**	**8**	**6**	**7**	**12**	**8**	**5**	**5**	**9**	**10**	**11**	**14**
Research Organisations															
ANSTO	Int.	Int.	Y	Int.	Y	Y	Y	Y	Y	Y	Y	-	Int.	-	-
CSIRO	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y		Y	Int	
NICTA	Y	Y	-	-	-	-	-	-	-	-	-	-	-	-	-
CAST CRC	-	-	-	-	Y	Y	Y	Y	Y	Y	Y	-	-	-	-
Advanced Manufacturing CRC	Y	-	Y	-	-	-	-	-	-	-	-	-	-	-	-
*Energy Pipelines CRC**	-	-	-	-	-	-	-	-	Y	-	-	-	-	-	-
National Fabrication Facility	-	-	Y	-	Y	-	-	-	-	-	-	-	-	-	-
DMTC	Y	Y	Y	Int	Y	Y	-	Int	Y	Y	Y	-	-	Y	-
*QMI**	-	-	Y	-	-	-	-	Y	-	-	-	-	-	-	-
Number of Institutions Identifying Capability	**14**	**16**	**11**	**11**	**13**	**10**	**10**	**16**	**13**	**8**	**9**	**9**	**11**	**12**	**14**

Key: **Y** – indicates capability present.
Int – Indicates institution has an interest in developing capability
* – Capability not validated due to unavailability of a senior university executive to provide information or respond to a request for information. In some cases it is apparent from university websites that there is minimal capability in areas of interest

The map identifies strong capabilities in areas such as automation, coating (strongly supported by BlueScope), casting, forming, building and construction management, and robotics. However, the map indicates that there is across the board capability in only a few universities (Deakin, Swinburne, University of Queensland, UTS and University of Wollongong) and several of these rate highly in Excellence in Research Australia (ERA) assessment for research excellence.

There are, however, a number of universities with strong capabilities in several areas (Monash, QUT, RMIT, ANU, Melbourne, and Sydney), and some universities with capability in one or two areas (reflecting the interests and reputation of individual researchers).

There is a strong argument for aggregating capability across universities to create critical mass in areas that are important for the future of the steel fabrication industry. These include automation and robotics, coating, assembly and forming (particularly cold forming), building/manufacturing information modelling and the broader built environment disciplines – architecture, design and building and construction management.

Recommendations

On the basis of consultation, project related research, and analysis of issues, and discussion, the following recommendations are provided. They fall under three broad headings:

Research and Education

1. Build research capability in technology integration, application and education – through, for example, a *National Institute for Steel Manufacturing Process Science, Engineering, and Technology (The Digital Steel Institute)*; the focus should be on steel – but also other metals. It would focus on the adoption and application of digital technologies in fabrication technologies and across the fabrication value chain to achieve integrated production capability.
2. Create avenues to fund research that achieves greater integration of the science and engineering domains and with a strong focus on application and adoption through technology.

Industry

3. The Steel Industry Innovation Council promote the Steel Fabrication sector as a high technology industry with a future built around the adoption, application and use of digital technologies. This should link to the promotion of steel as a clean and sustainable product in construction and other applications. Promotion should be based on evidence generated from research. The positive user 'experience' of steel should also be promoted.
4. Build capability in the fabrication sector in management capacity, innovation, marketing, and communication. Skills and capabilities for responding to change, strategy development, international marketing, and building trust-based relationships, must be given a high priority.
5. Establish a Steel Construction and Infrastructure Alliance across the professions – modelled on the British Constructional Steelwork Association (BCSA), the American Structural Steel Association, and the Singapore Structural Steel Society to promote the use of steel in commercial construction. The Alliance would aim to establish greater communication, cooperation, and collaboration among industry associations and professions.

Policy

6. Promote an understanding and culture of university-Industry relationships focussed on outcomes and creation of value for all parties through effective partnerships. University input metrics, such as research income generated, and output indicators, such as IP registered and start-ups formed, send the wrong signals and create the wrong behaviours. The view of knowledge as a 'commodity' that can be traded through economic transactions (e.g. sale and licensing of IP) must be dispelled.

7. Stimulate the demand for high quality steel for construction and manufacture through government procurement policies for public buildings and design competitions. Encourage fabricators to embrace crowd sourcing as an avenue for innovation.
8. Support the development of knowledge precincts, hubs and clusters that have relevance to the steel fabrication sector.

Institutional Options for a National Institute for Steel Manufacturing Process Science, Engineering and Technology

There is strong support from within the academic and business community for establishment of a research, teaching, training and engagement organisation that has a specific focus on the adoption, application and use of science and technology relating to the manufacturing process, science and technologies. This support was premised on broad fabricating industry involvement and end user interest.

A commitment and sustainability would require that the Budget should be $4-5m per year over 7-8 years ($28m to $40m).

The institutional and organisational options that have been canvassed during consultations are summarised below. Further information about each model is provided in Section 9.

1. **A designated hub, or hubs, of capability linking research and industry.**

   Within this broad option there are a number of possible models:

   a. A Hub established under the ARC Industrial Transformation Research Program.
   b. A model that picks up elements of the UK EPSRC collaboration programs including Industrial Doctorate Centres and the Collaboration Awards in Science and Engineering.
   c. A National Network for (Steel) Manufacturing Innovation – modelled on the US National Network for Manufacturing Innovation Program (see Attachment 4). An Institute for Additive Manufacture has recently been funded under the Program.

   The findings outlined in this Report point to a requirement for a model that is more specific to issues relating to the steel fabrication sector (and perhaps metal fabrication more generally). These include, for example:

   - The thin spread of capability and research funding in areas relevant to the steel fabrication sector.
   - The requirement for the Industrial Transformation Hubs to be researcher initiated, under ARC guidelines, and the limited pool of industry partners.
   - The need to address specific strategic and structural issues related to improving performance, productivity and competitiveness in steel fabrication.

2. **A new Cooperative Research Centre (CRC) for Steel Manufacture**.

   The merits of the CRC model were raised extensively during the consultations process. The CAST CRC had achieved success in working with SMEs and scaling projects up into investable programs.

   A CRC for Steel Manufacturing Process Science and Engineering would require substantial industry funding, strong commitment from lead universities, and a business case built around a strong innovation, science and capability development need.

   On 28 November 2012 Senator the Hon Chris Evans, Minister for Tertiary Education, Skills, Science and Research announced that innovative manufacturing, social innovation and sustainable regional communities would be priority areas for the 16th CRC selection round.

   An application for a Steel Manufacturing CRC could address both the innovation and sustainability dimensions recognising, in particular, the importance of steel fabrication businesses for sustainable regional communities. Steel fabrication businesses provide a significant level of employment in regional communities.

3. **A Research Association Model**.

   There are several possible models that have achieved success in various contexts:

   a. AMIRA (Australian Minerals Research Association)
   b. The Rural Research and Development Corporation
   c. The NZ Heavy Engineering Research Association (HERA)

   The AMIRA model has achieved success in the mining sector. It is a research-commissioning organisation, supported by the major mining companies. It is not certain whether the model could be extended to the steel fabrication sector with a large number of SMEs and limited research collaboration.

   The NZ Heavy Engineering Research Association (HERA) was established in 1978 as an industry owned, non-profit research organisation dedicated to serving the needs of metal-based industries in New Zealand.

   While the emphasis of its activities is on heavy engineering, HERA also services wider metals industry interests such as light-gauge steel, stainless steels, light alloys and metals-based composites. Further information is provided in Attachment 4.

   The Australian Steel Institute sees merit in this model.

4. **An institution modelled on the Fraunhofer Institute for Production Technology (IPT)**.

   The Fraunhofer-Gesellschaft's research work is oriented toward applications and adoption of research. Funding is obtained from both from the public sector (approximately 30 per cent) and through contract research earnings (roughly 70 per cent). This is said to encourage the Institutes to operate in a dynamic equilibrium between application-oriented fundamental research and innovative development projects.

   More information about the Fraunhofer Institute for Production Technology (IPT) is located in Attachment 4.

   Many organisations consulted saw merit in this model. However, given Australia's investment in CSIRO, and the direction being taken by the CSIRO Future Manufacturing Flagship, there is doubt whether such an Institute is warranted.

5. **Extending the role of the CSIRO Future Manufacturing Flagship**

   Incorporation of new research capability within the CSIRO Future Manufacturing Flagship where capabilities have been developed and are expanding in manufacturing production and process technologies as CSIRO seeks to further engage with industry.

   The Future Manufacturing National Research Flagship (FMF) is Australia's largest multi-disciplinary research program focused on manufacturing innovation. It was established to assist Australian industry meet the challenges of an increasingly globalised, competitive and resource constrained future; the FMF is also poised to help its research partners capture emerging global opportunities.

   Many of the issues raised in this Report would fit within this overall strategy.

6. **Establish a new collaborative *Centre of Excellence* (Institute) for *Steel Manufacturing Process Science and Engineering***

   The Institute would aggregate capability across current centres and university faculties. It would provide critical mass and ensure that the full range of technological capabilities is available for the fabrication sector.

It would be modelled on centres that have been established recently with strong industry involvement. It would focus on research translation and application – drawing in knowledge created in an academic environment and professional knowledge generated in industry. These include:

- The Centre for International Finance and Regulation
- The Australian Centre of Excellence for Local Government
- National ICT Australia.

All three Centres have strong links to universities and collaborations with industry. They are not in the first instance research centres but have strong research and industry connections. Such a Centre would provide a sustainable and industry focussed capability to address innovation, in production and processing, management capacity and capability, and value chain integration – issues that are critical for charting a way forward for the steel fabrication sector.

These models of university-industry-government collaboration provide a framework for thinking about an organisation that can address research translation and adoption, innovation, and industry modernisation in the steel fabrication sector.

How success will be evidenced

The success of the National Institute for Steel Manufacturing Process Science, Engineering and Technology (NISM) should be assessed, over time, in five areas. These are summarised below.

1. Widespread adoption of new technology and value chain integration

A key issue confronting the steel fabrication sector is the slow take-up of new technology in manufacture, and the need for greater integration of the value chain from design, engineering and detailing through to production, distribution and delivery, into a single unified business model.

The National Institute will have had a major role in undertaking research in the field of Manufacturing Engineering and transferring the outcomes to existing and new businesses.

Success will be evidenced through increased size and scale of businesses, more extensive business-to-business collaborations, partnerships and mergers, and the adoption and application of knowledge and best practice generated and disseminated by the Institute.

2. Increased production, sales and profitability

Increased production, sales and profitability will be associated with a greater commitment to innovation (the successful and sustained application of new ideas) and effective marketing to new and existing customers.

This will be associated with businesses committing to growth through clearly articulated strategies, leveraging distinctive capabilities, and building core competencies - and moving away from the 'orders driven' operational culture that currently characterises the sector. For many businesses this will mean specialisation in production technologies, development of new and 'branded' steel products, and working in niche markets.

This, in turn, will reflect a professional style of management and appointment of Boards that add value to businesses through broad ranging experience, knowledge, and connections within the steel fabrication value chain – nationally and internationally.

Success will be evidenced by the extent to which The National Institute for Steel Manufacturing has provided leadership in the take-up of technological innovation, training and professional development, and education for management in a manufacturing environment.

3. Increased export and international engagement

The Australian market is not large enough, on its own, to support the growth and sustainability of a vibrant steel-manufacturing sector. Already, a number of steel fabrication businesses have established international manufacturing capability in China, South East Asia and North America.

The viability of Australian businesses will depend to a large extent on expansion and growth through export and commencement of in-country operations overseas.

The National Institute for Steel Manufacturing will perform a role in building relationships with overseas universities and research organisations, and securing access to research funding from international sources. This would include, for example, participation in the European Framework program.

Success will be evidenced in increased exports and growth and extended internationalisation of the steel fabrication sector.

4. Enhanced collaborations and partnerships between industry, universities and research organisations

The National Institute for Steel Manufacturing will be a catalyst for partner collaborations and partnerships between universities, research organisations and businesses.

Success will be evidenced in the number of new collaborations and partnerships that result in the delivery of new products and processes in steel manufacture.

5. Employment

The National Institute for Steel Manufacturing will work with Universities, VET Institutes and professional organisations to ensure that research, courses and programs have the required blend of competency based training and academic learning to meet industry needs, and that courses are accredited to meet requirements for professional practice.

This outcome is particularly relevant for changing, new and emerging, technology oriented, professions such as steel detailing.

Success will be evidenced in the upgrading of skills and education requirements, and amelioration of shortages, in professional and para-professional employment categories that are necessary for a modern, competitive, and sustainable steel fabrication sector underpinned by the widespread application and use of digital technologies.

1 Introduction

1.1 Project Purpose

The Department of Innovation, Industry, Science, Research and Tertiary Education appointed Howard Partners to map research and development in the Australian steel fabrication sector, focussing on strengths and possible gaps in technologies and research activities, in order to improve competitiveness, energy efficiency and overall performance.

The objective of the project is to provide a report that will contain practical information and advice to the steel industry on existing research in a number of specified areas. A guide to understanding how to access this research and utilise existing research facilities was also sought.

It was intended that the project report will provide a basis from which industry can engage with the research and development community more effectively.

1.2 The brief

The project brief required that the following tasks be undertaken:

- Identify target sectors within the steel fabrication and R&D community
- Develop and distribute a template that can be used to update the report to facilitate ongoing interactions between researchers and business (via email to relevant R&D groups in the Australian Innovation System)
- Identify current and prospective research activity by timeframe, impact and funding
- Propose activities that encourage relationships between
    - Industry target sectors and researchers
    - Researchers and researchers
- Effectively map existing technologies and research, and record the needs and barriers to innovation as they are identified in the mapping process.

1.3 The problem, and the opportunity to be addressed

The project brief is premised on an assumption that steel fabrication related innovation and research is being undertaken by Australian universities and research organisations but that links to industry to effectively deploy and harness such research needs to be strengthened. In other words, the relationships between research organisations and industry need to be improved.

This sentiment is reflected in the Future Manufacturing Industry Innovation Council paper, trends in Manufacturing to 2020 (Australia. Department of Innovation Industry Science and Research 2011).

> There is a broad consensus that Australia is not deriving the full benefits of our research investment; especially from publicly funded research. Hence it is imperative to improve the strategic alignment between the output from research organisations and industry/market demands. This will only come about through greater engagement and linkage between providers and users (and potential users) of research to ensure that there is an appropriate balance between 'push' from research organisations and 'pull' from firms that can benefit from research. Understanding trends and potential opportunities in the future will also be crucial in establishing a globally competitive manufacturing sector.

The project brief also points to the absence of a coherent, easily accessible mechanism or resource that can maximise the practical knowledge gains into the Australian steel fabrication sector. It is envisaged that the project report will assist in realising the full commercial potential to Australian industry of such research.

It is intended that the project will support the Australian Steel Innovation Council's remit of championing innovation within the Australian steel industry and promoting improvements in the steel "value chain". It will complement the Future Manufacturing Industry Innovation Council's goal of promoting innovation-intensive, high technology, high value add and high-skill manufacturing (Australia. Department of Innovation Industry Science and Research 2011)

1.4 Report requirements

The brief indicates that the main focus of the project is on research and development (R&D) activities that can assist steel fabricators improve their competitiveness. Specifically, the project is to look at technologies, processes and energy efficiency.

A key requirement of the project was to map existing, enabling or emerging technologies and research activities, notably areas of strength and possible gaps, which would improve the competitiveness, energy use and overall performance of the industry.

The brief required that attention is to be focussed on developments in, but not limited to, the following manufacturing processes:

- Assembly – covers formation, building and erection of steel structures. Often the fabrications for structural work begin as prefabricated segments in a fabrication shop, then are moved to a site by truck, rail, or barge, and finally are installed by erectors.
- Automation – use of digitally enabled automated processes and procedures in factory operations.
- Casting – most often used for making complex shapes that would be difficult or uneconomical to make by other methods.
- Coating – protective layers that are spray-painted or metal-sprayed for corrosion, and usually with intumescent paint for fire protection.
- Cutting – sawing and oxy-cutting are the most common form of cutting, but there is increasing use techniques such as plasma cutting, laser cutting and water jet cutting.
- Forming – bending presses to produce a camber are sometimes incorporated into beam lines. Roll forming is also commonly used for lighter sections.
- Joining – bolted connections that are usually made by drilling, but occasionally punching is found to be more efficient.
- Machining – load-bearing end faces of columns are often machined by milling to achieve the desired tolerances.
- Robotics – the use of computer-controlled machines to perform manual tasks, especially in a factory setting.
- Welding – fully automated welding is used for the production of beams and columns fabricated from three plates, usually with the submerged arc welding process. Most other welding is done with hand-held, semi-automatic gas metal arc welding (GMAW).

The following areas were also considered in the broader context of demand side issues relating to developments and opportunities in steel fabrication:

- Additive manufacturing (three dimensional printing, rapid prototyping)
- Architecture and design
- Building and construction management
- Building Information Modelling (BIM).

Taken together, these areas provide a focus of on manufacturing processing science and technologies. There is, however, an important intersection between processing technologies and other technologies, including materials science and technologies that relate to the molecular and

1.5 Approach to the project

The project involved an extensive process of consultations, interviews and discussions with people and organisations involved in the steel fabrication sector. Over 100 people were interviewed in universities, research organisations, industry, intermediary organisations, industry organisations, professional associations and public sector innovation and industry policy agencies. Conversations with universities tended to be wide ranging, covering broader issues of research, innovation and industry engagement, while conversations with businesses were often shorter and focussed on one or two specific issues. The contribution of all people is greatly appreciated. A listing of people and organisations consulted is provided in Appendix 1 to the Report.

The Report relies on primary source documentation as well as research and policy papers concerning industry-research-government relations as well as previous Howard Partners work in this area (See http://www.howardpartners.com.au/publications.php)

1.6 Scope of this report

To address the requirements of the project brief, the remainder of this Report is presented in a number of Sections.

Section 2 provides an analysis of the steel fabrication research environment, covering relevant fields of research, capabilities and commonly used process technologies, and gaps. It was prepared on the basis of data analysis and discussion with universities and research organisations across the higher education and research sector. It identifies opportunities and issues to be addressed in building research capability.

Section 3 provides an analysis of the steel fabrication sector, covering the supply chain, the adoption and application of digital technologies, energy efficiency, sustainability and stewardship concluding with a discussion of relevant industry policy issues.

Section 4 brings together material form the earlier sections to address a way forward for the greater adoption and application of knowledge in the key areas of production and process innovation, management capacity and capability, and supply chain integration.

Section 5 includes a discussion of 'absorptive capacity' followed in Section 6 by an outline of principles and procedures to facilitate the initiation and maintenance of ongoing interactions between the research sector and industry.

Section 7 provides a discussion of ways to overcome barriers to innovation followed by a summation of activities that will encourage the strengthening of relationships between industry and research in Section 8.

Section 9 provides options to build and strengthen institutional capacity for applicable and translational research and practice improvement in manufacturing process science and engineering.

Additional information that informed the analysis, conclusions and recommendations contained in the Report are provided in a separate volume of Attachments. The Attachments are as follows

1. Profile of the Australian Steel Industry
2. Fields of Research relevant to the Australian Steel Industry
3. Australian Research Council grants fir steel related research projects 2010-2012
4. Summary of capability in universities and research organisations relating to steel fabrication
5. Research models from other sectors and internationally
6. Relevant literature
7. Extracts from key policy documents.

A separate Resource Document was also assembled containing source material that relates to the steel fabrication industry, research and policy environment. This document is retained by Howard Partners and can be made available on request.

2 The steel fabrication research environment

This Section of the Report looks into the scope, timeframe, impact and funding of research related to steel fabrication. It begins with an outline of the capabilities that are used in the fabrication sector and identifies technologies that are being developed and applied.

2.1 Research capabilities relating to steel fabrication

Steel related research is concerned with, but not by any means limited to, the processing technologies identified in the project brief. Research is also undertaken in relation to materials technologies, including materials science and nanotechnology, architecture and design, and construction where issues of buildability are addressed.

In order to gain a picture of research capability it has been necessary to identify the research fields and institutions that undertake research that is, or might be, relevant to steel fabrication. This is then used as a basis for identifying those institutions that have strengths, and looking further into the ways in which the engage with industry.

2.1.1 Relevant FORs relating to steel fabrication

The capabilities identified in project brief as being relevant to steel fabrication are cross-disciplinary – that is, they involve knowledge derived from two or more academic disciplines. Academic disciplines are classified by the Australian Bureau of Statistics (and the Australian Research Council) in terms of Fields of Research (FORs).

The FORs most relevant to the steel fabrication-manufacturing sector include:

Code	Field of Research
303	Macromolecular and materials chemistry
801	Artificial intelligence and image processing
803	Computer Software
806	Information Systems
904	Chemical engineering
905	Civil engineering
906	Electrical and Electronic engineering
910	Manufacturing engineering
911	Maritime engineering
912	Materials engineering
913	Mechanical engineering
914	Resources engineering and extractive metallurgy
1007	Nanotechnology
1201	Architecture
1202	Building
1203	Design practice and management
1204	Engineering design

Descriptions of the scope of each field are contained in Attachment 2. These fields are used by the Australian Research Council for assessing research excellence through the Excellence in Research for Australia (ERA) process. The latest published data, in the recently released 2012 Report, is for 2010 (Australian Research Council 2012). The rating scales are between 1 and 5, with 5 being evidence of performance "well above world standard", 4 being "above world standard", 3 being "at world standard". A 2 indicates "below world standard" and a 1 being "well below world standard". Assessments are summarised in Figure 2.

Figure 2: ERA 2012 Assessments in FORs Relevant to Steel Fabrication

FOR CODE	303	801	806	904	905	906	910	911	912	913	914	915	1007	1201	1202	1203
Institution	**Macromolecular & Materials Chemistry**	**Artificial intelligence and image processing**	**Information Systems**	**Chemical Engineering**	**Civil Engineering**	**Electrical & Electronic Engineering**	**Manufacturing Engineering**	**Maritime Engineering**	**Materials Engineering**	**Mechanical Engineering**	**Resources engineering & extractive metallurgy**	**Interdisciplinary Engineering**	**Nanotechnology**	**Architecture**	**Building**	**Design Practice & management**
Bond University	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
Central Queensland	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Charles Sturt University	-	2	-	-	-	-	-	-	-	2	-	-	-	-	-	-
Curtin University	-	3	2	4	2	3	-	-	1	4	3	-	-	2	2	-
Deakin University	-	3	2	-	-	3	4	-	5	4	-	-	4	2	2	-
Edith Cowan University	-	2	2	-	-	1	-	-	-	-	-	-	-	-	-	-
Flinders University	-	3		-	-	-	-	-	-	-	-	-	5	3	-	-
Griffith University	-	4	2	-	2	2	-	-	-	-	-	-	-	-	-	-
James Cook University	-	1		-	2		-	-	4	-	-	3	-	-	-	-
La Trobe University	-	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
Macquarie University	-	3	2	-	-	3	-	-	-	-	-	-	-	-	-	-
Monash University	5	4	3	5	5	4	-	-	5	4		5	5	3	-	-
Murdoch University	-	2	2	-			-	-	-	-	5	-	-	-	-	-
QUT	-	3	4	-	2	3	-	-	5	4	-	-	-	3	3	3
RMIT University	-	4	4	3	3	4	-	-	4	4	-	-	-	5	4	4
Swinburne University	-	3	2	-	2		-	5	4	3	-	-	-		-	2
The ANU	-	5	3	-	-	5	-	-	4		-	-	-	-	-	-
The University of Adelaide	5	5	-	3	4	3	-	-	-	3	4	-	-	3	-	-
The University of Melbourne	5	4	5	4	3	4	-	-	5	5	-	-	-	5	3	
The University of NSW	-	4	4	4	4	5	-	-	4	3	5	-	-	3	4	2
The University of Qld	5	3	5	5	3	3	-	-	5	4	4	-	5	4	-	-
The University of Sydney	5	4	4	4	4	4	-	-	5	4	-	-	4	3	-	3
The University of WA	-	3	-	-	4	4	-	-	3	4	-	-		3	-	-
University of Ballarat	-	2	2	-	-	-	-	-	-	-	-	-	-		-	-
University of Canberra	-	2	2	-	-	-	-	-	-	-	-	-	-	2	-	-
University of Newcastle	5	-	-	-	5	5	-	-		5	5	3	-	3	3	-
University of South Australia	-	3	3	-	3	3	-	-	4	4	5	-	-	-	-	-
University of Southern Qld	-	2	2	-	-	-	-		2	-	-	-	-	-	-	-
University of Tasmania	-	1	1	-	-	-	-	3		-	-	-	-	2	-	-
UTS	-	4	3	4	3	3	-	-	4	3	-	-	-	3	2	3
UWS	4	3	2	-	3	3	-	-	3		-	-	-	-	2	-
University of Wollongong	5	3	3	-	4	4	4	-	5	4	3	5	-	-	-	-
Victoria University	-	3	2	3	3	5	-	-	-	-	-	-	-	-	-	-
Number with ERA Result	**8**	**31**	**25**	**10**	**19**	**21**	**2**	**2**	**18**	**18**	**8**	**4**	**5**	**16**	**10**	**6**
Number assessed 4 or 5	**8**	**9**	**6**	**7**	**7**	**10**	**2**	**1**	**14**	**12**	**6**	**2**	**5**	**3**	**2**	**1**
Number assessed 3	**-**	**13**	**6**	**3**	**7**	**9**	**-**	**1**	**2**	**4**	**2**	**2**	**1**	**9**	**3**	**2**

Source: Australian Research Council, *Excellence in Research for Australia: National Report*, Canberra, 2012

According to the ERA assessments, research excellence in the relevant FORs is spread widely across the university sector in Artificial Intelligence, Information Systems, Chemical Engineering, Civil Engineering, Electrical and Electronic Engineering, Materials Engineering, Mechanical Engineering and Architecture. Only two universities, Wollongong and Deakin, were assessed as having research strengths in Manufacturing Engineering which is, according to the FOR definitions, the most relevant to steel fabrication in a factory environment.

The Manufacturing Engineering field covers:

- Manufacturing robotics and mechatronics, other than their automotive applications
- Flexible manufacturing systems
- Computer-aided design and computer-aided manufacture, also known as CAD/CAM
- Precision engineering
- Packaging, storage and transportation

It is the case, however, that universities select which FOR categories they are assessed on. Although only Wollongong and Deakin elected to be assessed on Manufacturing Engineering, it does not follow that other universities are not strong in this FOR. There is considerable manufacturing engineering interest within Materials Engineering, for example. It is nonetheless, a reflection of research priority and emphasis.

Discussions with universities during the project suggested that reasons for the low priority given to Manufacturing Engineering included a shortage of A* journals for publication and the limited availability of funding for research in the field. This is discussed further in 2.1.2 below.

On the basis of the ERA submissions and assessments it is clear that there is not a strong research commitment to Manufacturing Engineering within the Australian university sector. This gap will work its way through to limited opportunities for adoption and application of research – particularly in strategies and actions for innovation and modernisation of fabrication operations and management.

In other research fields there are many universities assessed at above world class: for the steel fabrication sector, strengths in civil and materials engineering are of particular significance in capabilities such as assembly (including modular construction), forming and joining (particularly welding).

Given the cross disciplinary nature of research relating to steel fabrication capabilities, it would be expected that those universities with the strongest capabilities would have ERA assessments of performance at the world class or above (3-5) in two or more relevant disciplines. They way in which disciplines intersect is reflected in Faculty structures and Centres for teaching and research that bring together several disciplines in an integrated academic and industry engagement strategy.

Several Universities have Centres that focus specifically on manufacturing research, technological development, and teaching that traverse disciplinary boundaries. But none have a specific focus on steel.

2.1.2 Research income

A profile of research income across relevant FORs for the period 2008-2010 is provided in Table 1. It shows that the relevant fields attracted $8.8 billion, or 12.1 per cent of total research funding. Funding for Manufacturing Engineering amounted to $31.8 million, or 0.4 per cent of the total. Publicly funded research (Categories 1 and 2) amounted to $8.8 million, while industry funded research amounted to $18.5 million. This data relates to *all* Manufacturing Engineering – not specifically for steel.

Table 1: Research income relevant to steel fabrication 2008-2010 ($m)

FOR	Category 1	Category 2	Category 3 (Australia)	Category 3 (international A)	Category 3 (International B)	Category 4	Total
303	28.2	7.4	2.8	0.5	1.3	2.4	42.5
801	34.9	25.9	9.0	2.0	4.5	6.2	82.5
806	19.3	15.1	8.8	1.9	5.3	5.6	56.0
904	34.5	24.6	14.9	0.8	7.4	8.2	90.4
905	37.7	43.6	41.6	1.0	8.3	10.6	142.8
906	50.7	44.6	25.2	3.4	20.7	5.5	150.0
910	**6.6**	**2.2**	**17.4**	**0.3**	**0.9**	**4.4**	**31.8**
911	3.1	0.9	2.3	0.0	0.6	0.0	6.9
912	52.3	18.6	14.0	1.2	8.4	22.3	116.9
913	26.1	22.8	26.7	1.5	7.0	24.2	108.2
914	34.5	13.3	46.0	1.9	15.8	24.1	135.7
915	14.2	3.4	4.0	0.6	0.4	0.4	23.1
1007	15.0	14.3	0.7	0.2	0.5	0.2	30.8
1201	8.1	5.0	3.5	0.3	2.1	1.0	20.2
1202	2.9	3.1	3.5	0.1	1.9	1.5	12.9
1203	1.9	2.8	3.0	0.4	0.4	1.7	10.3
Total Relevant FORs	370.0	247.7	223.3	16.1	85.7	118.1	1,060.9
Total All FORs	3,752.5	2,385.9	1,589.2	208.3	459.7	372.2	8,767.7
Prop Engineering	*9.9%*	*10.4%*	*14.1%*	*7.7%*	*18.6%*	*31.7%*	*12.1%*

Source: Australian Research Council, *Excellence in Research for Australia: National Report*, Canberra, 2012

The overall proportion of publicly funded research (Categories 1 and 2), amounting to $617.7 million, represents 58 per cent of research income – distributed across 33 universities that claim to have research excellence in one or more of these FORs.

Manufacturing Engineering received three per cent of research income for relevant FORs over the period and 2.9 per cent of publicly funded research income. It received almost eight per cent of Australian industry funding. The distribution of funding across relevant FORs is shown in Table 2.

Table 2: Distribution of research income across FORs relevant to steel fabrication

FOR	Category 1	Category 2	Category 3 (Australia)	Category 3 (international A)	Category 3 (International B)	Category 4	Total
801	9.4%	10.5%	4.0%	12.4%	5.3%	5.2%	7.8%
806	5.2%	6.1%	3.9%	11.9%	6.2%	4.7%	5.3%
904	9.3%	9.9%	6.7%	5.0%	8.6%	6.9%	8.5%
905	10.2%	17.6%	18.6%	6.5%	9.7%	8.9%	13.5%
906	13.7%	18.0%	11.3%	21.1%	24.1%	4.6%	14.1%
910	**1.8%**	**0.9%**	**7.8%**	**1.8%**	**1.1%**	**3.7%**	**3.0%**
912	14.1%	7.5%	6.3%	7.7%	9.8%	18.9%	11.0%
913	7.1%	9.2%	12.0%	9.0%	8.2%	20.5%	10.2%
914	9.3%	5.4%	20.6%	12.1%	18.4%	20.4%	12.8%
Other	19.8%	14.9%	8.9%	12.6%	8.6%	6.0%	13.8%
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Calculated from Australian Research Council, *Excellence in Research for Australia: National Report*, Canberra, 2012

Table 2 indicates that the FORs that attract the highest proportions of research income are Civil Engineering, Electrical and Electronic Engineering, Materials Engineering, Mechanical Engineering, and Resources Engineering and Extractive Metallurgy.

The policy argument that more could be done to transfer the results of publicly funded research to the steel fabrication sector, within existing funding levels, has to be seriously questioned. There is, arguably, insufficient funding for research to enable a transfer to be initiated – quite apart from the issue of maintaining capability.

There is, however, a significant amount of industry funded research that is supported by a handful of large and medium sized businesses. There is also growing interest among multinational businesses. The most significant areas of collaboration are in Civil Engineering and Materials Engineering. This is discussed in later sections of the Report.

2.1.3 ARC grants for steel fabrication related research

The Australian Research Council (ARC) has provided limited support for steel fabrication related research. Details of grants in 2011 and 2012 are provided in Attachment 4. Most grants have been in the field of Civil Engineering (FOR 905). Project titles, administering and partner organisations are listed in Table 3.

Table 3: ARC grants for steel related research 2010-2012

Program	Title	FOR	Administering organisation/Partners
Discovery awards for funding in 2012	Hybrid stainless-carbon steel composite beam-column joints at ambient and elevated temperatures	905	University of Western Sydney
Discovery awards for funding in 2012	The behaviour and design of composite columns coupling the benefits of high strength steel and high strength concrete for large scale infrastructure	905	University of Western Sydney
Discovery awards for funding in 2012	Durability of carbon fibre reinforced polymer strengthened steel structures against environment-assisted degradation	905	Monash University
Discovery awards for funding in 2012	A study of pull-through failures of thin steel battens to improve building safety and resilience during extreme wind events	905	Queensland University of Technology
Linkage awards for funding in Jul 2012	Reducing the environmental impact of steel making through direct strip casting	912	The University of New South Wales and Baoshan Iron and Steel Co Ltd
Linkage awards for funding in Jul 2012	Long-span cold-formed steel portal frames	905	The University of Sydney and BlueScope Lysaght
Linkage awards for funding in Jul 2012	New generation high efficiency thermoelectric materials and devices for waste heat recovery	912	University of Wollongong and Baosteel Company
Linkage awards for funding in Jul 2012	Bearing capacities of innovative LiteSteel beams and their floor systems	905	Queensland University of Technology and LiteSteel Technologies Pty Ltd
Linkage awards for funding in Jan 2012	Seismic behaviour of drive-in steel storage racks	905	The University of Sydney and Dematic Pty Ltd
Linkage awards for funding in Jan 2012	Flexible roll forming of advanced high strength steel sheet	913	Deakin University and Australian Rollforming M, BlueScope Steel, Wuhan Iron & Steel, Sheet Metal Solutions

2.1.4 Staffing

Staffing profiles across FORs are profiled in Table 4.

Table 4: FORs Relevant to Steel Fabrication Research – Staffing (March 2011)

FOR		Level E	Level D	Level C	Level B	Level A	Other	Total
303	Macro & Materials Chemistry	19.5	14.6	16.9	39.4	55.7	11.8	157.9
801	Artificial Intelligence and Image Processing	72.1	69.8	121.4	136.8	52.5	44.2	496.8
806	Information Systems	62.8	64.8	136.2	150.5	32.5	30.6	477.4
904	Chemical Engineering	39.5	33.1	44.7	64.5	78.4	28.5	288.7
905	Civil Engineering	66.6	53.8	81.4	105.1	43.3	22.3	372.5
906	Electrical & Electronics Engineering	75.5	64.0	127.3	120.1	56.2	40.3	483.7
910	**Manufacturing Engineering**	**11.2**	**7.1**	**18.8**	**20.1**	**8.7**	**10.2**	**76.1**
912	Materials Engineering	49.4	43.8	64.6	85.5	67.6	34.4	345.3
913	Mechanical Engineering	55.8	45.2	79.5	87.1	49.9	27.7	345.2
914	Resources Engineering	41.4	32.8	51.5	44.5	27.2	33.4	230.8
915	Interdisciplinary Engineering	20.5	14.1	25.6	29.1	14.3	8.4	112.0
1007	Nanotechnology	9.6	8.4	14.5	22.9	18.9	6.4	80.7
1201	Architecture	37.0	40.5	98.2	92.5	16.3	12.0	296.5
1202	Building	19.8	18.4	42.6	42.5	4.7	1.9	129.9
1203	Design Practice	17.2	21.6	52.2	94.9	17.4	4.0	207.3
1204	Engineering Design	0.8	1.3	1.5	2.6	2.5	0.2	8.9

Source: Australian Research Council, *Excellence in Research for Australia: National Report*, Canberra, 2012

The data indicate that there are only eleven Professors in the field of Manufacturing Engineering. This contrasts with 67 in Civil, 76 in Electrical and Electronics and 49 in Materials.

2.1.5 Research outputs

Across the system, research outputs are concentrated in a relatively small number of disciplines. This is indicated in Table 5, drawn from the 2012 ERA Report. Research outputs cover the period 2005-2010.

Table 5: FORs Relevant to Steel Fabrication Research - Research Outputs 2005-2010

FOR		Books	Book Chapter	Journal Article	Conference Paper	Other	Total
303	Macro & Materials Chemistry	5.1	62.6	1,847.7	141.2	-	2,046.6
801	Artificial Intelligence and Image Processing	30.1	523.5	2,144.6	5,483.3	-	8,181.5
806	Information Systems	31.4	541.3	1,866.5	4,280.1	-	6,719.3
904	Chemical Engineering	4.2	119.0	3,713.3	928.1	-	4,764.6
905	Civil Engineering	27.3	177.5	3,558.6	3,444.1	-	7,207.5
906	Electrical & Electronics Engineering	38.4	232.8	4,053.2	5,566.4	-	9,890.8
910	**Manufacturing Engineering**	**0.6**	**18.4**	**529.9**	**447.1**	-	**996.0**
912	Materials Engineering	12.9	125.3	5,057.8	1,122.6	-	6,318.6
913	Mechanical Engineering	15.7	157.5	3,171.0	2,452.9	-	5,797.1
914	Resources Engineering	4.0	49.4	1,151.4	1,116.4	-	2,321.2
915	Interdisciplinary Engineering	1.6	32.5	719.9	572.8	-	1,332.2
1007	Nanotechnology	2.0	41.1	591.9	231.7	-	866.7
1201	Architecture	68.9	431.5	528.1	893.3	690.9	2,613.2
1202	Building	17.2	92.8	616.3	917.2	8.0	1,651.5
1203	Design Practice	25.8	122.4	287.9	602.8	303.9	1,412.4

Source: Australian Research Council, *Excellence in Research for Australia: National Report*, Canberra, 2012

Research outputs in Manufacturing Engineering are the lowest of the engineering group. By contrast, Materials Engineering, which has a strong science base, has one of the higher research outputs, although less than civil and electrical and electronic engineering fields. The potential to transfer and translate discoveries and inventions in the more science oriented engineering fields into application and use in a manufacturing engineering environment is an area that has received little attention (and funding) in academic research.

2.1.6 Commercialisation

University commercial activity, that is, selling university outputs with a profit in mind, is indicated by commercialisation income submitted by universities. Universities do not prepare data that includes the full cost of producing those outputs.

ERA data relating to commercialisation income covers commercial sales and/or capital gains resulting from the commercialisation of research outputs, services, and intellectual property. Summary data is provided in Table 6.

Table 6: FORs Relevant to Steel Fabrication Research – Commercialisation income ($)

FOR		2008	2009	2010	Total
303	Macro & Materials Chemistry	494,997	37,777	18,718	551,492
801	Artificial Intelligence and Image Processing	3,035,980	3,572,595	7,836,305	14,444,880
806	Information Systems	29,357	43,340	114,891	187,588
904	Chemical Engineering	1,549,754	162,477	913,350	2,625,581
905	Civil Engineering	418,871	224,815	100,899	744,585
906	Electrical & Electronics Engineering	4,371,767	4,643,055	7,170,945	16,185,767
910	**Manufacturing Engineering**	**2,664**	**0**	**0**	**2,664**
912	Materials Engineering	136,628	1,039,246	1,378	1,177,252
913	Mechanical Engineering	419,699	2,984,960	755,122	4,159,781
914	Resources Engineering	1,954,021	6,581,020	1,656,236	10,191,277
915	Interdisciplinary Engineering	0	0	0	0
1007	Nanotechnology	0	0	0	0
1201	Architecture	72	0	0	72
1202	Building	0	71,997	0	71,997
1203	Design Practice	1,652	0	24,612	26,264
1204	Engineering Design	0	0	0	0
Total		**12,417,470**	**19,363,291**	**18,594,466**	**50,369,200**

Source: Australian Research Council, *Excellence in Research for Australia: National Reports*, Canberra, 2012

Patents provide a basis for collaborations, in terms of 'a seat at the table' in the management of collaborations as well as the sales and licensing of IP. Information regarding patenting on the FORs under consideration is provided in Table 7.

Table 7: FORs Relevant to Steel Fabrication Research – Patents sealed 2008-2010

FOR		Aus	US	Europe	Japan	Other Int	Triadic	Total	% of Total
303	Macro & Materials Chemistry	3.2	3.7	0.4	2.7	14.4	0	24.5	3.1
801	Artificial Intelligence and Image Processing	9.2	2.5	0.3	0.3	2.4	0.0	14.7	1.9
806	Information Systems	0.3	1.0	0.0	0.0	0.0	0.0	1.3	0.2
904	Chemical Engineering	8.2	5.2	5.1	0.4	25.6	0.0	44.5	5.7
905	Civil Engineering	4.0	0.0	1.0	0.0	6.0	0.0	11.0	1.4
906	Electrical & Electronics Engineering	8.9	12.7	1.7	0.9	7.8	0.0	32.0	4.1
910	**Manufacturing Engineering**	**0.0**	**1.0**	**0.0**	**0.0**	**2.0**	**0.0**	**3.0**	**0.4**
912	Materials Engineering	4.8	5.3	0.3	1.2	10.4	0.0	22.0	2.8
913	Mechanical Engineering	5.0	4.0	0.0	1.5	5.8	0.0	16.3	2.1
914	Resources Engineering	5.0	4.6	1.9	0.0	20.3	0.0	31.8	4.1
915	Interdisciplinary Engineering	1.0	1.5	0.0	0.0	0.5	0.0	3.0	0.4
1007	Nanotechnology	0.3	0.2	0.0	0.0	0.6	0.0	1.1	0.1
1201	Architecture	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1202	Building	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1203	Design Practice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1204	Engineering Design	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total		**49.9**	**41.7**	**10.7**	**7.0**	**95.8**	**0.0**	**205.2**	**26.3**

Source: Australian Research Council, *Excellence in Research for Australia: National Reports*, Canberra, 2012

The data in Table 7 indicates that the FORs relating to steel fabrication account for over a quarter of university patenting activity.

2.1.7 Research impact

The impact of research has not been assessed in this project. It is possible, however, that the impact in terms of new and improved processes, products and ways of doing business could be profound. There are challenges, however, in transferring new discoveries and inventions in areas such as civil engineering and materials engineering into manufacturing processes and new products that create value for end users. The potential in areas such as cold formed steel construction, joining, and coatings technologies is discussed later in the Report.

2.2 Mapping FORs to fabrication capabilities

In the following Table, FOR codes are mapped to the manufacturing capabilities identified in the project brief and other capabilities identified as being relevant to the project.

Figure 3: Fields of Research Relevant to Steel Fabrication Capabilities

FOR CODE	303	801	806	904	905	906	910	912	913	914	1007	1201	1202	1203
Field of Research	**Macromolecular & Materials Chemistry**	**Artificial intelligence and image processing**	**Information Systems**	**Chemical Engineering**	**Civil Engineering**	**Electrical & Electronic Engineering**	**Manufacturing Engineering**	**Materials Engineering**	**Mechanical Engineering**	**Resources engineering & extractive metallurgy**	**Nanotechnology**	**Architecture**	**Building**	**Design Practice**
Automation	-	Y	Y	-	-	Y	Y	-	Y	Y	-	Y	-	Y
Additive Manufacture	Y	-	-	Y	-	-	-	Y	-	-	Y	-	-	Y
Assembly	-	Y	Y	-	Y	Y	Y	-	Y	-		Y	Y	Y
Coating	Y	-	-	Y	-	-	-	Y	-	-	Y	-	-	-
Casting	Y	-	-	Y	-	-	-	Y	-	-	-	-	-	-
Cutting	-	Y	Y	-	-	-	Y	-	Y	-	-	-	-	-
Design	-	Y	Y	-	-	-	Y	Y	-	-	Y	Y	Y	Y
Energy Efficiency	-	-	-	-	Y	Y	-	-	Y	Y	-	Y	-	Y
Forming	Y	-	-	Y	Y	-	Y	Y	-	-	-	-	-	-
Joining (Welding)	Y	-	-	Y	Y	-	Y	Y	-	-	Y	-	-	-
Joining (Riveting, Bolting)	-	Y	Y	-	Y	-	Y	-	-	-	-	-	-	-
Building Information Modelling	-	Y	Y	-	-	-	Y	-	-	-	-	Y	-	Y
Machining	Y	Y	-	-	-	Y	Y	Y	Y	-	Y	-	-	Y
Building and Construction Mgt	-	-	-	-	-	-	-	-	-	-	-	Y	Y	-
Robotics	-	Y	Y	-	-	Y	Y		Y	Y	-	Y	Y	Y

This assessment was validated in conversations and discussions with senior staff in Universities and Research Centres.

2.3 Fabrication capabilities in Australian universities and research organisations

In this section of the Report the research mapping is extended beyond ERA assessments and research outputs to a broader assessment of research capability, teaching, analytical and testing equipment and industry engagement. Initial material was obtained from university websites and publications as well as contacts and referrals within the sector.

2.3.1 Capability map

From reference to ERA performance, review of university websites and published research staff résumés, and in follow-up discussion with senior executive, faculty and research centre staff at universities and research organisations in all mainland states (except Western Australia) a map of steel fabrication process technologies was obtained. This is represented in Figure 4 below.

Capabilities are only recorded where there has been agreement with the institution concerned. Where it was not possible to enter into a dialogue with a university or research organisation, capability is recorded where it has been clearly demonstrated through the reputation of a research centre, an individual researcher or a third party referral.

Whilst identified capability is connected with assessed ERA performance, it is also the case that some universities and research organisations have a focus on applied research and connections with industry that is not reflected in ERA criteria. Many universities, for example, UNSW, RMIT, Swinburne and Deakin have strong research capability as well as industry connections and state of the art facilities and equipment that are available for use in industry partnerships. Universities and research organisations are addressing the opportunities for broader industry access.

Figure 4: Map of Steel Fabrication Research Capabilities at Australian Research Institutions

	Automation	Robotics	Additive Manufacture	Assembly	Coating	Casting	Cutting	Forming (Incl. Cold Forming)	Joining (Welding)	Joining (Riveting, Bolting)	Machining	Building Information Modelling	Energy Efficiency	Architecture & Design	B&C Management
Bond University*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Y
Curtin University*	-	-	-	-	-	-	-	-	Y	-	-	-	-	-	Y
Deakin University	Y	Y	Int.	Y	Y	Y	Y	Y	-	-	Y	Y	Y	Y	Y
Griffith University*	-	-	-	-	-	-	-	Y	-	-	-	Y	Y	-	-
James Cook University*	-	-	-	Y	-	-	-	-	-	-	-	-	-	-	-
Macquarie University*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Monash University	Y	-	-	-	Y	Y	-	Y	Y	-	Y	-	-	-	-
Murdoch University*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
QUT	Y	Y	-	Y	-	-	Y	Y	-	Y	-	-	-	Y	Y
RMIT University	Y	Y	Y	-	Y	-	Y	-	-	-	Y	-	-	Y	Y
Swinburne University	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
The ANU	Y	Y	-	Y	-	-	-	Y	Y	-	-	Y	-	Y	-
The University of Adelaide	-	Y	-	Y	-	-	-	-	-	-	-	Y	Y	-	-
The University of Melbourne	-	-	Y	Y	-	-	-	-	-	Y	-	-	-		Y
The University of NSW	-	Y	-	-	-	Y	Y	-	-	-	-	Y	Y	-	Y
The University of Queensland	Y	Y	Y	-	Y	Y	Y	Y	Y	Y	Y	-		Y	Y
The University of Sydney	Y	Y	-	Y	Y	-	-	Y	-	-	-	-	Y	Y	-
The University of WA*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
University of Canberra	-	-	-	-	-	-	-	-	-	-	-	-	-	Y	Y
University of Newcastle*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Y
University of South Australia	-	Y	-	-	-	-	-	Y	-	-	-	Y	Y	Y	Y
UTS	Y	Y	Int.	Y	Y	-	-	Y	Y	-	-	Y	Y	Y	Y
University of Western Sydney		Y	Int.	Y	-	-	-	Y	Y	-	-	Y	Y		Y
University of Wollongong	Y	Y	Y	-	Y	Y	-	Y	Y	Y	-	-	Y	Y	-
Total University Sector	**10**	**13**	**5**	**10**	**8**	**6**	**7**	**12**	**8**	**5**	**5**	**9**	**10**	**11**	**14**
Research Organisations															
ANSTO	Int.	Int.	Y	Int.	Y	Y	Y	Y	Y	Y	Y	-	Int.	-	-
CSIRO	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y		Y	Int	
NICTA	Y	Y	-	-	-	-	-	-	-	-	-	-	-	-	-
CAST CRC	-	-	-	-	Y	Y	Y	Y	Y	Y	Y	-	-	-	-
Advanced Manufacturing CRC	Y	-	Y	-	-	-	-	-	-	-	-	-	-	-	-
*Energy Pipelines CRC**	-	-	-	-	-	-	-	-	Y	-	-	-	-	-	-
National Fabrication Facility	-	-	Y	-	Y	-	-	-	-	-	-	-	-	-	-
DMTC	Y	Y	Y	Int	Y	Y	-	Int	Y	Y	Y	-	-	Y	-
*QMI**	-	-	Y	-	-	-	-	Y	-	-	-	-	-	-	-
Number of Institutions Identifying Capability	**14**	**16**	**11**	**11**	**13**	**10**	**10**	**16**	**13**	**8**	**9**	**9**	**11**	**12**	**14**

Key: **Y** – indicates capability present.
Int – Indicates institution has an interest in developing capability
* – Capability not validated due to unavailability of a senior university executive to provide information or respond to a request for information. In some cases it is apparent from university websites that there is minimal capability in areas of interest

The map identifies strong capabilities across institutions in automation, coating (strongly supported by BlueScope Steel and a number of international corporations), casting, energy efficiency, information modelling and building and construction management (where universities offering AIB accredited courses are included).

Only a few institutions, however, provide all capabilities. Universities that have a broad range of capability relating to steel fabrication include:

- Deakin University
- Monash University
- RMIT University
- Swinburne University of Technology
- The Australian National University
- The University of NSW
- The University of Queensland
- The University of Sydney
- University of Technology, Sydney
- University of Wollongong

Many of these universities already participate in collaborations, such as the Defence Materials and Technology Centre (DMTC). The DMTC provides an example of the way in which capabilities can be aggregated and made available to an important industry sector. Further information on capability at universities and research organisations is contained in Attachment 3.

2.3.2 Education and training

Several universities are addressing the training need and have acquired modern machinery for the purposes of education. The machinery is also used in collaborative partnerships with industry. The recently opened Advanced Manufacturing Precinct at RMIT provides a leading example. There is also substantial capability at Advanced Manufacturing Centres at Swinburne and at The University of Queensland.

RMIT University's Advanced Manufacturing Precinct

The Precinct brings together RMIT's expertise and strengths in innovative technology and design. It houses the latest in industrial platform technologies focusing on additive and subtractive technologies, and can develop and realise conceptual design and its many iterations, across many disciplines of product and industrial design.

It can provide companies with access to a range of specialised equipment that can enhance product development and design, drawing on the University's international reputation for excellence in work-relevant education and high-quality research that is engaged with the needs of industry and community. Specialised equipment provides access to cutting-edge technology that can enable companies to develop new conceptual products, perform multiple design iterations, or develop existing products. Equipment includes:

- High speed multi-axis machining centres
- Additive and subtractive process manufacturing in a range of materials
- Selective laser melting (metal-based technology)
- Fused deposition modelling (polymer-based technology)
- Objet machines (polymer-based technology)
- U Print machines (polymer-based technology).

The Precinct houses internationally recognised multi-axis CNC machines (Okuma, Haas and BIESSE) for machining high-performance alloys and composites for engineering and furniture applications. It uses a range of automation robotics to simulate manufacturing production lines used in the furniture, textile and design industries. We have the latest in CAD software, allowing students and researchers to design components and models. The Precinct allows access to RMIT's full capabilities. Prototypes can be tested to determine limitations and specifications. Testing can include:

- mechanical analysis
- material analysis
- system power
- acoustics testing
- fatigue testing
- tensile testing.

Highly accurate digital coordinate measuring machines allow detailed verification for quality assurance and reverse engineering.

http://www.rmit.edu.au/browse/Our%20Organisation/Science%20Engineering%20and%20Health/Advanced%20Manufacturing%20Precinct/

2.4 Overview of fabrication capabilities in universities and research organisations

2.4.1 Automation and robotics

The Field of Research that is perhaps the most relevant to the steel fabrication sector is Manufacturing Engineering (FOR 902). This covers:

- Manufacturing robotics and mechatronics, other than their automotive applications
- Flexible manufacturing systems
- Computer-aided design and computer-aided manufacture, also known as CAD/CAM
- Precision engineering
- Packaging, storage and transportation.

It is an area that is of vital importance to the sector but, according to ERA and research output data, it receives a very small amount of research funding. Discussions with research staff in universities identified it as a seriously neglected area. Only Deakin University and University of Wollongong received an ERA assessment in the 2010 round.

Discussions at other universities, Swinburne for example, indicated that they have a strong research base, but it was not included in their ERA submission strategy. Some Universities, including Queensland, which also has a very strong research base, submitted under other ERA fields where the work was likely to achieve a higher recognition.

With a manufacturing sector under pressure, research in manufacturing engineering is not being accorded a priority within universities, funding agencies, or industry. Yet, manufacturing research should be seen as part of the solution to an ailing manufacturing sector, enabling modernisation, change, and restructure.

At the same time, the analysis reflected in Table 4 indicates that there is a substantial amount of capability in automation and robotics - with 10 universities having a capability in automation and 12 in robotics. In addition to Manufacturing Engineering, the research bases in these capabilities are: Artificial Intelligence and Image Processing (FOR 801), Information Systems (806), Electrical and Electronic Engineering (906), Resources Engineering (914) Architecture (1201) and Design Practice (1203).

It would appear therefore, that capability is not being applied to steel fabrication. Apart from the image of steel manufacturing, it is also the case that sophisticated machinery and equipment comes with embedded OEM systems and there is a large supplier market of proprietary factory automation software and CAD/CAM systems, including Building Information Modelling (BIM) systems).

A significant amount of industry research is a response to problems and opportunities identified by industry. The mining sector, for example, has been behind some innovative applications of mine automation and robotics. In the current steel fabrication environment, industry is not generally seeing research as a way of addressing current problems and opportunities. Yet research sits behind innovation, change and prosperity. The potential for disruptive innovation in roofing, driven by BlueScope, provides an example of this.

The factory of the future will be digitally driven, machine based, and seamlessly connected from the ordering process (probably in-line) to delivery to the end user. More steel will be fabricated in a factory environment rather than on site: developments in modular housing and building, referred to later in the Report, provide an indication of this future scenario. Innovations in cold formed steel for low rise structures is seen as a major opportunity.

But, generally, the Australian steel fabrication sector has been slow to embrace new technologies, including, but not limited to automation and robotics. There is a need to move the perception of steel fabrication from an industrial age to one that is based on the application and use of information and knowledge. It will require new skills developed through the integration of competency, knowledge, and theory based learning to support innate capacities for ingenuity and initiative that underpin innovation, and which is a characteristic of engineering based professions.

Issues concerning automation and robotics are discussed further in specific areas of capability.

2.4.2 Assembly

Assembly covers the erection of buildings, bridges, houses, racks and scaffolds. It is a capability that relates specially to the Civil Engineering Field of Research (FOR 905). 11 universities have identified a capability in assembly, including Deakin, James Cook, Swinburne, The ANU, The University of Adelaide, The University of Sydney, The University of Melbourne, QUT, The University of Melbourne, UTS and UWS.

Australia is a leader in the manufacture, use and application of cold-formed steel and roll forming. BlueScope has assisted in growing the number of fabricators producing cold formed steel products – but not all cold formed steel uses Australian steel coil. There is a good supply from China.

Australia has also defined the world standard for cold-formed steel structures through the work of Professor Greg Hancock at The University of Sydney (although the standard has not been updated since 1998).

Professor Gregory Hancock

Professor Gregory Hancock is an Emeritus Professor. He was formerly Dean of the Faculty of Engineering and IT, University of Sydney, from May 2004 to August 2009. He was also BlueScope Steel (formerly BHP Steel) Professor of Steel Structures in the Department of Civil Engineering, from 1990 to 2009. He was Director then Chairman of the Centre for Advanced Structural Engineering in the University of Sydney from 1988 to 2003. His research interests are in the area of cold-formed steel structures and he was awarded the degree of Doctor of Engineering in 2003 by the University for a collection of 69 papers on this subject.

He is a board member of the Australian Steel Institute, a member of the American Iron and Steel Institute Specification Committee (only non-North American member), and chairs the Standards Australia committee on cold-formed steel structures and is a member of 5 other Standards Australia committees in structural engineering. He is a Fellow of the Institution of Engineers Australia, and the Singapore Structural Steel Society. He was elected as a Fellow of the Australian Academy of Technological Science and Engineering in 2004. He is a member of the Editorial Board of the Journal of Constructional Steel Research published in London, as well the Journal of Advances in Structural Engineering (Hong Kong).

He is the author of "Design of Cold-Formed Steel Structures to AS/NZS 4600:2005" published by the Australian Steel Institute in 2007, and joint author of "Cold-Formed Steel Structures to the AISI Specification" (Hancock, Murray and Ellifritt) published by Marcel Dekker, New York in 2001.

http://sydney.edu.au/engineering/civil/people/hancock.shtml

Academic staff educated at The University of Sydney School of Engineering occupy prominent research and teaching positions in Australian universities and overseas. The School has worked closely with BlueScope over many years. Cold-formed steel has the ability to produce lightweight, strong, structures. This is indicated by research at the University of Sydney under an ARC Linkage Grant that commenced in 2012.

Long-span cold-formed steel portal frames

Investigators: Rasmussen, Prof Kim J; Zhang, Dr Hao ; Filonov, Mr Alexander ; Mysore, Mrs Kavitha ; Sharma, Mr Sandeep
Total Funding: $135,000.00
Primary FOR 0905 CIVIL ENGINEERING
Partner Organisation(s) BlueScope Lysaght
Administering Organisation: The University of Sydney
Project Summary: Novel solutions will be developed for building portal frames in cold-formed steel at effectively twice the span currently available. Economies are derived from using cold-formed steel, which will benefit the end consumer and help the Australian steel industry to maintain its position as preeminent provider of innovative cold-formed steel solutions.

A project to examine the bearing capacities of OneSteel's LiteSteel beams and their floor systems was also awarded for commencement in 2012.

Bearing capacities of innovative LiteSteel beams and their floor systems

Investigators: Mahendran, Prof Mahen
Total Funding: $195,000.00
Primary FOR: 0905 CIVIL ENGINEERING
Partner Organisation(s): LiteSteel Technologies Pty Ltd
Administering Organisation: Queensland University of Technology
Project Summary: This project will develop accurate bearing capacity design models for the new LiteSteel beams (LSB) to enable innovative and safe applications of LSBs in various flooring systems in buildings. Improved LSB floor systems will also be developed. This will enable expansion of the worldwide market for LSB products and systems by the industry partner.

Cold-formed steel is being used extensively in storage racks and warehouses, where there are risks of failure under load and seismic instability. An ARC Linkage grant has been made available to The University of Sydney and Dematic, a provider of precision storage systems for automated materials handling in large warehouses and distribution centres.

Seismic behaviour of drive-in steel storage racks

Investigators: Rasmussen, Prof Kim J; Zhang, Dr Hao; Clarke, Dr Murray J; Yang, Dr Demao; Berry, Dr Paul A
Total Funding: $202,489.00
Primary FOR: 0905 CIVIL ENGINEERING
Partner Organisation(s): Dematic Pty Ltd
Administering Organisation: The University of Sydney
Project Summary:
The purpose of this project is to study the behaviour, analysis and design of drive-in steel storage racks in an earthquake event. The main research outcome is the development of scientifically-based guidelines for the safe design of drive-in racks in seismic regions.

The popularity of cold-formed steel in construction has stimulated research into its wider use in low riser construction (retirement villages, prisons, country hospitals, and schools). The National Association for Steel Framed Housing (NASH) and the Australian Steel Institute have been major supporters of research, experimentation and the dissemination of good practice in relation to steel sheds.

Steel framed housing accounts for between 10 and 13 per cent of residential construction, but the proportion could be significantly higher. It tends to be higher among second and third homeowners.

Application of cold-formed steel built-up sections in building construction

Lau, H.H. and Ting, T.C.H and Tang, Fu Ee and Mei, C.C. 2010.

Researchers have noticed the advantages of utilizing built-up sections in steel structures. Several studies have shown that the performance of a structure is improved using built-up sections. Current industry design has taken advantage of cold-formed steel sections with limited in-depth knowledge and comprehensive design codes on built-up sections. The potential of built-up sections is limited without strong research and development works. These sections are generally used in cold-formed steel construction to resist loads induced in a structural member when a single section is insufficient to carry the applied load. By doing so, the weight of the structure can be greatly reduced while maintaining a large clear span.

http://espace.library.curtin.edu.au/R/?func=dbin-jump-full&object_id=154317&local_base=GEN01-ERA02

According to NASH, steel framed builders tend to be more commercial – that is, good business people, capable of using new methods, experience in technology and manufacture, and in design. There is higher market penetration where there are good operators. There is, however, a problem in assembly, which is regarded as being in 'the stone age'. There is virtually no automation in assembly as most companies are SMEs and viability in automation requires scale. This is starting to change as larger players enter the field.

NASH has been working with The University of Melbourne and Swinburne University. There are no active research grants at the moment although options are being canvassed with other industry partners. NASH, with many SMEs among its members, has the capacity to bring this component of the fabrication sector into the research environment.

There is also growing interest in modular fabrication in the resources sector. Research by Martin West at Curtin University for the Industry Capability Network points to the advantages in modularisation in cost reduction, schedule improvement and improved risk management. There are also disadvantages associated with higher costs in steel in the module frame, shipping costs, engineering costs, complexity, quality variability and cost of installation (West, 2011).

Assembly is also impacted by the adoption of steel detailing technologies and the use of Building Information Modelling (BIM) in the construction industry.

Thiess Teams Up with iConstruct

When integrated engineering services provider Thiess teamed up with iConstruct there was no doubt a technological revolution was in the pipeline.
Thiess BIM Manager Andrew Miller said iConstruct's unique BIM technology was creating major changes for design and construct delivery.
"The rapidly evolving field of BIM Management is the craft of incorporating as much project information as possible in the one multi-layered virtual model.
"With iConstruct, we not only have the three dimensional visual representation of a project, we also have the fourth dimension which is time and the fifth dimension which is cost.
"Embedded in the model is the hard data required by the various disciplines on the project. It's not just a visual representation but a full project manual," he said.
Thiess Queensland Senior Design and BIM Manager Paul Nunn said BIM was playing a critical role in the so-called fifth dimension of cost.
"BIM allows us to add value to a design through what we call 'optioneering' which gives us the ability to modify a design and cost the change immediately compared to a week or more in the old 2D world," he said.
iConstruct BIM Development Manager Rob Lawson believes a quantum shift is coming.
"I see a day in the near future when projects will be viewed virtually, through augmented reality goggles while walking around key aspects of the design onsite.
"The more user-friendly and available this technology becomes, the more useful it's going to be," he said.
http://www.iconstruct.com/news/news-article/thiess-teams-up-with-iconstruct

2.4.3 Casting

The casting industry, built around ferrous-based alloys is a significant part of the economy. There are a large number of businesses, mostly SMEs, and employees. A substantial amount of the research in relation to casting is in the area of Materials Engineering (FOR 912) rather than steel specifically. Casting also draws on Macromolecular and Materials Chemistry (303) and Chemical Engineering (904).

A strong research capability in casting was built up in the CAST CRC, which was created in 1993 and reaches the end of its funding period in 2012. The capability remains with the partner universities and research organisations, namely Swinburne, The University of Queensland, Monash University, Deakin University and CSIRO Light Metals Flagship.

The University of Queensland has immense technical knowhow developed through the CAST CRC and grant funding from the Queensland Government. This was of major benefit to the foundry industry in Queensland. CAST CRC may continue in a new organisational arrangement through AMPAM (Centre for Advanced Minerals Processing and Manufacturing) with participating universities and centres, including Monash, Deakin and Swinburne.

Casting at AMPAM

The University of Queensland has a long history of working with industry on solidification and casting problems. Our industry partners include Rio Tinto Alcan, Nissan Castings, Ford Australia, Investment Castings, Bradken, Hydrexia, Nihon Superior and others. We have a world leading research group with a reputation for excellent science and providing technical solutions to industry. With our research partners in CSIRO and Monash University all casting processes are investigated. AMPAM has particular strengths in grain refinement, silicon modification, lead-free solders, microstructural control and defect minimisation of porosity, hot tearing and segregation. We currently work on aluminium, magnesium, titanium and other high temperature metal alloys, electronic and energy storage materials, and wear resistant cast irons.

Key researchers are Prof David StJohn, Assoc Prof Ming Zhang, Assoc Prof Ma Qian, Assoc Prof John Taylor, Assoc Prof Kazu Nogita and Dr Stuart McDonald.

http://www.uq.edu.au/ampam/our-expertise

AMPAM has credentials to undertake further projects and wants to broaden into related areas. It has developed an effective way of working with SMEs by aggregating projects into programs. The Centre has also initiated a global light metals alliance, which will continue after CAST. It is targeted at industry intensive research and includes groups at Brunel, Austria, Germany, Canada, and the US.

A major issue for consideration, and for research, is the link between materials science and engineering and manufacture, and how to get the benefit from improved material properties through automation. Automation and robotics have substantial potential in the casting sector. The benefits of automation include:

- Low cost of robots, enabling early return on investment
- Increased requirements for system flexibility
- Workplace safety
- Variety of production rate requirements
- Cycle time requirements
- Life cycle of manufactured product to ensure acceptable ROI

- Product handling requirements
- Maintenance requirements
- Safety standards related to heat and gas exposure.

The project did not identify research projects being conducted in these areas. RMIT has recently established a link with ABB, a global supplier of industrial robots.

ABB announces India – Australia research collaboration

Bangalore, February 24, 2012

ABB's India Research Center to work on advanced technologies in the area of automation and robotics

ABB today announced a new joint initiative between their India and Australia operations to help set up the Australia-India Research Centre for Automation Software Engineering (AICAUSE) in collaboration with the RMIT University in Australia.

The initiative was announced in the presence of Ted Baillieu, Premier of the State of Victoria in Australia and Bazmi Husain, Country Manager and Managing Director, ABB India.

Research laboratories at RMIT campus, ABB in Australia and ABB Corporate Research Center in India will be linked up to form a virtual R&D laboratory supporting joint industry research collaboration. This collaboration will not only provide opportunities for software engineers from Australia and India to take part in cutting-edge automation software engineering research but also lead the way for future partnerships and investment between the two countries.

Commenting on the initiative, Bazmi Husain said, "ABB invests more than US$1 billion a year in R&D globally and initiatives such as this are vital for academia, students, organisations and society to benefit from the synergy of experience and domain knowledge. They also engage the student community in a rich and practical way, providing experience of real-world technology challenges."

Speaking at the signing of the MoU, Ted Baillieu said "We are delighted to be associated with ABB. There is great potential in bringing together academia and researchers to develop solutions that tackle issues core to industry such as improving energy efficiency, raising productivity and addressing climate change. Australia-India Research Centre for Automation Software Engineering (AICAUSE) will generate hundreds of new jobs for Victoria and help put the State at the forefront of global software engineering for advanced automation technologies."

The virtual laboratory will provide a platform for global software and systems engineering research and training. More than 20 engineering colleges in India associated with ABB, including RV College of Engineering in Bangalore, would be part of this initiative. RMIT has strong research ties with India, and conducts its research through a transdisciplinary approach that considers both the technological and social dimensions of the work at hand.

http://www.abbaustralia.com.au/cawp/seitp202/fdd96b318f97eb21652579ad0026547b.aspx

In October 2012 ABB invited proposals from academic and research institutes around the world to support promising graduate students with projects that combine academic research with industrial application in the power and automation area. The Research Grant Program is intended to enlarge and complement the circle of the company's university partners (see http://www.abbaustralia.com.au/cawp/seitp202/04de0fdf938b0771c1257a8a00411ebc.aspx).

2.4.4 Forming

Forming capabilities draw on knowledge generated through research in Materials Engineering (FOR 912), Manufacturing Engineering (910) Macromolecular and Materials Chemistry, Chemical Engineering and Civil Engineering. Capabilities exist in 11 universities including Deakin, Monash, QUT, ANU, The University of Queensland, UTS, and University of Wollongong.

There are two aspects of capability:

- Deformation
- Structural strength.

Deformation is also a largely neglected academic area, but where there is still work to be done. There are several key researchers, including Peter Hodgson at Deakin, and groups at Monash University, ANU and RMIT.

Modelling and Simulation of Materials and Processes at Monash

A number of researchers in the Department of Materials Engineering are involved in modelling and simulation of materials and processes. In most cases, these activities are part of larger research programs that contain substantial experimental components and all efforts are made to make the most of the synergies between experiment and modelling

A major area of activity in the department is in modelling the mechanical properties and forming or deformation processes of metals and alloys. The bulk of research conducted is on steels and copper, as well as for light alloys based on aluminium, magnesium and titanium. These studies cover a range of materials length scales. At the largest scale this includes finite elements (FE) simulations of metal forming, while homogenization techniques such as elasto-plastic and visco-plastic self-consistent methods are used to incorporate texture into simulations of polycrystalline deformation.

Physically motivated models of large strain deformation are used for process optimisation in such areas as equal channel angular pressing (ECAP), microforming, and other modern technologies. A large fraction of the modelling activities within this area are focused at the microstructural length scale. Physically based constitutive approaches are used to explicitly incorporate microstructural features in the modelling methodology. This includes internal variable based approaches due to Kocks, Mecking and Estrin, as well as gradient plasticity models with an emphasis on incorporating microstructurally based origins for the gradient terms.

These approaches are used to model tensile deformation and creep behaviour, the microstructure evolution during severe plastic deformation used as a means for obtaining nanocrystalline materials, localisation of plastic flow, e.g. as a result of dynamic strain ageing, the mechanical response of magnesium and titanium alloys where twinning is an important deformation mode, the evolution of texture during deformation and the deformation behaviour of micro-materials (microforming). An emerging research direction is centred around molecular dynamics simulations (MD) of the mechanical properties of nanostructured metals and alloys.

A new research effort in the Department addresses modelling of corrosion processes in metals. An example is studying the kinetics of damage accumulation through the 3D simulation of the evolution of pits on metallic surfaces. These simulations aim to serve as predictive tools for assessment of component lifetimes, particularly aerospace materials (high strength Al alloys and Ni based superalloys).

http://www.eng.monash.edu.au/materials/research/capability/modelling.html

There are very few people doing research in structural steel. It is concentrated at The University of Melbourne, The University of Sydney, Swinburne, UWS and QUT. There is some individual capability at Griffith and James Cook universities.

Structural strength research has been a major focus of a strong collaboration between the University of Western Sydney and The University of Melbourne with significant industry collaboration.

Institute for Infrastructure Engineering, UWS

The Institute is currently involved in 13 national grants funded through the Australian Research Council Discovery and Linkage Grants Scheme which have formed the basis for the majority of honours projects in Engineering. Industry partners contributing to the Linkage Projects include a plethora of leading National and International Companies, namely Ajax Fasterners, Arup, BlueScope Lysaght, Coffey Geotechnics, Lincoln Electric, One Steel, Penrith Lakes Development Corporation, Roads and Maritime Services and Stramit Industries.

http://www.uws.edu.au/iie

Current and recent projects include:

- The behaviour and design of composite columns coupling the benefits of high strength steel and high strength steel and high strength concrete for large scale infrastructure (Uy, Tao, Mashiri, Liew and Han), Australian Research Council - Discovery Grant; 2012-2014: $400,000
- The use of innovative anchors for the achievement of composite action for rehabilitating existing and deployment of demountable steel structures (Uy, Zhu and Mirza), Australian Research Council - Discovery Grant; 2011-2013: $255,000
- Unified theory for the behaviour and design of composite steel-concrete beams subjected to generalised loading and support conditions, (Uy), Australian Research Council - Discovery Grant; 2008-2010: $300,413
- Utilising the benefits of high performance steels (HPS) and infill materials for critical infrastructure protection (CIP) against extreme loads, (Uy and Remennikov), Australian Research Council - Discovery Grant; 2008-2010: $371,000
- Time dependent response and deformations of composite beams with innovative deep trapezoidal decks, (Bradford, Uy, Ranzi and Filonov), Australian Research Council - Linkage Projects (Round One); 2008-2010: $256,188 (ARC) + $ 252,900 (BlueScope Lysaght)
- Innovative retrofitting techniques for the protection of anchorage zones in cable stayed bridges subjected to blast loads, (Mendis, Samali and Uy), Australian Research Council - Linkage Projects (Round Two); 2008-2011: $ 211,000 (ARC) + $ 178,638 (RTA)
- Development of innovative beam-column connections within robust composite steel-concrete structural frames, (Goldsworthy, Gad, Uy and Fernando), Australian Research Council - Linkage Projects (Round Two); 2006-2009: $ 450,000 (ARC) + $ 465,000 (Ajax, OneSteel, Smorgon)
- Behaviour of post-tensioned composite steel-concrete slabs, (Ranzi, Uy, Gowripalan, Gabor), Australian Research Council - Linkage Projects; 2009-2012: $300,000 (ARC) + $225,850 (Stramit and Arup).

There is a significant amount of research on cold forming and thin walled structures. An example of the work being undertaken, evidenced in a recently published article by researchers at the Griffith School of Engineering and the School of Civil, Mining and Environmental Engineering, University of Wollongong is provided below.

Self-shape optimisation application: Optimisation of cold-formed steel columns

Benoit P. Gilbert, Timothee J.-M. Savoyat, Lip H. Teh b

This paper presents the optimisation of cold-formed steel open columns using the recently developed self-shape optimisation method that aims to discover new profile shapes. The strength of the cold formed steel sections is calculated using the Direct Strength Method, and the rules developed in the present work to automatically determine the local and distortional elastic buckling stresses from the Finite Strip and constrained Finite Strip Methods are discussed. The rules are verified against conventional and optimum sections yielded in this research, and found to accurately predict the elastic buckling stresses.

The optimisation method is applied to singly-symmetric (mono-symmetric) cold-formed steel columns, and the operators behind the method for the special case of singlysymmetric open profiles are introduced in this paper. ‘‘Optimum’’ cross-sections for simply supported columns, 1.2 mm thick, free to warp and subjected to a compressive axial load of 75 kN are presented for column lengths ranging from 1000 to 2500 mm.

Results show that the optimum cross-sections are found in a relatively low number of generations, and typically shape to non-conventional ‘‘bean’’, ‘‘oval’’ or rounded ‘‘S’’ sections. The algorithm optimises for distortional and global buckling, therefore likely subjecting the cross-sections to buckling interaction. A manual attempt to redraw the ‘‘optimum’’ cross-sections to include limitations of current manufacturing processes is made.

Future developments of the method for practical applications are also discussed.

There is wide potential for application in steel structures and steel framed housing and low-rise construction. In the United States, cold steel framing is being used for buildings up to 12 floors.

Several universities and research organisations have sophisticated testing facilities for structural steel and for testing for corrosion and the structural strength of joins and welds. It was pointed out on several occasions during the project that the weakest and riskiest components of structural steel are the joins. Joining capabilities (welding, bolting and riveting) are considered further below.

Several universities and research organisations have powerful electron microscopes and testing equipment for the chemical, molecular analysis, and tensile strength of structural materials. Details are provided in Attachment 4.

2.4.5 Cutting

Sawing is the traditional, and still the most commonly used method for cut-to-length beams and columns. Oxy cutting and plasma cutting are both widely used for cutting plates for welded beam webs and flanges, and profiling the end of beams (also known as coping). Computerised numerical control (CNC) cutters, using a laser, mill bits, torch, or water jet, are being increasingly used.

Capabilities relating to cutting have been identified at the technology universities, including Deakin University, QUT, RMIT University, Swinburne University, and The University of NSW and The University of Queensland. Capabilities have been developed around investments in machinery and equipment that is used for both teaching and research purposes.

In industry, there is a range of new machinery and technology that is available for steel fabrication, but little research on how to adopt and apply and integrate the technologies.

Comments on major technologies in use are provided below.

- ***Beam lines***

Beam lines are the most commonly used technologies in steel fabrication. They are designed for processing columns and beams. *Steel – Framing the Future* estimated that there are 40 beam lines in use, with 14 on order. The vast majority of beam lines have a saw for cut-to-length, including a mitre capability, and hole drilling or punching capability. Australia does not produce castellated beams that allow for efficient ducting systems.

Many fabricators have installed beam lines, and whilst the majority of fabricators have computer numerical control (CNC) capability, the machine controls do not generally provide for download of data from steel design packages at present. The majority of beam lines owned and operated by fabricators, but some steel distributors have also installed beam lines to provide partial pre-fabrication.

- ***Laser and high-definition plasma cutting***

Laser technology has advanced rapidly, but is a major capital expense. It is, nonetheless, finding more and more application in metal fabrication due to the very rapid and precise parallel-sided cut that can be achieved with very high surface finish. Due to the energy demand, most applications have been for light gauge metals, but laser cutting is now being used in shipbuilding in Europe for cutting steel up to 20mm thick.

Plasma cutting, where an arc is used to remove metal rather than weld it, has been a popular alternative to the more traditional oxy-cutting process. But like oxy cutting, plasma cutting has had the disadvantage of producing a wedge-shaped cut, and a surface finish similar to oxy cutting.

High-definition plasma cutting, where the two cut surfaces are much closer to parallel, improves the precision of the cut and the surface quality. Although still not as precise as laser cutting, it is a much more economical process and arguably superior to oxy cutting at higher speeds.

- ***Machining***

In a modern factory environment machines driven computer numerical control (CNC) technologies perform machining operations. Traditional machining processes, including turning, boring, drilling, milling, broaching, sawing, shaping, planning, reaming, and tapping are being transformed by technology. New technologies are coming into play such as electrical discharge machining, electrochemical machining, electron beam machining, photochemical machining, and ultrasonic machining.

In drilling, for example, new designs of low-vibration machine tools and advancement in drill design have resulted in major reductions in drilling time, to the point where a 26mm diameter hole can be drilled in 12mm plate literally in seconds. As a result, CNC single tool drilling stations are replacing gang drilling in some applications because of the greater flexibility offered (Leadbeater 2007).

Machining is known as 'subtractive manufacturing' in distinction from processes of controlled material addition, known as 'additive manufacture'.

- ***Water jet***

Water jet cutting is a preferred method when the materials being cut are sensitive to high temperatures generated by other methods, for example when sensitive coatings have been applied. In all of these areas, a major area for research relates also to identification of steel components through the lifecycle.

2.4.6 Joining

Joining capabilities relate to welding, bolting and riveting. Capabilities have been identified at Curtin University, Monash University, Swinburne University, The ANU, The University of Melbourne, The University of Queensland, The University of SA, The University of Western Sydney, and the University of Wollongong.

Comments on capability are provided below.

- ***Welding***

A substantial amount of welding capability was created in the former Welding CRC, based at the University of Wollongong. The CRC finished in 2006 and the University then became a partner in the Defence Materials and Technology Centre (DMTC) and the Energy Pipelines CRC. Welding is a major issue in the construction of pipelines.

Advanced welding processes require automation and robotics. The University of Wollongong has been working on Automated Off-line Programming (AOLP), which reduces programming time and captures most of the required welds.

Welding in marine engineering is currently very manual. Efficient and effective welding requires modern software tools to connect design to the weld. The knowledge about how to weld is understood, but building the software to automate is not. Problems in hull fabrication for Defence projects have been traced to poor application of welding methods. In the Hunter, Forgacs is installing and using robotics under air warfare contracts with BAE Systems.

The problem in welding is not R&D. It is a skills problem. The shortage of welders is critical. Welders require skills at the coalface and key supervisory roles. A robot costs $50k, which is much cheaper than a welder, but welders get better pay and status when working with fancy tools.

There is also a shortage of welding engineers. Problems are occurring during manufacture that shouldn't. There is a concern that professional knowledge is disappearing. The problem is apparent in pipelines where large diameter pipes must be welded mechanically. This requires specific knowledge, skills, and experience.

People are not exploiting the best technology because they do not know the detail of it. Trades based training may not deliver the knowledge that is required for welding using advanced technology. Professionalization of engineering practice is emerging, as with municipal engineering a decade ago.

New technologies in welding have been described in the Warren Centre Report *Steel - Framing the Future*.

New Welding Technologies

Power source inversion

Inverter technology development has reached the point where high power (1000amp+) welding power sources are now readily commercially available. These new inverters allow much greater flexibility in the welding current waveform. Until now, submerged arc welding processes commonly used tandem arc for greater welding speeds.

With the advent of new waveform control, new configurations are possible that may allow full penetration welds to be achieved in welded beam fabrication, and require smaller external fillets with proportional increases in welding speeds. The result should be higher quality welded beams at lower cost due to less wire being used and lower power consumption.

Laser/laser hybrid welding

Laser welding allows deep penetration and very precise welds, and the heat source can be directed into tight area locations. These advantages have allowed joint configurations not possible before. However, a weld requiring 4kW requires an input power of approximately 340kW with a Nd:YAG laser, compared with approximately 4.2kW with arc welding. Laser welding also requires very precise fit-up as no filler material is added and the weld pool is small.

Laser hybrid welding, where a laser is used in conjunction with an arc weld, overcomes some of these disadvantages. It is being used increasingly in the automotive and shipbuilding industries.

Both laser and laser/GMAW hybrid welding in conjunction with robots can be used for welding in all positions. It is possible to weld connections to large components that are difficult to move with this process.

Friction stir welding

Friction stir welding (FSW) was developed in the early 1990s by TWI in the UK and has been widely used to join aluminium and other non-ferrous alloys. The technology uses mechanical forces to create a plastic state in which the surfaces of the parts to be joined can be mixed together without reaching a liquid state. This has significant advantages for welding alloys that are too volatile for arc welding.

The process produces high-integrity joins at high speed with little residual thermal stress. The process does not require welding consumables or join preparation, and cost savings of a factor of three or more are claimed in comparison with arc welding process, ignoring establishment cost (Leadbeater 2007)

These technologies are not in widespread use across the fabricating sector.

- ***Riveting***

Swinburne University, through the Industrial Research Institute, has been conducting research into laser assisted self-piercing riveting, a new solid state process that enables low ductility materials to be mechanically joined without cracking. Self-piercing riveted connections, applied under extreme pressure, are increasingly used in steel framed housing in Australia. It involves the joining of two or more plates by using a rivet to pierce and clinch in a single operation.

- ***Bolting***

The University of Melbourne, Ajax Fasteners and OneSteel have been collaborating on the development of efficient, robust and architecturally-flexible structural systems using innovative blind-bolted connections.

Blind-Bolted Structural Systems (BBSS) Research

In an Australian Research Council (ARC) sponsored Linkage project between three universities (The University of Melbourne, Swinburne University of Technology and The University of Western Sydney) and two manufacturers (OneSteel Australian Tube Mills and Ajax Engineered Fasteners), blind bolts (Oneside fasteners) invented by Dr. Saman Fernando at Ajax Engineered Fasteners have been used to develop structural connections between steel beams and circular or square hollow sections manufactured by OneSteel Australian Tube Mills.

The hollow section columns can either be filled with concrete or remain unfilled. If filled columns are used, a variety of extensions to the blind bolt have been investigated by researchers at The University of Melbourne to anchor the connection to the concrete within the steel tube, and hence increase the stiffness and strength of the connection.

Another ARC Linkage Grant has recently been awarded to determine the structural systems that would best utilise these connections, ones that would be attractive to structural designers because of their resilience, sustainability and efficiency of construction. This new project will open opportunities for the construction industry to use tubular sections in building construction, the mining industry and infrastructure.

http://bbssresearch.com/

2.4.7 Coatings

Capabilities have been identified at Deakin University, Monash University, RMIT, Swinburne University, the University of Melbourne, the University of Sydney, and UTS. CSIRO also has developed a significant capability.

The Australian environment has a major issue with corrosion, weathering, and deterioration of 'submerged' or 'buried' infrastructure. Several universities are involved in monitoring, research, and repair of infrastructure assets. BlueScope Steel has been leading collaborative research in coating technology.

BlueScope Steel has been leading collaborative research in coating technology with several universities as part of its development of the Colourbond product and photovoltaic coatings. Much of the research has an international focus. BlueScope has also been working on Photovoltaic coatings with the University of Wollongong.

CSIRO has been working on fire resistant coating material that can be used as a render or on structural steel. The hybrid inorganic polymer system (HIPS) coatings can withstand temperatures of over 1000°C, where current commercial coatings used on building materials and structures break down at 150-250°C (See http://www.industrysearch.com.au/CSIRO-has-developed-a-fire-resistant-coating-material/n/42377.

2.4.8 Additive manufacture

The casting process is being revolutionised through technical advances in 3D printing, rapid prototyping, direct metal deposition, and what has become known as additive manufacture. Swinburne, RMIT, The University of Queensland and the University of Wollongong have capabilities in this area. CSIRO also has capability.

Additive manufacturing is now moving to the steel industry. The University of Queensland is working on a steel fabrication powder in which it has the only expertise in Australia. It is a new area, with rapid growth potential, and high barriers to entry (capital, knowledge, and funding). New businesses forming around additive manufacture will require technology investors.

The metal powder industry is 70 per cent steel related. The listed value of companies dealing with powder is $4 billion.

2.4.9 Design, architecture

There is potential for innovation in steel fabrication research with the creation of Schools and Centres for the built environment and design that bring together engineering, design, architecture, technology, and management disciplines. UTS, Swinburne, and RMIT have moved down this track.

New academic structures will not, of themselves, assure interdisciplinary research and address industry opportunities – which are rarely, if ever, defined or contained within disciplinary boundaries. Innovation tends to occur at the intersection of disciplines and the genuine collaboration of researchers within academia and between academia and industry.

A reconnect between technology and design is essential for innovation and innovation systems. The connection was a strength in the early processes of industrialisation as is now evidenced on a day to day basis in the area of consumer electronics and consumer products more generally. It is a recognition that end users place additional value in a product than in its physical and functional properties and price. Consumers value quality, reputation, aesthetic and the 'look and feel' properties of products, structures and services.

Integration of research and closer collaboration with industry will be associated with funding and recognition of the value of interdisciplinary research by research granting agencies.

2.4.10 Building and construction management

Building and construction management is an emerging and growing discipline in universities. It is an area strongly promoted by the building and construction industry as a way of securing the professionalisation of the increasing number of project managers. The Australian Institute of Building accredits courses.

In some universities there is a strong preference for building and construction management programs to be located in a management school rather than with engineering or architecture. This is intended to play up the importance of management capacity and capability in the industry.

Building and construction management provides an important link in the application of technology in the construction industry value chain through Building Information Modelling (BIM) systems.

2.5 Research capabilities in industry

Research and development activities in the steel industry are undertaken primarily by the larger steel producers, BlueScope and OneSteel. Both companies have close links with Australian and overseas research organisations, as well as research laboratories of partner companies.

2.5.1 BlueScope

The BlueScope Steel Research Laboratories in Port Kembla conduct research for the flat products and coated products business. Technology development is also provided for the global steel businesses. The Research and Development team provides the technological base for the company's future growth and competitiveness by:

- Stimulating creativity for new products and processes;
- Providing advanced technical support and fast implementation of newly developed/acquired technologies;
- Maintaining a watch on competitive materials and technologies; and
- Providing technological forecasting.

These teams provide services to customers throughout Australasia. Significant achievements in the past 40 years include:

- The adoption and refinement of the technology to produce ZINCALUME® steel;
- The growth and continuing improvement of COLORBOND® steel;
- The invention of the mini-galvanising process line, which has been licensed to a number of operators in South East Asia and the Indian sub-continent;
- Assisting in the development of strip casting of plain carbon steel; and
- The development of model-based control tools for operating blast furnaces more efficiently.

The majority of research work is in the areas of ironmaking and steelmaking, rolling and metalworking, metal coatings, polymer coatings and product applications. The common objective in all areas is the improvement of existing processes and products and the development of new ones.

University of Wollongong and BlueScope Steel open new research centre

On Thursday 25 November 2010, the University of Wollongong and BlueScope Steel officially opened the Wollongong node of the Centre of Excellence in Free Radical Chemistry and Biotechnology following an invitation from the Australian Research Council Centre to open the centre.

The Wollongong research team, which comprises Dr Phil Barker from BlueScope Steel Research and Dr Stephen Blanksby from the University of Wollongong's School of Chemistry, has been invited to join the prestigious Centre of Excellence following their work over the past seven years into the paint formulation used to make COLORBOND® steel.

The team has been developing a new understanding of the chemical processes which underpin the durability of the paints employed in the COLORBOND® steel range of products and how they continue to display high levels of performance in the Australian environment.

Working with a team of four students, they have developed new technologies based on state-of-the-art mass spectrometry (a technique for identifying molecules by their individual masses) to monitor chemical processes within the paint at a molecular level. "It is almost like we can see inside the paint and watch what the molecules are doing – it's a very exciting time!" said Dr Blanksby.

The Centre of Excellence in Free Radical Chemistry and Biotechnology was originally founded in 2005 by a collection of eminent Australian scientists interested in the chemistry of free radicals. Its funding has been recently renewed by the Australian Research Council who will provide almost $10m over the next four years to fund the centre's critical research into the role of free radicals in health and disease, surfaces and materials and even climate change mitigation.

Dr Barker said: "It's a great outcome for us at BlueScope Steel and a result of our strong collaboration over the years. We have already made great advances in the understanding of chemical factors important to the durability of our prepainted products and the work we do with Dr Blanksby is enabling us to design new, highly-specialised, anti-oxidant molecules to soak up harmful free-radicals which can form in the paint. The outcomes will help to make COLORBOND® steel products even more durable in the future".

http://www.colorbond.com/case-studies/university-of-wollongong-and-bluescope-steel-open-new-research-centre

BlueScope has also been collaborating with RMIT to adapt Colorbond steel to suit a South East Asia climate environment. The product has to take into account the way buildings can be stained in tropical weather. High temperatures and tropical rain bring down a lot of atmospheric pollution. BlueScope has been working in Asia for 40 years.

A building product developed for the harsh Australian sun may not fare as well in an Indonesian tropical monsoon.

The research involves developing a close understanding of the coating through modelling at the 10 nanometre scale. It is rare that research conducted on nanoscale features is applied to large-scale manufacturing, but the approach is helping keep the Asian variation of Colorbond - named Colorbond Clean - at a price that reflects its everyday use while maintaining quality.

The features the research team are modelling have been influenced by the lotus leaf. The surface of the lotus leaf is sparkling clean usually, in a dirty environment, which reflects its hydrophobic characteristic – the ability to repel water. Leaves are also rough, meaning that the contaminant can't go in and the water droplet just rolls off, carrying the contaminant with it .

In their modelling, the research team is testing similar concepts for the surface of Colorbond Clean. By modelling the potential changes at an atomic level first, only the best will be manufactured for real-world testing. Some of those options may take us years to develop in the laboratory but it will take us far less time to develop the nanoscale models and test the models," he says.

Colorbond Clean is already well suited to tropical weather, but improving it may allow BlueScope Steel to remains a major challenge in the Asian markets. Bluescope and RMIT are looking at the next generation of this product to build on our market leadership position in Asia.

Source: RMIT's Making Connections magazine.

http://www.rmit.edu.au/browse/RMIT%20News%2FNews%2Fby%20date%2F;ID=ydbqshfnugzuz;STATUS=A?QRY=its&STYPE=LOCATION

BlueScope Research has an objective for 'disruption' in the use of coated steels in commercial and residential construction. It is already a leader in coatings technology and works with several universities in this area.

In July 2012 the Federal Government announced a $2.3 million grant to help BlueScope develop a new solar roofing system. The company is working on a prototype that combines its steel roofing with thin-film solar panels, creating a sleeker, more efficient roof profile for use on new buildings. It follows an earlier grant from the Australian Solar Institute. It is expected that the project will make Australia a ''world leader'' in BIPV systems.

The research has involved a partnership with the University of Wollongong and Germany's Fraunhofer Institute in research and development of Building Integrated Photovoltaic Thermal (BIPVT).

Combining roofing profile designs and incorporating solar panels

BlueScope expects its product will be suitable for "mass deployment" across residential, commercial and industrial rooftops, and without the need for subsidies. It believes it will offer cost advantages over conventional rooftop PV systems by reducing installation and energy costs and reducing peak demands on the grid.

"The prototype will be easily scaled up to the operational stage ensuring future BIPV systems can be cost-effective without government subsidies," Resources and Energy Minister Martin Ferguson said in a statement. "This project will help make Australia a world leader in BIPV development."

In a recent interview with RenewEconomy, Bluescope's head of coating product development, Dr Troy Coyle, said that the company – as a big seller of roofing materials – recognizes that innovation in designs, and incorporating energy production was a key part of the future market. "That is where the roofing industry is heading," she said.

The global BIPV market was estimated to be worth just 1,200MW in 2010, but it expected to jump 10-fold to 11,300MW by 2015. "The market motivator is energy reduction, and the motivator for integration into rooftop design is a reduction of material costs and in building heating costs," Coyle said. "That way we can have it all done in one."

http://reneweconomy.com.au/2012/bluescope-seeks-share-of-fast-growing-bipv-market-97791

BlueScope has been working on the renewable energy project for several years that would see solar cells rolled onto hot rolled coil – to effectively roll-form it "straight onto houses''. The current prototype would bring BlueScope a step closer to allowing a solar component to be coated on like paint, something considered up to 10 years away. The opportunities for the fabrication sector to adopt and apply this technology in years to come are immense and would further position Australia as a leader in coating technology and energy efficiency.

There has been a substantial amount of research and development in photovoltaic coatings in Australia and internationally. In Australia, start up company Dyesol has been working with multinational partners to integrate and embed the Dye Solar Cell (DSC) technology into products for the building supply sector (such as windows and steel roofing material).

Dyesol partners with world-leading building materials manufacturers such as Tata Steel Europe in the UK and Pilkington North America in the USA (through the joint venture Dyetec Solar). The company is said to be on track to offer DSC solutions for commercial and residential buildings in the next few years.

2.5.2 OneSteel

Technical and engineering groups support all parts of OneSteel's business to allow the company to develop new technologies and to rapidly implement relevant technology improvements developed externally. Examples of successful developments include DURAGAL® galvanised open and hollow sections and galvanised and colour coated wires.

Research activities in most areas rely on external research organisations. Many co-operative ventures exist with universities. These activities are primarily centred on product and manufacturing system development. OneSteel currently co-operates with the Victoria University of Technology, the University of Western Sydney, The University of Sydney, and Monash University.

OneSteel also has extensive international contacts to support its activities, such as technical exchange agreements with Sumitomo, Nippon Steel Corporation, Von Moos, Bekaert, as well as using the services of international technical providers such as Corus and Kobe Steel.

Since 2000, OneSteel's R&D program has seen the development of many new and improved products and processes, including:

- Following the closure of steelmaking operations at Newcastle in the late 1990s a billet casting plant was installed at the Whyalla Steelworks to extend the range of products produced from a slab, structural and rail steel maker to include the feed material for the rolling mills in Newcastle. These included many different high-grade steels for local manufacturers whose products would otherwise have been imported.
- Environmental projects such as the elimination of coal tar contamination from fence posts on farms, the treatment and handling of waste materials to be suitable for reuse and the continuing reduction of dioxin emissions to world's best practice levels.
- The design and installation of a new type of heavy mining rope plant in Australia allowing OneSteel to continue to be a world leader in this specialist market.
- Ongoing development of grinding media for the world's resources industries which is another specialist market in which we are a world leader.
- New products such as the LiteSteel Beam which is expanding into the US and other international markets.
- Development of new mining techniques for iron ore.

- The extension of the life of Whyalla Steelworks with a major program to convert from hematite to magnetite as the source material for operations and at the same time to reduce significantly the impact of operations on the ambient dust levels in Whyalla.

This program has also had major regional economic impact and secured the future of operations to at least 2027.

2.5.3 Orrcon Steel

Orrcon Steel is a leading Australian distributor and manufacturer of steel, tube and pipe. It employs 500 people and provides an extensive product range of RHS, SHS & CHS structural tubular steel, hot-rolled structural steel and a variety of fencing, roofing and building accessories.

The company supplies steel to fabricators, furniture and trailer body manufacturers, housing and construction companies, pipeline and infrastructure engineering firms.

Orrcon Steel Wins 2011 Australian Business Award

01 July 2011 ,

Orrcon Steel has been recognised as being amongst Australia's most innovative organisations, winning the Australian Business Award for Best Software Product in the 2011 Awards. The software awarded was the Section Translation Guide (STG) www.sectiontranslation.com.au an internet based software application.

The Australian Business Award for Best Software Product recognises software products that demonstrate product superiority offering a point of difference from their competitors. This includes operating systems, development tools, applications and utilities.

Commenting on the award, Managing Director for Orrcon Steel Mr Leon Andrewartha said: "This award shows Orrcon Steel is very competent technically and reinforces our commitment to research and development. This innovative approach in support of Australian design technology is just a part of our efforts to enable our customers to improve their energy efficiency and reduce the level of green house gases".

Dario Beccia – Senior Project Engineer with Orrcon Steel, has guided the development of this Australian first, internet based service.

"The STG will allow structural design engineers and architects to assess the use of hollow sections to replace open sections with just a click of a mouse - providing numerous benefits on top of the simplicity of choice. The STG is a free resource to industry, which will introduce more structural designers to Orrcon Steel".

http://www.orrconsteel.com.au/en/News-Promotions/News/STG-Australian-Business-Award

2.5.4 Baosteel

The Baosteel-Australia Joint Research and Development Centre is a world-first joint venture between Baosteel - one of the world's largest steel companies, and four Australian universities. It seeks to create an enduring collaboration between Baosteel and four leading Australian universities, The University of Queensland, The University of New South Wales, Monash University and the University of Wollongong, to conduct research and to provide innovative technologies in areas of interest to Baosteel.

The mission of the Centre is to engage in exploring and developing new knowledge and technologies within selected areas of particular significance for Baosteel's longer term, strategic development and business activities, and to promote the application of innovative technologies and the development of new, high value and low carbon products. The Centre is functionally located within the School of Chemical Engineering, Faculty of Engineering, Architecture and Information Technology (EAIT) at the University of Queensland.

The opening of the Centre is an indication that China is now looking to Australia for the development of industry innovation. Baosteel is the third largest producer of steel in the world and is a leading manufacturer of high-technology steel products. The Centre will also provide a platform for Baosteel to access the international technical and personnel recruitment marketplace and strengthen the academic and technical exchange between Baosteel and Australian universities. Baosteel was impressed with Australia's research strengths in the materials and energy environment.

2.5.5 Small to medium enterprises and the potential for disruptive innovation

Small to medium, size businesses are likely to be the source of disruptive innovation. Whilst innovations often reflect knowledge sourced from research and development, innovation in SMEs is also driven by ingenuity, initiative and entrepreneurship on the part of owners and employees.

Clayton Christensen found that leaders with an innovation track record spent 50 per cent more time on these activities than leaders without such attributes. This translated into:

> ". . . spending almost one more day each week on discovery activities. They understand that fulfilling their dreams to change the world means they've got to spend a more significant amount of time trying to discover *how* to change the world. And having the courage to innovate means that they are actively looking for opportunities to change the world (Dyer, Gregersen, and Christensen 2011)"

Innovators with these attributes are found in the steel fabrication industry. Examples of SME innovations are provided below.

- ***Ajax Fasteners Innovations***

Ajax Fasteners Innovations (AFI) is the research and development arm of Ajax Engineered Fasteners. AFI has a wealth of experience in leading-edge fastening technology. Over 40 products, most of which are patented world-wide, have been developed.

International trends point toward fasteners that are cheaper, faster to use, but of excellent quality and functionality. To achieve this, it has to be recognized that a fastener must be designed for an application, not the other way around. Through intensive research and innovation, developed through collaboration with customers, universities and other research organizations, AFI has managed to provide efficient fastening solutions to complex problems.

ONESIDE

AFI was instrumental in the development of the successful ONESIDETM blind structural fastening system. Most systems and fasteners developed for bolting into hollow sections require some form of alteration or deformation that restricts the ability of the fastener to carry a full structural load. ONESIDETM is a simple solution to a complex problem. The fastener is not compromised in anyway, which means the full structural integrity of the joint is maintained.

http://www.ajaxfast.com.au/index.asp?d=5A4C5A717251477C70080F080004

Fastening has been an afterthought in many applications, which can cause problems with joint design. AFI has witnessed many examples of this problem, and becomes involved with design teams very early in the concept to ensure the integrity of the final assembly.

- ***Henrob – Self piercing riveting***

Australian company Henrob has pioneered the development of Self Piercing Riveting Systems. Henrob Self-Pierce Riveting (HSPR) is a cold joining process used to fasten two or more sheets of material by driving a rivet through the top sheet(s) and upsetting the rivet, under the influence of a die, into the lower sheet without piercing it. Speed and quiet operation are features of the system. Typical riveting cycle time ranges one to four seconds.

High Speed Riveting Systems (HSRS)

HSPR has a number of advantages over other joining techniques, such as welding and blind riveting:

- Joins a range of dissimilar materials such as:
    - Steel
    - Aluminium
    - Plastics
- Joins multiple material stacks
- A non-thermal process - can be used after coating or painting with virtually no aesthetic or other damage
- Low energy demands
- Fast cycle times
- Operator and environment friendly; no heat, fumes, sparks or waste
- Repeatable quality
- Visually checkable joint

- Compatible with adhesives and lubricants
- Automatic rivet feed allows continuous production

Henrob has a global reach, with an office in Michigan to respond to the enormous potential for HSPR in the automotive industry in the USA, Canada and Mexico. In 2001 Henrob GmbH is established in Herford, Germany, offering European customers complete flexibility, with a choice of direct service or working through dealers. It now has 3,000 installations including a presence in South Korea.

Henrob's philosophy is to design reliable, robust solutions for production. This is achieved with the aid of 3D computer-aided design (CAD) software allowing in-depth modeling of tools and product access studies. Finite Element Analysis (FEA) software is used to ensure adequate life expectancy of components. Design data can be exchanged via the web, e-mail or FTP servers, offering rapid turnaround of rivet joint designs and equipment proposals.

- ***Unitised Building***

Unitised Building (Aust) Pty Ltd (UB Australia) is a privately owned building company focusing on the construction of medium and high-rise residential, hotel, aged care facilities and hospital projects in Australia.

The company utilises an innovative structural building technology that allows accelerated on-site and off-site construction programs. It has the ability to deliver buildings faster, to a higher quality standard, while produced in a safer and more controlled work environment. UB fabricates all of its technology in Australia. The company has worked collaboratively with The University of Melbourne.

The UB System also provides potentially better sustainability characteristics of the finished buildings, better quality finishes and facades at comparable or better pricing, and a number of other ancillary cost savings from financing, structural footings and preliminary costs of head contractors and consultants.

Building on modular approach

Wednesday 31 October 2012

In a Brooklyn factory a 240-room hotel is rolling off the production line.

The hotel's rooms and adjoining corridors are modular in design. They start life at one end of the factory floor in Melbourne's west on an automated machine that spot welds the 13.5 by 3.5-metre metal base to the walls and ceiling within four hours.

It's all based on car manufacturing technology and welding techniques. As they progress, other components: lighting, plumbing, cyclone-proof shutters and spray-on insulation, are added.

By the time they reach the end 15 days later, each room, complete with fixtures and fittings, is plastic wrapped and stacked ready for shipping to Port Hedland.

On site they will be dropped into place like Lego, with a one-millimetre factory-precision tolerance.

The hotel is due to be completed by the end of this month for delivery via empty China-originated ships, but may be held up until next year by funding issues and northern Australia's tropical cyclone season. A second stage of 130 hotel rooms is planned.

The Unitised Building technology and factory is the brainchild of Melbourne architect Nonda Katsalidis.

Apart from the Pilbara hotel, the system has been used to make 425 apartments in four Melbourne apartment buildings, including the Nicholson in Brunswick and Little Hero in the city. Another small apartment for a site in Moonee Ponds is in the production pipeline.

http://www.unitisedbuilding.com.au/news.php

UB is run as a joint venture with the Hickory Group, one of Australia's largest apartment builders and is looking to expand beyond apartments and mining into education, aged and health care sectors. UB is also specialising in modular bathrooms for Hickory's development projects.

UB is also extending manufacturing innovation into design and development. The company is backing an off-the-shelf, pre-designed, prefabricated apartment product called Klik created by Elenberg Fraser architects. The Klik system will use factory-based manufacturing to build anything from houses to high-rise apartments and is expected to cut developers' costs by up to 10 per cent. The modular system can be used to create either square, linear, C-shape or L-shape building bases that can house up to 14 different one to three-bedroom apartment or hotel types.

Elenberg Fraser director Callum Fraser has said:

> We see Klik as being just as much a tool for architects as developers. We believe there is a real desire in the housing industry for larger cheaper, multi-level apartments. Architects were looking for a systematised approach to construction. Everything we do, we do from first principles, for the first time, every time. That is at odds with the way the world works. It's a big change. To get there, what we need is volume.

- ***Dematic***

Dematic is a supplier of logistics automation, warehousing, materials handling and automatic storage systems. The company has a turnover of $160m and employs 385 people in Australia and NZ. The company's systems configurations are built around process and supply chain improvements and may be manually operated, mechanised or automated.

Precision Storage Systems for Automated Materials Handling

2012 Endeavour Awards Finalists: Australian Steel Innovation

7 May, 2012

Dematic's single source, vertically integrated capability can reduce time, cost and risk - achieved through ownership and control of design services, real time WMCS software, material flow technologies and engineering, project management and customer services.

Steel components in Dematic storage products are manufactured from high tensile grades of steel supplied by BlueScope at advanced production facilities in Australia and incorporate the latest innovations in production technologies.

The high precision steel racking components within Dematic Multi-shuttle and Mini-Load solutions are used extensively across a wide and varied range of applications which require automated materials and storage handling.

Key features of Dematic's innovation in Australian steel storage components include their modularity, patented components, being globally standardised and the design being optimised with regard to steel content and structural efficiency.

The components can be used within standalone automatic crane storage retrieval systems and in-rack shuttle systems and have been designed to be used in storage systems destined for both non-seismic and seismic areas.

Dematic has successfully utilised the components recently in a mini-load ASRS storage system in the heavy seismic area of Palmerston North, NZ.

http://www.manmonthly.com.au/news/2012-endeavour-awards-finalists-australian-steel-i

- ***Keech Australia***

Keech Australia has been designing and manufacturing high integrity steel castings for nearly 80 years, for leading companies domestically and globally. The company employs 160 people, but this is expected to grow to over 200. It has a major commitment to innovation.

Keech wins BRW award

September 12, 2012

We've recently been named Australia's best regional private business in the prestigious Business Review Weekly Awards. The award recognises our growth and our commitment to the Australian manufacturing sector.

Unlike many other businesses, rather than moving our manufacturing offshore, we've spent the past three years heavily investing in our people and our facilities. We've transformed the company from a traditional foundry to a global provider of innovative products. Every year, 7.5 per cent of sales are invested into the research and development of new product solutions. With this work carried out by staff at our Innovation and Quality Centre in Bendigo, Victoria, we're committed to keeping employment alive and well in regional Australia.

On top of this, we've spent the past few years upgrading our facilities in Bendigo, with a recent $3 million upgrade to our No. 2 Foundry and a planned $7 million upgrade about to commence on our No. 1 Foundry.

Our environmental footprint is an important focus as we move forward. Our foundry upgrades have included the installation of new environmentally friendly processes and equipment and we're also working to become a carbon neutral manufacturer.

On the export front, we're also working hard to grow the company, expanding to include a branch in Chile and pushing forward with an aggressive export strategy that sees us taking our products to mines around the world.

http://www.keech.com.au/news/

- ***Sovereign Design***

The experience of Sovereign Design, a Queensland based automobile accessory manufacturer provides a good example of what can be done when the market changes.

Evolution of the Bumper Guard

The Sovereign team took up the challenge to design an effective, attractive accessory that does not compromise on any of the vehicle features. To provide optimal protection for vehicle occupants, and cater for the international pedestrian safety vehicle standards, an alternative to conventional bullbars had to be found.

With the support of Queensland based suppliers, using advanced manufacturing materials and methods, a new vehicle front protection system was created to establish a new benchmark for the industry. The attractive design of the Sovereign-Bumper-Guard™ compliments the vehicle features and is mounted directly to the vehicle "crash structure".

All care has been taken not to impede or reduce the function of features of modern vehicles. Extensive computer modelling and internal testing has been carried out, as well as third party tests measuring "air-bag compliance", effectiveness, and ensuring that the design meets the European Standards regarding pedestrian safety.

In order to deliver the above requirements, a novel mounting system has been developed. Instead of using a conventional metal bracket arrangement, a multi-point mounting system has been developed that, in low impact speed incidents, absorbs impact loads without experiencing permanent deformation. This is the Sovereign Bumper-Guard Absorber™.

It is the belief of our design team that accessory designs must evolve in the same way that vehicles evolve. That approach led to the creation of a modular product system utilising manufacturing methods that give us the styling capability to make the Sovereign-Bumper-Guard™ an integral part of each unique vehicle model. The connection of the product to the vehicle is done via its Absorber mounting system.

Due to the high cost of extensive local product development projects, in recent years the Australian accessory industry has been increasingly affected by imports of conventional product designs. This trend has been applied by trading companies that are driven mainly by their short term goals, rather than making investment in innovative new designs that keep up with the changes in motor vehicles and new global safety standards. With our new product we are making an effort to retain unique local design know-how and a commitment in using local, superior raw-materials and manufacturing skills.

http://www.sovereigndesign.com.au/about/evolution-of-the-bumper-guard/

Sovereign provides a good example of how a business can redefine itself by looking for opportunities, and 'designing to differentiate' with products that have to have an edge. Sovereign built and maintained contact with the CAST CRC and the QMI. Sovereign argues that businesses that do well know what's happening – they are well networked.

2.6 Gaps

2.6.1 Funding for foundation discovery research

A small number of Australian researchers have achieved international reputations in discovery research and work in international collaborations with universities and the R&D laboratories of multinational companies. This reflects world-class strengths in *basic and discovery* research in fields such as materials engineering, chemical engineering and materials chemistry.

Professor Peter Hodgson honoured by the Institute of Metal Research at the Chinese Academy of Sciences

Thu, 01 Mar 2012 11:29:00 +1100

Professor Peter Hodgson has received the Lee Hsun Lecture Award after being nominated by two of China's leading metal experts, Professors Yiyi Li and Dianzhong Li.

The Selection Committee of Lee Hsun Lecture Award made its decision in recognition of Professor Hodgson's contribution to the materials science and technology.

Professor Hodgson, head of Deakin's new Institute for Frontier Materials had been invited to China for a conferring ceremony, and also to present the Lee Hsun Lecture. Distinguished physical metallurgist Professor Li Xun (Hsun Lee) was the first director of the IMR when it was founded in 1953.

Professor Hodgson sees the Award as not only a personal honour but also recognition for what Deakin University is achieving in China. The University is building a wide range of relationships with some of the biggest players in China, including the Wuhan Iron and Steel Company (WISCO) which is one of China's largest steel making companies.

The results of that are increased collaborations between WISCO and Deakin and the growth of partnership that first started when WISCO came to Geelong to sign the MoU last year.

Deakin and WISCO are co-hosting the second Australia-China Forum for Advanced High Strength Steels in April on the Waurn Ponds campus.

http://www.deakin.edu.au/research/stories/2012/03/01/lee-hsun-lecture-award

Australia's world class capabilities in materials science and engineering, as well as in related fields such as civil engineering, mechanical engineering, architecture and design, are not well integrated across the university sector, and there is limited transfer through applied research and translation into capabilities relevant to where steel is being used, or has the potential to be used in the steel fabrication industry.

While researchers know each other and collaborate, there is limited funding and research infrastructure support to create a critical mass of capability. At the same time, there is little research and development investment by Australian steel fabrication companies to 'pull through' research. Some of the larger fabrication companies have a commitment to research as well a small number of SMEs developing a niche market position.

2.6.2 Funding for applicable and integrative research

The ability to transfer and translate research into adoption, application and end use is influenced by demand side issues such as perceptions of business need, dictated by business strategy, and the capacity to receive and absorb, influenced by knowledge of the possibilities and potential for new knowledge and technologies in application to product development, process improvement and business transformation. There are also important supply side issues including institutional commitment to relevant research fields and the availability of research personnel.

While the structural problems facing the steel fabrication sector are well understood, it is less than fully appreciated that universities have not been undertaking the basic research that forms the foundation for applicable research that can be transferred to industry.

There is a large amount of funding for scientific research in relevant engineering fields, but very funding for applicable research, particularly in fields such as manufacturing engineering, and for research that integrates knowledge across disciplines within and external to engineering disciplines.

The major focus of basic research in engineering fields appears to be in the newer and more exotic fields, such as electronics and new materials, which may lead to the introduction of new products, whereas *the need* for research is in the field of manufacturing *processes*. This reflects an inherent bias towards science based discovery activity as distinct from application based engineering disciplines.

This gap suggests a need for new funding and institutional models, building on existing capabilities but providing a focus on *new applicable and integrated knowledge* that will support the restructure and modernisation of the steel fabrication sector.

2.6.3 Linking research, education and training

The research and development effort must be supported by new approaches to education and training that integrate competency-based learning, in the VET model, with theory based learning, that typifies the university model.

Significant progress is being made in dual sector institutions, such as RMIT and some VET providers offering bachelor's degree qualifications through pathway programs form Certificate IV and Advanced Diploma qualifications.

But change and improvement is likely to require significant institutional change and development, including the development of polytechnic models that are in use in Europe, Scandinavia, the United States and Asia.

2.7 Opportunities

This section is not intended to be exhaustive of the research and development opportunities for the steel fabrication sector. It is intended to provide an insight into research activity and point to opportunities for take up in the broader fabrication sector.

2.7.1 Internationalisation and export

The Australia domestic market for fabricated steel products is small. Many fabrication companies have entered the export market with considerable success.

Export involves a combination of domestic research, development and management combined with overseas production.

2.7.2 Coating technologies

Australia is a world leader on coating technologies. BlueScope has engaged effectively with a number of universities to develop and advance the technology for international application.

The prospect for greater use of coated steels in commercial and residential construction is immense and is a major opportunity for fabricators in these parts of the industry. It is important too to convince architects, designers and developers of both the energy efficiency and aesthetic features of the products.

2.7.3 Additive manufacture/rapid prototyping

Additive manufacturing – balance between speed and profitability and porous characteristics – opportunities for individually designed items

AW Bell – Rapid Parts

Rapid Parts' in-house rapid prototyping and manufacturing facility ensures that we are responsive to your need for fast, accurate, metal parts. This process is ideal for runs from 1 to 50 units depending on part characteristics. Small runs can be delivered in as little as 2 weeks.

Parts are produced from your CAD data giving you control of the final part shape. The parts are inspected throughout the production process to ensure final size is as close to your specifications as possible. Our machining and CMM inspection facilities can be utilized where high accuracy and repeatability is required.

A high degree of complexity can be achieved by using our combination of rapid prototypes and investment casting. The rapid prototype patterns can contain undercuts and untapered walls allowing you to test ideas still in development.

An enormous variety of metals can be used to produce your castings including numerous grades of aluminium, steel, stainless steel, zinc, silicon brass and iron. A variety of coatings, treatments and tests are available, just ask.

Simply email us your 3D CAD data at any stage of the design and you can be safe in the knowledge that the parts you receive are faithful metal versions of your idea.

http://www.rapidparts.com.au/metal_rapid_prototyping.htm

2.7.4 Cold formed steel unitised construction

Australian capability in cold-formed construction and fabrication provides opportunities in low-rise buildings in the health, education and transport and logistics sectors, as well as in modularised construction.

2.7.5 Ship building

Research and technological development for Defence capability in the areas of sea warfare have valuable spinoff benefits for the broader maritime and ship building industries.

2.7.6 Composites

There has been technology advances in the design of structural steel metal deck, which has opened up the field of composite construction. The renewed interest in fire engineering, with a focus on performance-based outcomes, has also been a significant catalyst to the enhanced competitiveness of multi-storey composite construction.

It became apparent, after The Warren Centre's consultation with sectors of the building construction industry, that there was a lack of knowledge of the benefits of composite steel construction. However, there is substantial capability in composite construction at the University of Western Sydney and The University of Melbourne.

2.7.7 Integrating innovation, design, technology and manufacture

The *Steel – Framing the Future* report pointed to the potential to integrate a design model with the CNC commands for beam lines and robotic welding, cutting, cleaning and painting offers an exciting opportunity to improve the efficiency of steel fabrication.

Software already exists that translates design data into a format that can be used directly by CNC beam lines, CNC cutting machines and robots, and this technology is finding wider appeal.

The opportunity to create new connections and component design that is conducive to fully automated, high-volume production has significant implications for the construction industry. Automation on the shop floor with electronic linkage to design and detail sources has the potential to catalyse innovative construction ideas and slash production cycle time.

The challenge now is how to take full advantage of these innovations.

2.7.8 Cost reduction through technology adoption

In the past decade there have been significant advances made in design documentation and detailing software, 3D modelling, NC output and fabricating shop automation by way of beam lines incorporating automated cutting, coping, drilling and welding. Automation, at all levels of fabrication, is being driven by the more capital-intensive industries, such as shipbuilding, heavy mobile plant manufacture, bridge and infrastructure construction.

The building structures fabricators have traditionally been slow to take up technology pioneered by the more capital-intensive industries. The *Steel – Framing the Future* project identified ongoing potential for significant reduction in fabricated steel real costs through these technology advancements. Structural steel therefore has the potential to remain competitive, which further endorsed the need to restore its market position.

There has been, in parallel with design and fabrication technology advances, in the field of composite construction. The renewed interest in fire engineering, with a focus on performance-based outcomes, has also been a significant catalyst to the enhanced competitiveness of multi-storey composite construction.

2.7.9 Intelligent Manufacturing

In steel fabrication Intelligent manufacturing is the progressive building of an integrated control of manufacturing chains including all technological aspects (utilization of sensors, process control loops, IT systems, and production scheduling with the addition of intelligence provided by modelling, advanced control, diagnostic tools, advanced maintenance concepts, optimization and simulation, expert knowledge, artificial intelligence (European Commission 2009).

The European Commission Intelligent Manufacturing Roadmap argues:

> To strengthen the long term competitiveness of the steel industry, innovation is required not only in materials but also in the production processes and manufacturing technologies that will achieve the highest standards of quality, just in time delivery at minimal cost with high production through safe and sustainable processes.
>
> Moreover, the steel sector has discovered the benefit of more compact lines with very short response times and extended ranges of capability. These shorter production routes, integrating the operations from liquid stage up to final shape whilst avoiding the most oxidizing processes, are being considered and investigated (towards scale free processes).
>
> Beside important savings in energy and rough materials, great flexibility is needed in the whole production chain to cope with the expanding range of products that will have to be supplied at low cost. Intelligent manufacturing technology should contribute to developing these more flexible and lower raw material and energy consumption processes.

The Commission's IM programme is fully in line with the sub-programme Intelligent Manufacturing of the Manufacture platform and the 3rd R&D major partnership initiative "factories of the future" of the European Recovery Plan.

A shift in manufacturing toward smaller runs and custom-designed products is favouring agile and adaptable workplaces, business models, and employees, all of which have become a specialty in the United States. There are important connections in Australia and opportunities for research and application.

2.8 Issues in building research capability

2.8.1 What gets funded gets done

Discussions with research staff at universities indicated that grants applications were managed in a way that they would most likely attract funding. Moreover, the 45 per cent weighting of ARC assessment to research track record limits extension into new areas of research.

As a result, there are limited grant applications to the ARC in areas where research could deliver an immediate and applied research outcome for industry. Collaborations and partnerships with industry for Linkage grants are more likely to have success.

2.8.2 Maintaining capability

Although research in the traditional areas of engineering and manufacturing technology is not being funded, and researchers are working in other fields, it is important that capability be maintained for the longer-term benefit of industry. Universities achieve this capability through Emeritus, Honorary and Adjunct appointments.

2.8.3 Integrating processing and production technologies

Discussion with university research staff indicated that there was a need, and an opportunity, to achieve greater integration between science and engineering approaches to addressing industry issues. A dedicated research centre that brings together capability enables this integration.

The Defence Materials and Technology Centre was cited as a successful model of research and technology integration.

2.8.4 Striking a balance in funding science and engineering research

Discussion with the research community pointed to biases in research funding towards funding discovery science rather than applicable, cross-disciplinary research in engineering and technologies.

Changing existing funding structures will be difficult. It would be preferable to design funding in a way that gave stronger support for manufacturing process science and engineering.

Funding should be strategically driven and linked to strategies for transformation and modernisation of the steel fabrication sector.

2.9 Conclusion

During consultations of the project it was said on a number of occasions that while Australia is the largest supplier of iron ore, it is a producer of low quality steel – a commodity product. There is an argument for more research to produce better quality steels. It was also observed that only the University of Wollongong and Deakin University are seriously working in steel research. Australia is a long way behind. There is widespread capability, but research is being channelled towards where the funding is.

To make an impact in steel fabrication, Australian businesses must find new markets, develop new products, with better materials. They must find pathways to market for an Australian solution. Research must be related to high value products and manufacturing processes around a business case that will secure buy-in from companies. The larger steel fabricators do invest in research, and understand the benefits. But collaborative research with universities is necessarily long term and sometimes difficult to negotiate.

Building research capacity and capability takes time, commitment and resources. It is important therefore that capacity building take a long term perspective that builds depth as well as establishes a critical mass of capability across universities and research organisations. Whilst networks and collaborations are important from a short and medium term perspective, and even in writing grant applications, it is important that institutional and organisation arrangements be established to create and extend bodies of knowledge and ensure sustainability.

3 The Australian steel fabrication sector

3.1 Industry context

3.1.1 The steel industry supply chain

The steel fabrication sector is an important component of the broader Australian steel industry. It consists of the following supply chain elements:

- **Research and development**: industry, business and academic research services related to new and improved products, processes and ways of doing business. This aspect of the supply chain is the major focus of this Project. It is addressed separately in Section 3 of the Report.

  Research and development may 'push through' innovations in products and processes on the basis of scientific discoveries and technological inventions, as well as 'pull though' new products and processes stemming from end user needs and requirements, changing tastes and preferences and requirements relating to the environment, carbon emissions, and sustainability.

- **Mining**: a small number of global iron ore and coal miners that supply raw materials to the Australian industry and globally. Most Australian output is exported with prices determined in the international commodity markets. Australia is one of the largest iron ore and coal exporting countries.

- **Steel production**: there are two major Australian steel producers (BlueScope and OneSteel) that produce for Australian and international markets. There are also several international producers that provide product for the Australian market. A number have subsidiary sales and marketing representation in Australia.

- **Trading and distribution**: Both BlueScope and OneSteel are also distributors. There are also approximately 40 companies (largely represented by the Australian Steel Association) engaged in steel trading and distribution. Traders and distributors source steel in Australia and internationally.

- **Fabrication**: businesses that engage in a range of steel related manufacturing activities including cutting, bending and forming, assembly (welding, riveting, bolting), boiler-making, and erection. Most of these activities have a strong trade skills orientation, although there is a growing professional orientation with the introduction of new production technologies, new approaches to marketing, and adoption of modern management practices.

- **Machinery and equipment supply**: steel fabrication is becoming increasingly capital intensive with the automation of production tasks and use of computing and robotics, giving greater precision and reliability in the fabrication process. Machinery comes with embedded OEM software. There are also other specialised software suppliers in CNC and CAD. There are many agents and brokers who source and supply equipment, predominantly from overseas. Major brands include Fecci, Headland and ABB, for example.

- **Professional advisers, consultants and contractors**: growing specialisation, use of technology and application of knowledge has witnessed the growth in professional services for the steel industry in areas such as steel detailing, engineering, architecture, procurement, and project management. Many Australian firms are leaders in this element of the supply chain.

- **Financial services**: investors, financiers, insurers, credit providers and analysts. Investors may be shareholders in a public company or family members in a privately owned business. They have a strong influence in relation to modernization of the industry and in the development and implementation of business strategy.

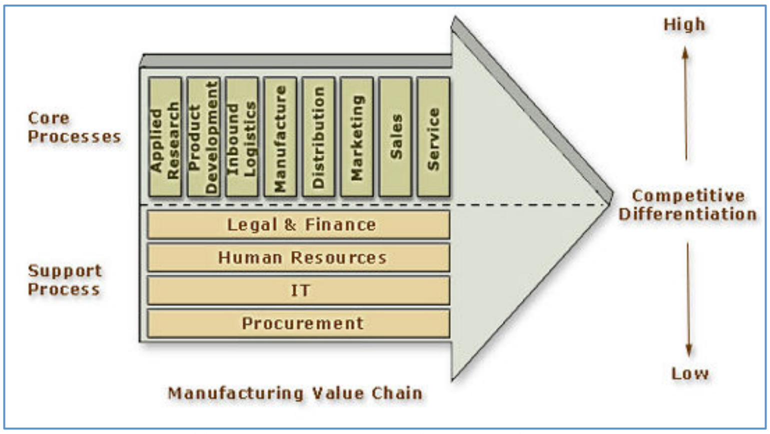
- **Regulation, standards and public policy**: the steel industry is subject to an extensive array of national and international regulations, standards and public policies and programs that aim to support, assist and grow the industry. This is associated with an extensive infrastructure of industry and professional organisations, trade associations, and a complex system of advisory, advocacy and consultative councils, boards and committees. There is no single organisation or 'network' that represents the totality of the steel industry.

- **Intermediaries**: People and organisations that make connections between potential users of new knowledge, technologies and capabilities and providers. Intermediaries may be 'for profit' technology advisers and grant writers, or people in industry associations, universities and research organisations supported by programs such as Enterprise Connect and 'third mission' initiatives. The role of intermediaries in innovation systems is becoming more important as innovation becomes more knowledge intensive. Many universities have technology transfer offices and senior executives with a specific industry engagement role.
- **End users**: organisations in downstream industries, including resources, construction (commercial and residential), machinery and equipment, defence, transport (including rail, trucking, and pipelines), automotive, shipbuilding, chemicals, energy, infrastructure, and consumer appliances. Demand from these businesses in these industries, in Australia and internationally, has an overarching impact on the Australian steel industry.

The Mining and Steel Production elements are not in scope for this project. Most recent policy concern and advocacy relating to the steel industry has tended to focus on these elements. The significance of, and issues relating to, other elements of the supply chain, and how the interrelate and connect, are often overlooked.

In relation to the fabrication and associated elements, it is useful to refer to the framework developed by Michael Porter and adapted in numerous ways by industry analysts and management strategists. A typical representation is provided in Figure 5.

Figure 5: Supply chain relevant to the steel industry



Source: http://www.actiontech.com/solutions/manufacturing.cfm

Where attention has been directed towards the steel fabrication sector, it has been directed towards the manufacture and distribution elements (including servicing the resources sector). There is comparatively little discussion about marketing, sales and business development and the service elements embedded in steel products. In most industries it is now well understood that end users value the 'service' elements of a product – sometimes to a greater extent than extrinsic physical properties relating to price.

Service value can relate to something as simple as aesthetics (for example, colour, look, and feel embodied in design, coatings and functionality) or more complex aspects such as durability, running costs and whole of life cycle costs. The aesthetic, environmental and service elements of steel are well understood within the industry, but have not been well communicated to broader constituencies.

Industries such as wine, red meat and grains have transformed from a commodity orientation to a differentiated product base emphasising aesthetic, satisfaction and other intrinsic attributes. There are numerous brands of wine, meat and grain, each with their own specific characteristics and market niches. The industries have large big brand manufacturers and niche players. The transformation of these industries has involved extensive application of product and process related research and development, marketing, management strategy and strong industry leadership. There are important insights relevant to the steel fabrication industry.

A consistent message through consultations for this project was a need to emphasis the *value of the outcome* of fabrication in terms of providing a solution to an end user - rather than a fixation on the minimum cost of the output. Moreover, long-term solutions, such as lower whole of life usage costs (energy, maintenance, repair), can be underestimated by developers, project managers, and end users.

Comments on aspects of the supply chain in Australia are provided below.

3.1.2 Production and distribution

Steel production and use is seen as a foundation of an advanced industrial economy and economies undergoing an 'industrial revolution'.

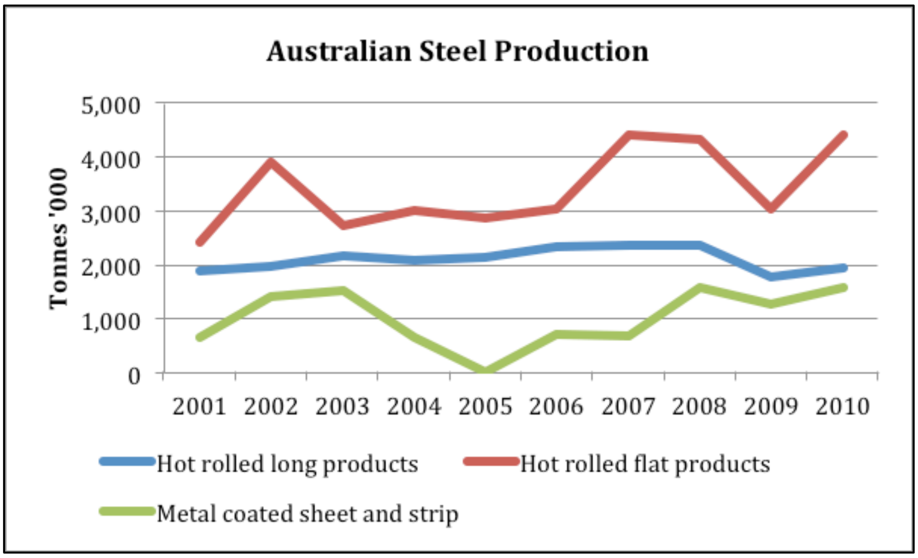
The World Steel Association estimates that annual world steel production of steel has increased from 851 megatonnes (Mt) in 2001 to 1,490 Mt in 2011. (It was 28.3 Mt in 1900). World average steel use per capita has steadily increased from 150 kg in 2001 to 215 kg in 2011.

China is the largest producer, with an output of 683 Mt in 2011. The ten largest steel producing countries (China, Japan, United States, India, Russia, South Korea, Germany, Ukraine, Brazil and Turkey) accounted for 82.9 per cent of global steel production. Australia, with a production of 6.4 Mt in 2011, is the 25th largest producer (out of a total of 64) accounting for 0.5 per cent of global output. It has a similar level of output to South Africa (6.7 Mt).

The Australian steel production industry consists of two main producers: BlueScope Steel Ltd and OneSteel Ltd. In 2011 BlueScope was the 45th largest global producer with a total output of 8.0 Mt. OneSteel had a production of 1.9 Mt, down from 2.4 Mt in 2008. In the 1970s, BHP was the 16th largest global producer.

87 per cent of Australian steel output is in the form of hot rolled long products or hot rolled flat products. A major component of output is metallic coated sheet and strip.

Figure 6: Australian Steel Production Trends

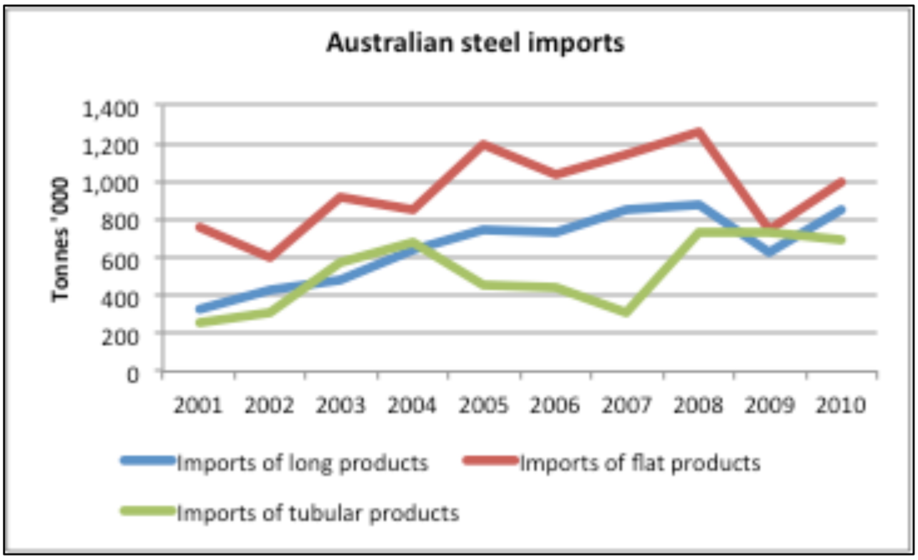


Source: World Steel Association, *Steel Statistical Yearbook 2011*, Brussels, 2011

Raw material costs account for around 60 per cent of steel production. There has been a 700 per cent increase in the price of iron ore over 10 years. As most steel companies no longer mine or sell iron ore or coal, there is little that can be done except absorb price increases. Australian producers do not receive a direct cost advantage by proximity to coal and iron ore reserves.

Australia is a net importer of steel. Over the period 2001 to 2010 *both* exports and imports have shown a trend increase. Flat products have been the major component of exports, while imports are constituted by three product categories. This is indicated Figure 7 below.

Figure 7: Australian Steel Imports



Source: World Steel Association, *Steel Statistical Yearbook 2011*, Brussels, 2011

A short profile of the Australian steel production sector is provided in Attachment 1.

The World Steel Association identifies three challenges for the global steel production industry, which also have relevance for Australia:

- Weak economic growth is expected almost universally in all regions in 2012, which presents the steel industry with more challenging market conditions.
- Changes in the raw material markets and the increasing volatility of these markets are presenting steel makers with a significant challenge. The options to steel makers are varied and include the option of investing in own raw material capacities to developing a focus on more exclusive steel products in an effort to maintain profit margins.
- The steel industry will have to invest in technological solutions to become more sustainable and to limit the impact of the industry on the environment.

The Association notes, however, that it is impossible, to consider a future, modern sustainable society, without also thinking about steel as the core element in such a future sustainable society. The Association considers that it is up to the steel industry to capture the opportunities that the road to a future sustainable society offers.

3.1.3 Fabrication

The Australian Steel Institute, in *Capabilities of the Australian Steel Industry to supply major projects in Australia reports* that the Australian steel fabrication industry is characterized by a diverse range of businesses operating across a wide range of markets from industrial buildings to complex structures in the oil and gas field. The total market output is estimated to be approximately 1.6 million tonnes per annum. Capacity is estimated to be approximately 1.8 million tonnes, with the largest fabricators producing in excess of 20,000 tonnes annually (Australian Steel Institute 2011).

Drawing on material in the ASI Report, the number of fabrication businesses, categorised by capacity and State/Territory, is summarised in Table 8.

Table 8: Fabrication businesses and capacity by State and Territory, 2010

Capacity (Tonnes p.a.)	Number of Businesses								
	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	TOAL
15,000 +	7	5	1	2	15	-	1	-	31
10-14000	17	7	10	6	11	1	1	1	54
5-9,000	13	17	17	16	47	1	4	-	115
1 - 4,000	34	12	23	8	37	2	-	1	117
Under 1000 and n.a	4	3	1	-	24	-	-	-	32
	75	44	52	32	134	4	6	2	349

Table 8 indicates that 38 per cent of businesses are located in Western Australia, 22 per cent in NSW and 15 per cent in Queensland. Businesses in Western Australia are closely tied to the resources sector.

Nine per cent of businesses have capacity in excess of 15,000 tonnes, 16 per cent with a capacity between 10,000 and 14,000 tonnes – totalling a quarter of all businesses. A third of businesses have a capacity between 5,000 and 9,000 tonnes and a further third have capacity of between 1,000 and 4,000 tonnes. There is a broad industry concern about the viability of the smaller businesses, particularly in the current difficult trading environment.

The businesses that were reported as having a capacity of 20,000 tonnes or more include:

- Allltype engineering services (WA) http://www.alltypeengineering.com.au
- Bradken international (WA) http://bradken.com/ourbusiness/manufacturing-and-engineering
- Nepean Engineering (NSW) http://www.nepeanengineering.com.au/index.htm
- Thornton Engineering (Vic) http://www.thorntoneng.com.au/home/index.html
- Sebastian Engineering (NSW) – now in liquidation.

These five businesses had a capacity of 500,000 tonnes, representing 27 per cent of total reported steel fabricating capacity.

Nepean Engineering

Nepean Engineering was established in 1975 and now employs approximately 150 people at our Narellan facility.

Our skilled team has a "can do" approach combined with a commitment to engineering excellence, that enhances our capabilities and enables us to offer customers a full range of product development, engineering manufacture, equipment refurbishment, turnkey and maintenance services.

Our facilities are some of the most modern available today, displaying a diversity of manufacturing processes and products. The technology we utilise is "state of the art" and incorporates CAD systems such as Catia, X-Steel, AutoCAD, Mechanical Desktop and Inventor.

Nepean Engineering operations include medium to heavy metal fabrication, structural steel and sheet metal fabrication, machining, tool and mould making along with design and construction of special purpose machinery. The type of work handled ranges from the very small jobs to multi-million dollar contracts.

Operations are supported by extensive design facilities through to shot blasting, painting and powder coat finishing.

Nepean Engineering is the founding member of the Nepean Group whose capabilities are diverse, extending from complex underground mining and solutions, to food production engineering, patented vehicle testing systems, and build to order fabrication.

These capabilities, and the quality of our product, now sees the Nepean Group supplying international markets in the USA, Canada, Middle East, Africa and Asia as well as Australia.

In order to maintain our position at the forefront of industry, we are also committed to research and development and currently invest $3 million each year in this area. We are accredited to ISO 9001-2000 quality standards, and have comprehensive OH&S and environmental management systems.

http://www.nepeanengineering.com.au

Businesses with a capacity of 15,000 tonnes or more include:

- Australian and Overseas Alloys (NSW) http://www.aoa.com.au/index.html
- Forgacs Engineering (NSW) http://www.forgacs.com.au
- H&M Engineering and Construction (NSW) No website
- Performance Engineering Group (NSW) http://www.performance.net.au/about.html
- Steel Fabrications Australia (NSW) http://www.steelfabau.com.au
- S&L Steel Fabricators (NSW) http://www.slsteel.com.au
- Alfasi Steel Constructions (Vic) http://www.alfasi.com.au/Alfasi-Steel-Constructions
- Notley Engineering (Vic) No website
- OneSteel Pipeline Systems (Vic) No specific website
- Page Steel Fabrications (Vic) http://www.pagesteel.com.au
- Shearform (Vic) http://www.shearform.com.au/mambo/
- Stable Australia (Vic) No specific website
- Ausclad Group (WA) http://www.agc-ausgroup.com
- Bossong Engineering (WA) http://www.bossong.com.au

- Boyd Metal industries (WA) http://www.boydmetal.com.au
- Dwyer Engineering and Construction (WA) http://www.dwyereng.com.au
- Freemantle Steel Fabrication (WA) http://www.fremantlesteel.com.au
- Pacific Industrial Company (WA) http://www.pacind.com.au
- Park Engineers (WA) http://www.parkeng.com.au
- RCR Tomlinson (WA) http://www.rcrtom.com.au
- Steelpipe (WA) No specific website
- Swan Fabrications (WA) http://www.swanfab.com.au
- Transfield Services (WA) http://www.transfieldservices.com/page/Services/Engineering/
- UGL Resources (WA) http://ugllimited.com
- Unique Laser Cutting Services (WA) http://www.uniquemetalworks.net
- Western Construction Co (WA) No specific website
- Tristar Industries (NT) http://www.tristarindustries.com.au

These businesses have a total capacity of 540,000 tonnes, representing a further 29 per cent of industry capacity.

The fabrication industry can be classified into three broad areas:

- Structural steel fabricating
- Metal product manufacture
- Iron and steel casting and forging.

IBISWorld reports that the steel fabricating industry reflects trends prevalent in the housing and non-housing construction industry. This relationship has historically provided the industry with strong opportunities to grow—until the onset of the economic downturn in late 2008. IBISWorld states:

> Prior to the downturn, the industry was buoyed by robust activity in non-residential construction, especially institutional buildings and public infrastructure works such as roads and bridges. The overall situation for the industry has not been ideal since the economic downturn. Global competition has exacerbated the situation.

IBISWorld *comments are from the publicly available 'snapshots'. Detailed reports have not been purchased for this project.*

- ***Structural steel fabricating***

The structural steel fabricating sector produces structural steel components for use in buildings or other structures. The main production activities relate to making steel sections, girders and joists of prefabricated steel, perforated steel plate, prefabricated structural steel parts and rafters, reinforcing mesh of welded steel, reinforcing steel rods, roof trusses and scaffolding. The Australian structural steel sector is about equivalent in capacity to the highly regarded UK fabrication industry, but with a focus on the engineering projects sector.

IBISWorld estimates that there are 1,700 small to medium businesses included in the industry class employing 22,860 people in 2010-11 with total revenues amounting to $8 billion. Trend annual growth over the period 2007-12 has been 1.0 per cent. The Australian Steel Institute has provided production capacity data of 1.8 million tonnes covering derived from 350 member businesses (Australian Steel Institute 2011).

According to IBISWorld the fortunes of the industry are closely tied to activity in the housing and non-housing construction industry, including mining and resource related construction, institutional buildings and public infrastructure. The industry has been subject to intense international competition and a preference among builders for reinforced concrete solutions to building design. During consultations for this Project, the Australian Steel Institute described the sector as being in 'survival mode'.

Nonetheless, with a large number of businesses, the fabrication sector is highly competitive. This promotes diversity and responsiveness to market and end user needs and requirements. It also provides an incentive to invest in innovation, play to distinctive capabilities, and engage in marketing and business development through networks and relationships. These are management as well as production and technology issues.

The ASI advises that Australian steel's market share for the industrial buildings market is worth approximately 120,000 tonnes a year (which equates to only 7.5 per cent of Australian output), whilst its percentage of the multi-storey buildings market segment is about 13 per cent. This compares with 50 per cent in the UK.

The Institute points to the potential advantage of steel in speed of construction, lightweight and reduced foundation costs and a smaller manufacturing footprint to the construction site - as most fabrication is off-site in more secure and safer manufacturing environments. Steel fabrication also brings significant environmental and energy efficiency benefits. However, the sector is confronting many problems in demand, securing viability, and sustainable growth.

According to the Australian Steel Institute (ASI), the typical steel fabricator is a family owned business employing between 10 to 100 employees. Owners generally have a trades background, having risen through the ranks from apprenticeship and shop worker. Employee classifications include detailers, shop workers, equipment operators, welders, painters, delivery drivers and administrative personnel. Projects may range from the fabrication of several tons of structural steel for a small shed to tens of thousands of tons for large, high-rise structures.

The Fabrication Process

The fabrication process is driven by plans developed by licensed structural engineers specifying all design aspects of the structural components of a building based on the building layout developed by an architect. Upon award of the project the fabricator is typically responsible for creating detail drawings of each piece of structural steel. These details are produced by a steel detailer and refine the design drawings from the structural engineer developing a dimensionally accurate drawing of the member including all connection details.

Steel detailers may either work directly on the staff of the fabricator or on a sub-contract basis. The detail drawings are then submitted to the structural engineer for approval. BIM technologies detail drawings provide for direct connection between three dimension CAD drawings to machine instructions. There is a move towards BIM consultants taking more of the engineering risk.

Following a determined sequence optimized for erection in the field, the appropriate structural steel members are then cut to the proper length, drilled or punched and all additional shop work is performed on the member. US data suggest that a typical fabrication project will require between 10 and 20 hours of shop time per ton of fabricated steel. Material costs account for between 30% and 35% of the final cost of the fabricated and erected structural steel.

Source: Australian Steel Institute

Fabrication and erection costs for structural steel vary greatly based on the type of structure being constructed, the number of pieces, local labour conditions and the complexity of the connections. With the availability and application of technology, the fabrication process has the potential to become more integrated. The BuildingSmart initiative is directed towards achieving progress in this vision. But the issues are complex and there is a severe shortage of qualified personnel (builingSMART Australasia 2012) .

The Warren Centre for Advanced Engineering Report, *Steel: Framing the Future* (Leadbeater 2007) used case studies of multi-storey CBD, suburban and industrial park developments to identify five root causes affecting the steel-frame construction industry's performance:

- lack of strong leadership
- inability to provide reliably accurate cost estimates
- non integrated supply chain
- inability to articulate the value proposition for steel framing
- poor take-up and integration of proven technology.

In the construction industry steel competes with reinforced concrete as a construction option. An assessment of the performance of the steel frame construction in the *Steel: Framing the Future* report is reproduced below.

Steel - Framing the Future - Diagnosis of Steel Frame Construction Industry Performance

Australia has an efficient, competitive and well-established concrete-framing industry. By comparison one of the earliest insights of the *Steel – Framing the Future* project was that builders and developers considered the use of steel to be a far riskier option than concrete. The perception of high risk was based on: apparent price volatility, poor access to consistently reliable data impacting on costs and estimates, concerns about safety on site, confusion about steel's sustainability credentials and exposure to additional supply chain complexity.

Other findings specific to the steel-framed value chain that emerged over the course of the project included the following:

- Decision makers in the preliminary design phase of construction rarely considered a steel-framed solution unless it was a stipulation of the design or if concrete was not viable, and when selected, rarely involved fabricators at the design stage.
- Engineers were largely unaware of the improvements brought about by modern fabrication technology.
- Few projects exploited the benefits of an integrated steel design and manufacture process, which can significantly reduce both cost and time to completion.

- The accuracy of cost estimating for steel-framed structures suffered from a lack of reliable cost data and an absence of regular communication between quantity surveyors, fabricators and engineers.
- There was a lack of critical-size fabricators providing the builder/developer with pricing and delivery confidence.

There were also general construction value chain issues that contributed to the problem:

- Adversarial contract structures, with parties locked into fixed price contracts, provided no incentive to collaborate to achieve better results during the construction process.
- The take-up of 3D modelling and 3D documentation, enabling broad and accurate access to project information, is poor.

The project found overwhelmingly that the steel-framed value chain suffered from a broken value-delivery system across its many disconnected parts, which, if mended, could offer real advantages over the concrete alternative.

This project found new technologies can be applied to steel- framing that make it easier to design and alter, and allow builders to fully capitalise on the new collaborative business models delivering steel-framed structures to the market.

These matters must be addressed by the industry, with the support of the many industry associations, professional bodies, and publicly supported advisory councils and committees that operate across the industry

These observations were validated in many conversations and discussions for this project.

There are, however, a number of fabricating businesses that are doing quite well. These tend to be larger, have a professional management structure and skilled, capable and experienced personnel, are committed to clearly articulated business and marketing strategies and a focus on innovation in products, processes and ways of doing business. Many are involved in export and have facilities in Asia. Successful companies have Boards that bring external capabilities and connections in Australia and internationally.

AusGroup posts a 101% increase in first quarter earnings

AusGroup Limited ('AGL' or 'AusGroup') today announced its results for the quarter ended 30 September 2012. Key indicators for the quarter have improved across the board when compared to the comparative period (quarter ended 30 September 2011):

- 101% increase in profit after tax
- 86% increase in EPS from 0.7 to 1.3 AU cents per share
- 26% increase in revenue
- Improved gross margins
- Strong cash flow generated from operating activities of $16.4 million
- Cash and cash equivalents of AU$45.2 million as at 30 September 2012

"The Group continues to experience a consistent level of demand for pricing and tendering requests. The Group expects these levels of pricing and tendering activity to continue as committed major projects enter their construction phase." said CEO and Managing Director, Laurie Barlow.

Outlook

Despite the softening of commodity markets, the longer term outlook for the Australian resources sector in the Western Australian, Northern Territory and Queensland markets – in oil and gas, LNG, coal seam methane and in iron ore mine development continues to be positive. The Group is confident of seeing sustained demand for its services over the next few years due to the range of services that the Group can offer these markets as a multidisciplinary contractor.

The Group has work in hand to the value of AU$303 million as of 8 November 2012.

http://www.agc-ausgroup.com/investors-media/announcements/2012/259-ausgroup-on-track-after-posting-a-101-increase-in-first-quarter-earnings.html

AusGroup provides a range of fabrication, construction and integrated services to natural resource development companies. There is a view, however, that the Australian fabrication companies can achieve more in the resources sector (Australian Steel Institute 2011).

The ASI notes that the local fabrication industry has invested heavily in new plant and automation to expand capacity and improve efficiency. Information obtained by the ASI and confirmed with ABS statistics, projected across all of fabrication suggests that $400 million was committed to these upgrades in 2006-08. These investments preceded the GFC in 2009 and many businesses were subjected to significant financial pressure, with many going out of business over the last two years as demand has failed to recover.

The Institute points to a current trend for fabricators to invest in detailing or to liaise closely with detailers to enable the benefits of computer files to drive their Computer Numerical Controlled (CNC) processing which is progressively being applied to plate profiling, line marking, identification marking, drilling and tapping and where required weld preparation and robot welding.

The Warren Centre Report, *Steel - Framing the Future* (Leadbeater 2007), reported that in the UK the real cost of fabricated steel has effectively fallen by nearly 50 per cent over the past 25 years to around £1500 per tonne or A$3750 per tonne. This has given steel structures a significant price advantage. Unfortunately a similar comparison for Australian conditions is not available.

The Warren Centre argues that, (based on the UK comparisons) for steel fabrication to gain significant market share from a highly competitive concrete industry, fabrication costs will need to be more competitive. To achieve this, the industry must take full advantage of the digital technologies available. The Centre believes this is achievable within totality of the steel value chain, but that it will be associated with some rationalisation and consolidation within the industry.

The ASI points to productivity step changes that have been generated with a shift from labour-based fabrication to numeric controlled CNC, beam lining, angle lines and plasma and gas profile cutting. This equipment can efficiently create fabricated steelwork straight from the detailer model through the use of Building Information Modelling (BIM) software. Discussions with industry observers during this project suggested that there was quite some way to go before adoption of digital technologies is widespread.

There has also been the adoption of new business models that provide a more formal linkage between engineers, detailers and fabricators through 'Design and Construct" Steel Contractors in the portal frame buildings (factories and warehouses) and low rise commercial buildings such as offices, shops, schools, health and civic facilities.

There is now widespread use of the 'Design and Construct' Project Manager, which may also be the construction company, taking an increased role in the architecture and design for the buildings. Architects have become, in effect, clients of the Project Manager rather than directors of the project. Considerations of short term cost rather than longer-term outcomes and full life cycle costing are pushing builders and developers towards cheaper reinforced concrete solutions. Innovative construction companies, Including Brookfield and Grocon, are working effectively with steel.

- ***Metal product manufacturing***

Firms in this industry are primarily involved in the manufacturing of boilers and fabricated metal products. Firms may also apply coatings to enhance quality, prevent leakage, and protect against corrosion.

IBISWorld reports that the market size of this sector is in the order of $6 billion annually with 6,653 businesses and 26,937 employees. Trend growth over the period 2007-11 has been -5.1 per cent. The IBISWorld industry analysis and forecast of trends is:

> The five years through 2010-11 were problematic for domestic manufacturers operating in the Fabricated Metal Product Manufacturing industry. The downturn in the global economy negatively affected the Australian market's appetite for industry products, so much so that domestic demand for the period decreased by an average of 3.5% per annum. In addition, expanding import penetration, particularly from China and other Asia-Pacific markets, exacerbated the effect of softening domestic demand. These two factors combined to see the industry revenue contract by an average annualised rate of 5.1% to a value of $5.5 billion over the five years through 2010-11. Outside of the massive 12.8% decline in 2008-09, 2010-11 was significantly painful for the industry with revenue declining by 4.9%

IBISWorld has a view that the diverse range of product lines creates a fragmented industry landscape. The larger product segments include boiler and plate work and residential construction.

In the coming years boilers and plate work is forecast to account for the largest proportion of revenue growth. This segment includes manufacturing boilers, prefabricated silos, metal plate storage tanks as well as copper stills. It also includes service activities such as other welding and plate work. The service activities have been the primary driver behind the segment's product share of revenue. Shipbuilding is an important driver of growth in the use of steel plate and application of welding technologies.

Ship construction, particularly for the defence industry, is emerging as an major user of steel and adopter of steel research in welding and automation technologies. The sector also makes extensive use of testing and analytical facilities at Australia's research institutions.

- ***Iron and steel casting and forging***

The manufacture of cast iron and steel products involves melting the metal to be used, pouring it into a mould, letting it cool and then knocking out the casting. Forging involves the use of machinery with a hammering or pressing action to convert iron or steel bars or other basic shapes into a pre-determined form.

The main industry activities are:

- Iron and steel casting
- Moulded cast iron pipes or tube mass production
- Spun cast iron fitting
- Seamless or welded pipes or tube galvanising
- Ferrous stainless steel seamless pipefittings, pipes or tube.

IBISWorld reports revenues of $3 billion, employment of 8,080 in 368 businesses and an annual growth of -3 per cent over the 2007-12 period. The major businesses are Arrium, Bradken, CHAMP, and Tyco Flow Control International.

Bradken

Bradken is Australia's largest combined foundry and heavy engineering group and one of the leading ferrous-casting companies in the world. Bradken has a vast network of manufacturing facilities and sales and service centers throughout Australia, New Zealand, China, United States of America and the United Kingdom. This geographical diversity underpins its position as a world class, cost effective, high quality foundry and heavy engineering company.

Bradken's manufacturing facilities employ the latest technologies in product development, design, tooling manufacture, casting processes, robotics, machining and assembly. Within Bradken there is a broad wealth of technical expertise encompassing a wide range of alloys and complex fabrication in addition to operational and field experience. This positions the company as one of the world's most cost effective and quality founders complemented by the extensive product range and capacity offering customers high security of supply now and in the long term.

Bradken's skilled product development teams, together with worldwide technology partners, enable development and delivery of products and services that set new benchmarks for excellence, whilst offering significant advantages to customers. Bradken boasts strong alliances with leading international organisations.

Bradken's reputation for producing high quality, innovative products result from understanding customers operating conditions and providing superior performance. Bradken designs are based on providing functional solutions and are characterised by their reliability, efficiency, cost effectiveness and whole of life value.

The advanced technologies utilised allow Bradken to link engineering with manufacturing and ensure a strong synergy between the product design process, application requirements and interactions of customers' operations. This combination of design skills and application expertise guarantees that Bradken products provide superior performance in service and deliver tangible economic benefits to customers at all times.

Bradken's investment in new generation technology and focus on product development reinforces the company's commitment to provide customers with specific, world competitive solutions to their individual needs.

http://bradken.com/ourbusiness/manufacturing-and-engineering

Bradken works with CSIRO Future Manufacturing Flagship and Board Member Dr Eileen Doyle has recently been appointed as Deputy Chairperson of the CSIRO Board. Dr Doyle has held senior executive roles in BHP, Hunter Water and CSR. She was a founding Director of OneSteel and on the Board for 10 years. She is currently Chairman of the Hunter Valley Research Foundation and Hunter Founders Forum.

According to IBISWorld, the industry has weathered changing conditions over the past five years.

> From global downturn to a mining boom, upstream and downstream industries have affected many facets of business – from the availability and price of iron and steel inputs and labour, to the changing demand in downstream mining and automotive industries. Rising fuel prices, domestic spending on infrastructure and booming Asian economies have placed demand on different areas of the forging and casting segments. While domestic steel prices reached historic heights in 2008-09 and crashed in the following year, industry revenue fluctuated, resulting in an annualised decline of 0.3% in the five years through 2011-12. During 2011-12, industry revenue is expected to increase 2.8%

3.1.4 Equipment (hardware) and software suppliers and their agents

The fabrication sector is growing in capital intensity. Business directories suggest that there are over 170 businesses that supply machinery to the metal working industry.

Much of the equipment is manufactured overseas and marketed in Australia through sales agents. Processing equipment has embedded OEM software as well as a capacity to integrate with factory automations systems.

FICEP

Ficep S.p.A. of Northern Italy has become the principal supplier of structural steel and plate fabrication equipment in the world market during the past 10 years. For example, Ficep currently controls approximately 75% of the world market for structural steel and plate processing systems.

In October of 2002 Ficep S.p.A. founded a new subsidiary, Ficep Corporation, to address the sales and service requirements of North America. Since the beginning Ficep Corporation, based in Forest Hill, Maryland has sold over 350 CNC lines in North America. This subsidiary is engaged in the manufacturing, sales, and service of new Ficep equipment plus the rebuilding of used structural steel fabrication equipment.

Italy is Currently the World's Largest Manufacturer of Metal Forming Machine Tools in the World

Even though 2009 was thought to be a global recession, Italian Machine Tool Manufacturers in the metal forming category (bending, forming, punching, shearing, cutting, drilling, etc.) managed to grow their sales over the figures of 2008 which was generally thought to be the best year in recent history. The level of increase, while small (1.1%) when compared to prior years, was still extremely impressive in view of the general negative developments in the machine tool industry and the worldwide recession.

http://www.ficepcorp.com

FICEP has a research commitment with 50 dedicated staff, including engineers, technicians and Cad/Cam operators, who interface with the production department for creating prototypes. Investments in research are presently aimed at new solutions for reducing energy consumption and for improving quality in the light of increased productivity.

3.1.5 Technology investors

Fabrication businesses tend to be family owned and operated. Funds required for investment are sourced from family assets, cash flow and trade creditors. Thin margins and competition limit the scope for investment in new capital equipment, modernisation and expansion.

There has been little interest in the part of venture capital investors in supporting start-up companies with technologies relevant and applicable to the steel fabrication sector.

3.1.6 Steel detailers

According to the Australian Steel Institute, Australian detailers are widely sought and internationally recognised for application of advanced technologies and tight management with established relationships built from work in the US, Canada, East Asia, the UK and Africa. They have led the charge in Building Information Management (BIM), the process of generating and managing building data across its life cycle (Australian Steel Institute 2011).

BIM uses three-dimensional, real-time, dynamic building modelling software to enhance design in construction. It takes account of building geometry, spatial relationships, geography as well as quantities and properties of building materials. Australian detailers have demonstrated capability on resource projects such as the early stages on Woodside’s LNG Train 4 and Pluto Project, Worsley’s Alumina Expansion, and more extensively on various iron ore projects for BHP Billiton and Rio Tinto.

PDC Consultants

PDC Consultants is one of the largest and most experienced engineering design, detailing and 3D Building Information Modelling (BIM) companies in the world. Since its establishment in 1972, PDC has grown from a team of three to a company of more than 300 engineering design, detailing and 3D BIM teams.

PDC's successful business model works around delivering project solutions rather than individual solutions using its suite of unique 3D Modelling processes and BIM software.

PDC has earned a reputation for providing a quality, professional service, on schedule and within budget. Our proven expertise combined with the latest in 3D modelling technology has built an impressive portfolio of projects across a range of industries, including mining, oil and gas and power and infrastructure.

PDC Consultants offers world-leading Building Information Modelling (BIM) 3D systems and iConstruct software that delivers cost, schedule, safety and environmental solutions for every project. Offering a range of enhanced efficiencies and savings to clients, BIM is a powerful but relatively new industry concept.

With the continued development of its unique iConstruct BIM tool, which creates intelligent 3D models and exceptional functionality for project solutions, PDC now offers a BIM Consultancy Service to support the implementation and maintenance of the BIM process.

This specialist consultancy is designed to ensure that PDC clients realise the full potential of BIM and iConstruct across the project life cycle, from conceptual design to construction and operations. iConstruct capitalises on advantages provided by BIM and Information Management and creates a common platform between all parties.

Steel detailers are anxious to achieve professional recognition for their work.

3.1.7 Professional advisers, specialists and consultants

People and organisations that perform specialist functions are becoming more important in the steel fabrication supply chain. It is generally uneconomic and inefficient to maintain all required capability in-house.

Fabrication businesses require access to expertise in estimating, project accounting, and cost management, as well as ICT systems and software. There are many specialised steel fabrication software products that are capable of integrating with enterprise systems. The absence of good estimating software was noted during the consultations for the project.

Expertise in business development and support services including human resource management and OH&S is also required. For the industry to move form and "orders based" model of operation to one built around relationships and value, there will be a requirement for management, marketing and business development capability. Social media, as a marketing channel, is also increasing in importance for business development.

3.1.8 Engineering, procurement and construction managers

Engineering, Procurement, and Construction Management (EPCM) is widely used in the mining industry. An EPCM is contracted to provide engineering, procurement and construction management services to a developer. Other companies are contracted by the developer to provide construction services, but the EPCM contractor on the owner's behalf usually manages them.

In commercial construction a 'design and construct' project manager is accountable for the outcome of the project in terms of all deliverables, usually stated as performance, time, costs, and scope. In many projects, the construction management and project management are done together. Many companies offer this service to their client.

Global EPCM companies include GHD, founded in Australia in 1928, and SKM, formed in 1964 in Sydney as a private company. SKM has a fee income now greater than A$1 billion.

3.1.9 Regulators and standards agencies

The steel industry is subject to a wide and extensive range of standards. There are 140 standards/regulations in steel construction.

The Australian Certification Authority for Reinforcing Steels ("ACRS") administers an independent, expert, industry-based, third-party product certification scheme, certifying manufacturers and suppliers of reinforcing, prestressing and structural steels to Australian/New Zealand Standards.

ACRS is supported and endorsed by member companies ranging across engineering, inspection, manufacture, government, and importantly, customer bodies. ACRS currently certifies over 150 manufacturing locations, in 12 countries around the world, and has undertaken more than 500 technical conformity assessments to AS/NZ steel Standards.

Why is ACRS necessary?

Reinforcing, prestressing and structural steels have arrived on construction sites that fail to meet the minimum requirements of the applicable AS/NZ Standards. Non-complying materials have been shown to result in project delays (for instance, requiring additional testing), cause consequential costs to involved parties (for instance, requiring substantial redesign) and even ended in court cases. Some of the problems identified are:

- Inadequate product traceability
- Misleading and false supporting documentation
- Excessive variation in materials properties
- Inappropriate product markings

http://www.steelcertification.com

3.1.10 Innovation and industry intermediaries

Intermediaries are independent third parties that play an integral part in collaborative activities supporting any aspect of the innovation process. They can play a key role in the 'market for knowledge' in relation to the transfer and translation of knowledge and technologies from creators to users in a business (commercial) context. In this sense creators include universities, other research organisations and other businesses.

Intermediary activities include:

- Helping to provide information about potential collaborators.
- Brokering a transaction between two or more parties.
- Acting as a mediator, or 'go-between', between bodies or organizations that are already collaborating.
- Helping to find advice, funding and support for the innovation outcomes of such collaborations (Howells 2006).

Intermediary roles are performed by case officers and advisers in the Enterprise Connect network, and by a range of people working providing fee for service roles in consulting and business advisory networks. Intermediary roles are also supported in Universities through Technology Transfer Offices and senior executive positions that have an industry engagement responsibility. Resources to support these activities are limited. There is also limited opportunity to build professional skills, knowledge and experience in this area.

The Australian Government has provided a high level of support for intermediary activities through Enterprise Connect programs.

Enterprise Connect

Enterprise Connect offers comprehensive advice and support to eligible Australian small and medium-sized enterprises to help them transform and reach their full potential. Eligible businesses are able to request a comprehensive, confidential and independent Business Assessment. Enterprise Connect also delivers a number of targeted support programs to address specific business and regional development needs. These include:

- Enterprise Learning and Mentoring
- Researchers in Business
- Tailored Advisory Service
- Technology and Knowledge Connect
- Technology Partnerships Equipment Register
- Workshops, Industry Intelligence Networking

There are 12 centres located across the country that work with small and medium businesses in industries as diverse as manufacturing, clean technology, resources, defence, tourism and the creative sector by providing business improvement services.

The program is delivered largely through industry associations and independent contractors.

Discussions and consultations with Enterprise Connect Business Advisers indicated that there was very little contact with the steel fabrication sector. Only four per cent of Enterprise Connect clients are in the steel fabrication sector. This lack of penetration is occurring notwithstanding the experience of Enterprise Connect Business Advisers in the steel industry.

The CSIRO operates a SME Engagement Centre (SME-EC) to help Australian SME's access research and development from within the National Innovation System in order to help define and address technical issues and facilitate business growth. The objectives of the SME-EC are to:

- Increase the number of Australian SMEs that grow their business through the application or use of scientific research and technical services
- Assist CSIRO research programs, especially Flagships, to generate impact from scientific research by making it easier to connect with Australian Industry.

The SME-EC seeks to engage with innovative, high-potential, small- and medium-sized businesses for which the application and use of research and technical services can translate into successful business outcomes.

There are a number of other intermediary organisations including the Industry Capability Network (ICN) and State Government supported initiatives such as QMI solutions and the Victorian Centre for Advanced Materials Manufacturing. There is also a National Database for Research Capabilities and Expertise that has a focus on advanced materials supported by the ANU – see http://capabilities.anu.edu.au

University also provide intermediary services through their engagement, industrial liaison and partnerships offices. These are generally not well funded. They do not receive funding from Government, as is the case in the UK.

The *Steel Supplier Advocate* also takes an important intermediary role for the industry. This is to champion and lead industry initiatives aimed at providing leadership and support to current and potential steel suppliers to the resources sector. Mr Dennis O'Neill was appointed as the Steel Supplier Advocate on 24 August 2011. His appointment formed part of the first stage of implementing the Government's *Buy Australian at Home and Abroad (Buy Australian)* initiative.

Through *Buy Australian*, the Steel Supplier Advocate provides an important leadership role in implementing and promoting supply chain development activities. Key areas identified for industry development include: improving tender readiness, building a culture of working together and benchmarking supplier performance. Buy Australian builds on existing industry and government initiatives and programs, such as Enterprise Connect, the Industry Capability Network and the Australian Industry Participation National Framework.

In August 2011 Mr O'Neill submitted a report to Government with recommendations intended to assist the industry better position itself to secure work on major local resource projects. A key recommendation involves businesses establishing incorporated joint venture partnerships to build the necessary capacity to undertake large contracts. It included a template covering financial, management and governance arrangements. Based on feedback from stakeholders, Mr O'Neill is now working to refine the draft template document and develop a variant suitable for smaller firms.

In September 2012 Mr O'Neill led two groups of Australian steel fabricators on visits to major steelyards and facilities in Asia. The first group visited Thailand and China to pursue opportunities in the global supply chains that service the development of major resources projects. The second group targeted opportunities in the wind energy sector through a series of visits in China.

3.1.11 End users

The market segments that are relevant to steel fabrication research are broadly as follows:

- Mining, resources and energy

- Infrastructure and transport
- Construction
- Defence
- Industrial machinery and equipment
- Automotive
- Shipbuilding
- Consumer products

These categories provide a base for assessing capability across institutions for targeting industry research collaboration.

Industry	Research potential
Mining, resources and energy	Modular design. Unitised housing
Infrastructure and transport	Roads, rail, bridges, tunnels and pipelines. Infrastructure protection, cleaning and maintenance has become more important as profits in the sector are being squeezed
Construction	Modular techniques and automated production and fabrication of trusses, walls and components. Cold formed steel: Steel framed housing; commercial buildings to 9-12 levels Modelling the forces, stresses and redundancies in residential housing and low rise buildings Warehouses and distribution centres
Defence	Extension of technologies in shipbuilding and submarine
Industrial machinery and equipment	Heavy engineering Additive manufacture Lean manufacture
Automotive	Lightweight steels, deformation and impact
Shipbuilding	Extension of technologies in shipbuilding and submarine
Consumer products	Customisable products and embedded services

3.2 Adoption, application and use of digital technologies

In the modern manufacturing environment, the adoption, application and use of digital technologies is pervasive. In broad terms, digital applications include the following:

- Computers and processors – workstations, mainframes, servers, personal digital assistants, programmable logic controllers (PLCs), bar code readers.
- Actuators or effectors – robot arms, automated ground vehicles, numerically controlled cutters, micro-actuators.
- Sensors – dimensional gauges, machine vision, tactile and force sensors, temperature sensors, pressure sensors.
- Communications devices and infrastructure – telephone, local area network, wide area network, wireless networks, radio frequency identification devices (RFIDs).
- Commodity products, acquired 'off the shelf' – such as operating systems, enterprise resource planning (ERP) systems, customer relationship management (CRM) systems, supervisory control and data acquisition (SCADA) systems, information and data modelling, and decision support packages.
- Differentiable and customisable products – such as process models and algorithms, business process configurations.
- Software for the storage and management of intellectual property – including customer information, business capabilities and procedures, resources, designs, formulas, methods, configurations, analyses.
- Optimisation software – including artificial intelligence.
- Embedded firmware.

Adoption and use of ICT applications has, in effect, changed the orientation of manufacturing operations from predominantly mechanical and electric to electronic and digital. It has also changed manufacturing from a craft and trades based occupation to knowledge and professionally based practice. It has involved a broadening of the nature of innovation from one built around experience, ingenuity and initiative to one that values innovation derived from knowledge and evidence generated through research.

The Australian Steel Institute has reported that:

- The medium and larger fabricators (2,000–20,000 tonnes per annum) process approximately 1.1 million tonnes with a large shift from labour-based fabrication to CNC, beam lining, angle lines and plasma and gas profile cutting.
- There is a trend for fabricators to invest in detailing or to have close liaison with detailers to enable the benefits of computer files to drive their CNC equipment.
- Automated processing is progressively being applied to plate profiling, line and identification marking, drilling and tapping and where required, weld preparation.
- A characteristic of steel fabrication in recent years has been the move to introduce technology throughout the steel value chain, including processing facilities at distribution level.
- New and innovative business models are being developed with better interface in the technology areas between engineers, detailers and the fabricator.
- There has been an emergence of the Design and Construct Steel Contractor who takes an increased share of design and erection for the entire steel component.

As digital networks and more powerful computing allow companies to collect, communicate, exchange and analyse data more quickly and cheaply than ever before, manufacturing businesses are, potentially, able to adopt a broader range of approaches (strategies) to the management of their core functions and processes. This can lead to better-informed business decisions and reduce levels of uncertainty and risk.

Digital technologies are embedded in all aspects of steel fabrication – in the new tools and equipment used for cutting, shaping, moulding and joining (both welding and riveting), and in the machines used for assembly, and in the methods for packaging, transport and distribution to end users. The high levels of accuracy and precision required for cutting, shaping, moulding and joining can only realistically be achieved by machinery that has embedded ICT design and control systems.

In the modern factory there is also a high use of robotics and factory-wide automation systems. These systems interface with company enterprise resource management systems as well as CRM systems that are used for estimating, costing, ordering, inventory management, invoicing and financial control.

The Australian Steel Institute advises that leading fabrication firms are equipped with state-of-the-art Computerised Numerical Control (CNC) automated fabrication equipment and are adept at utilising digital information direct from the Engineer or Detailer to run fabrication machines. This improves cost and quality and enables 'just in time' processing and erection.

The discussions and consultations for this project indicated that this capability is not widespread and that technology is not well integrated across all aspects of the manufacturing environment.

3.3 Energy efficiency, sustainability and stewardship

The steel industry argues that not only is steel essential to the modern world, it is fundamental in a greener world, whether in lighter more efficient vehicles, renewable energy generation, new highly efficient power stations and construction of smart electrical grids or transport infrastructure development and high energy efficient residential housing and commercial buildings.

On average, 1.9 tonnes of CO2 are emitted for every tonne of steel produced. According to the International Energy Agency, the iron and steel industry accounts for approximately four to five per cent of total world CO2 emissions. In this respect, steel is seen as the major part of the problem in greenhouse gas emissions. But steel can also be an important part of the solution.

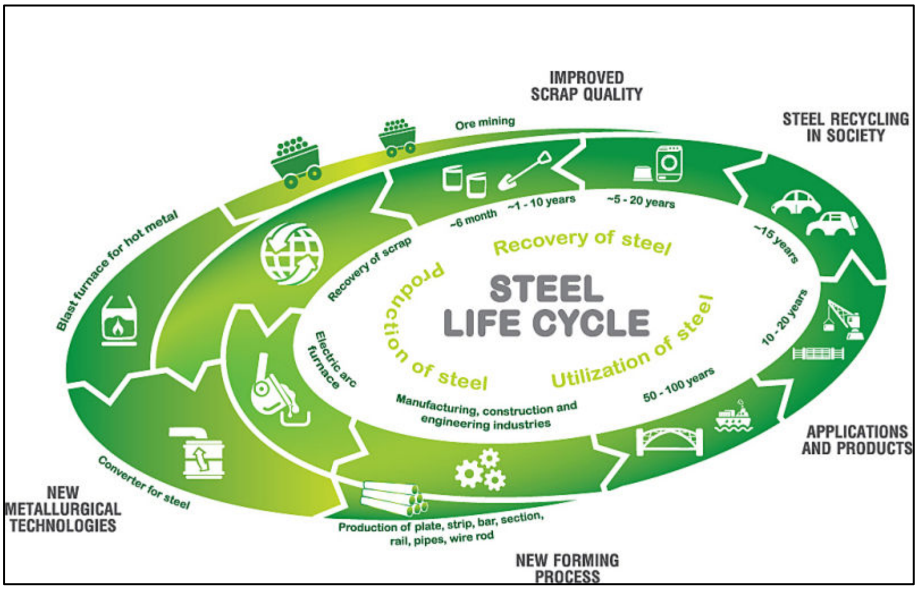
A critical element in reducing the carbon emissions from steel is to optimise the use of recycled materials. Steel is an almost unique material in its capacity to be infinitely recycled without loss of properties or performance. Approximately 36 per cent of steel production is from recycled materials.

In many applications steel has a very long life and, as a result the contribution of modern steels in improving the energy efficiency of buildings, plants, machinery and transportation, it is becoming more important in helping reduce its carbon footprint than the emissions associated with the initial steel production. The key contribution from the steel industry in this regard is to work closely with end users in optimising the design and use of steel in steel-using products and structures.

In order to continue these efforts and to identify all the opportunities to reduce the carbon emissions from steel's life cycle, it is essential to take a full life cycle approach. This approach not only considers the emissions associated with the manufacture of steel products, but also the reduction in energy consumption associated with the use of new generation-steels in lighter and stronger products. Further, the inherent recyclability of steel must be given prominent consideration in the search for sustainable materials for the future.

Steel's lifecycle is represented below.

Figure 8: The Steel Life Cycle



Steel also brings added advantages in speed of construction, lightweight and reduced foundation costs and a smaller manufacturing footprint to the construction site, as most fabrication is off-site in more secure and safer manufacturing environments. Its high strength to weight ratio makes it highly suitable for additions and extensions to existing buildings without the need to recast foundations or substantially reinforce existing structures. Getting greater use and efficiency from an existing building is a good environmental outcome.

Australian universities and research organisations have been giving a major commitment to energy efficiency. However, there is little apparent research that addresses the lifecycle benefits and attributes of steel in construction. Attempts during the project to contact researchers in construction research and engage with the Green Building Council were unsuccessful.

OneSteel has also been supporting research in the area of clean energy and minimising energy use.

OneSteel: Polymer injection technology gives energy efficiencies to steelmaking

Challenge

The steel industry is energy intensive. In the US, for example, it accounts for approximately 2% of all energy consumed.

At the same time, rubber tyres are disposed of in landfill in large quantities, adding to an already major environmental hazard. According to the Rubber Manufacturers Association, 477,000 tonnes of tyres were land-disposed in the US in 2005. The increasing shortage of available landfill sites means that alternative processing methods or increased recycling are needed.

Action

To minimise energy use, electric arc furnace (EAF) steelmaking facilities use coke or anthracite to insulate molten steel, keeping it hot for longer. These are injected into the steelmaking process to produce a foaming slag that forms a blanket over the steel.

The University of New South Wales (UNSW) has demonstrated that polymers (for example, rubber from tyres) can replace some of the coke within the EAF steelmaking process and increase the volume of foamy slag.

Professor Veena Sahajwalla of UNSW first developed the idea that polymers contain an essential source of carbon required for slag foaming in EAF steelmaking. This led to a three-year technology development and testing programme in partnership with OneSteel at its Sydney EAF facility. Regulatory approval followed, in 2008, for use of the polymer carbon in steel mills.

The commercialisation arm of UNSW, NewSouth Innovations Pty Ltd (NSi) Australia, now holds patents for the technology and has granted OneSteel the exclusive right to sub-license this technology in key EAF steel-making regions around the globe.

Outcome

At OneSteel's Sydney steel mill, polymer injection technology reduced electrical energy consumption per billet tonne from 424 kWh to 412 kWh, reduced the amount of carbon injectant required from 464 kg/heat to 406 kg/heat, and improved the number of liquid tonnes per power on time minute from 2.12 to 2.20 tonnes/minute as demonstrated through controlled condition trials.

Polymer injection of rubber sourced from waste tyres is now in commercial operation at two of OneSteel's EAF facilities, in Sydney and Melbourne, Australia. Extrapolating savings measured under controlled conditions at both facilities to total annual production means a carbon dioxide saving equivalent of the removal of approximately 4,000 cars from the road. OneSteel is awaiting regulatory approval for use in a third facility.

http://www.worldsteel.org/steel-by-topic/sustainable-steel/company-case-studies/polymer-injection-onesetel.html

In December 2012 Professor Sahajwalla was awarded the $30,000 top prize in the Innovation Challenge awards run by *The Australian* for her patented "green steel" process.

BlueScope Steel in collaboration with OneSteel, BHP Billiton, Rio Tinto, the ASI, Australian Steel Alloy Association, the Galvanizers Association, the WTIA, Steel Reinforcers Association, FAPM and CSIRO has initiated the Steel Stewardship Forum. The Forum has mapped Australia's Steel Value Chain Footprint (http://steelstewardship.com/news/australias-steel-value-chain-footprint-has-now-been-mapped/)

The Purpose of the Steel Stewardship Forum

The Steel Stewardship Forum (SSF) is a body formed to develop steel stewardship in Australia and a stewardship scheme across the entire steel supply chain and for this to be a template to be presented by Australia at the APEC Mining Ministers Forum as a 'best practice' model for the region.

The concept of the Forum is to bring together all major sectors of the steel product life cycle – from mining through to steel manufacturing, processing, product fabrication, use and re-use, and recycling – in the shared responsibility of working together to optimise the steel product life cycle using sustainability principles including minimising the impact on society and the environment. The SSF believe that collectively we can continue to add value to and improve the performance of the steel industry across the whole product life cycle – thereby reducing negative commercial, social and environmental impacts

http://steelstewardship.com/about-us/

3.4 Innovation and industry policy issues

The discussions with industry and within the research community indicated that there are strong prospects for a modernised steel fabrication industry built around natural advantages and producing high value steel products that the large steel producing nations cannot make – high value steel products that are linked to high technology manufacturing. There are already many steel fabricators that have become significant exporters and manufacture overseas.

3.4.1 Manufacturing industry transformation

In September 2012 the United States National Academies reported that:

> Manufacturing is in a period of dramatic transformation. But in the United States, public and political dialogue is simplistically focused almost entirely on the movement of certain manufacturing jobs overseas to low-wage countries. The true picture is much more complicated, and also more positive, than this dialogue implies.
>
> After years of despair, many observers of US manufacturing are now more optimistic. A recent uptick in manufacturing employment and output in the United States is one factor they cite, but the main reasons for optimism are much more fundamental.
>
> Manufacturing is changing in ways that may favour American ingenuity. Rapidly advancing technologies in areas such as biomanufacturing, robotics, smart sensors, cloud-based computing, and nanotechnology have transformed not only the factory floor but also the way products are invented and designed, putting a premium on continual innovation and highly skilled workers.

Australia also has made substantial strides in manufacturing technologies, but there are challenges in adoption and application. It is important that Australia is aware of international trends and is an active participant in global networks.

Future manufacturing will involve a global supply web, but the United States has a potentially great advantage because of its tight connections among innovation, design, and manufacturing, and also our ability to integrate products and services.

3.4.2 Industry structure

There is a need to get over the idea that 'steelmaking' is an old fashioned industry: it is a vital industry facing many technical challenges. It is also a global industry with some very large producers. The largest, ArcelorMittal, had a production of 97.2 million tonnes in 2011.

In Asia, large structural steel producers have also emerged to serve rapid industrialisation processes that are underway. Almost 58 per cent of the world's steel production now takes place in China, India, Taiwan, and South Korea. By including Japan, the United States, Russia and Germany, the proportion jumps to 77 per cent. Companies in these countries invest heavily in research and development and have strong relationships with universities. ArcelorMittal, has its own university.

Opportunities exist in smaller countries in niche markets for high-quality, differentiated, and technology intensive steel products. Sweden, for example, is only a small producer (4.9 Mt) but has a global reputation in specialist steel products.

Swedish steel producers are world leaders	
Stainless steel:	Outokumpu biggest in hot rolled plate; Outokumpu Stainless Tubular Products one of the biggest in welded tubes; Fagersta Stainless one of the two biggest in wire rod; Sandvik biggest in seamless tubes
Tool steel	Böhler Uddeholmbiggest
High speed steel	Erasteel Kloster biggest
Electrical resistance wire	Kanthal biggest
Ball bearing steel	Ovako biggest
Carbon steel	SSAB biggest in abrasion-resistant and structural steels with extra-high strength
Iron and steel powder	Höganäs biggest
Source:http://www.met.kth.se/asialink/Curriculum/Royal%20Institute%20of%20Tech-KTH/Swedish%20steel%20industry%20in%20english-Birgita.pdf	

Sweden exports almost 85 per cent of production and imports 80 per cent of its consumption.

3.4.3 Australian context

Australia produces 0.5 per cent of global steel output, and ranks 45th out of 64 steel producing countries. However, in 2010 apparent steel use per capita at 307.2 kilograms is higher than the world average of 206.2 kilograms per capita, but below that of Canada.

In 2010 Australia exported 22.7 per cent of semi finished and finished steel products and imported the equivalent of 35.6 per cent of production. The trend over the period 2001 to 2010 has been for growth in both exports and imports. It reflects an internationalisation of the industry – notwithstanding the challenges brought about by the exchange rate and imports.

It is important to emphasise that many Australian steels are world class, which allows broad range of steels to be used in fabrication work. There are also benefits to be realised by combining structural steels with high strength concrete. Moreover, Australia leads the world in the production and utilisation of cold formed steel, steel decking and coated steels.

The import of steels that Australia does not produce, provided that they meet required quality and standards, should encourage end user industries to use steel. The overall result would be more steel consumption – not less. Australia imports more steel that in exports, although the gap has been narrowing since 2006 after a considerable widening between 2002 and 2005. This is illustrated in Figure 9.

Figure 9: Australian Trade in Steel

World Steel Association. 2012. Statistics Archive.

Australia has a demonstrated capability in the manufacture of medical devices and is leading the way in the development of steel powders for additive manufacture at the University of Queensland.

3.4.4 Sustaining competitive advantage

Developing and sustaining competitive advantage in a global industry requires a high level of scientific and engineering input. Australia has many steel specialists working with global companies that use Australia's raw materials. There are potential spin-off benefits for Australian producers and location of research capability in Australia. Research and education, also generates employment and economic benefits.

Unfortunately, Australian research capabilities relevant to steel fabrication, where they exist, are dispersed across the university and research organisation sector, are poorly funded for basic/discovery research by Australian grants agencies, face limited funding opportunities for applicable research, and operate in a narrow industry base where steel is associated with rapid industrialisation: automotive, railways, heavy engineering, and chemical and petroleum, for example. These industries are also globally oriented, dominated by multinational businesses, and Australia is a small participant.

But Australia has a robust resources sector and a commitment by Governments to spend in infrastructure investment and renewal. Strategies to lift Australia's participation in major resource projects has been addressed by the Steel Supplier Advocate (O'Neil 2012). There are opportunities to make greater use of steel in urban and regional infrastructure investments: motorways, bridges and tunnels, for example, can require large quantities of steel.

Although one third of steel produced and consumed in Australia goes into residential and non-residential buildings, the proportion of steel used in this form of construction is well below world averages – not withstanding its strong environmental, architectural and design credentials. While there is some research capability in this area, it is not generally well funded and the linkages between professions are weak. There is also a widespread misunderstanding in the university sector and among policy advocates about steel's sustainability strengths.

Within this milieu there are a number of developers, project managers, and steel fabricators who have a vision for a more functional, aesthetic and sustainable construction paradigm.

3.4.5 Modernisation

A traditional (typical) steel fabrication environment is characterised by a "factory" with a regular flow of requests for quotation and orders coming through on a fax machine. Businesses have been built around responding to orders (tenders) rather than developing and implementing strategies for sustainability and competitive advantage. This has changed. There is now competition – from alternative materials and overseas suppliers. Lower costs of production is not the only reason that steel fabricators are losing out to international competition.

What is occurring is a classic Michael Porter situation of pressures for industry restructure, and a need for transformation, and modernisation. Inevitably, business owners will leave the industry and new ones will emerge. Existing businesses will need to invest in capability and be responsive to market opportunities and adopt new knowledge generated through research (where available) and commit to process innovation and new product development.

In this environment businesses must be more involved in marketing capability to fabrication customers, and follow up with service. This study has identified a number of businesses that have generated success along these lines.

Restructure, transformation and modernisation have occurred across Australian manufacturing. In food processing it was assisted by research and innovation at the 'on-farm' production end, which 'pushed through' innovation in 'off-farm' processing. The turnaround performance of the Australian wine industry is testament to the importance of research and development and the 'productisation' of a commodity output though branding and marketing. Wine products are now among Australia's most significant exports. Similar transformations have occurred in red meat and grains.

Already, Australian steel producers are concentrating in a limited range of product areas, such BlueScope with Colorbond and ZincAlum coated steels products and XLERPLATE LITE, which was used in the Singapore double helix walkway at Marina Bay.

3.4.6 The potential of scientific discovery

Australia has performed well in high value manufactured products (medical devices for example) and there is every reason to expect with the research being undertaken in materials sciences that opportunities will exist in that domain. At the same time, there is an urgent need for fabricators to reduce production costs in the domestic market through manufacturing process innovation and delivering solutions that end users value. To that end, however, there is a need to educate end users (particularly architects and designers) about the benefits of steel construction.

The potential for innovation in steel fabrication through the adoption, application, and use of research in manufacturing process science and technologies is as yet unrealised. The transfer of knowledge and technology is inhibited not only by a perceived resistance among businesses to invest in and take up the results of research, but also by a very low level of public investment in these areas for discovery research that would establish a base for applicable research for use in industry contexts.

Without industry engagement in research, researchers will either ignore the area or follow their own research interests and build their reputations in basic research capability, and then seek business opportunities for commercialisation. This is essentially a flawed model. It is far more effective to build research capability through collaboration. This can address both basic (discovery) and applied research outcomes. Global steel companies are funding Australian researchers to do exactly this. They want to ensure that basic research capability is maintained and nurtured, whilst at the same time having researchers available to work on collaborative projects.

This project has discovered that while there is very little research being undertaken at Australian Universities and research organisations in the steel fabrication capability areas identified in the project brief, the scale and level of support is very small. Even in research areas that would be expected to 'pull through' research in steel fabrication, such as architecture and design, there has been very little interest in exploring the environmental credentials of steel in construction and other industrial applications.

3.4.7 Moving beyond industrialisation

As Australia has moved beyond a period of industrialisation to the position of advanced economies where knowledge is, itself, a key factor of production, it is important that the steel fabrication sector embrace the adoption and use of advanced manufacturing techniques, digital applications, knowledge intensive, practices and processes in product development, production and distribution, and new business methods.

This will be associated with modernisation and transformation of the industry, the arrival of new entrants, a commitment to innovation and the professionalization of management, marketing and business development. Already this is occurring in some of the larger enterprises, but the smaller ones will need to embrace change and respond to both challenges and opportunities. A commitment to 'survival' is not a sustainable strategy.

3.5 Conclusion

The availability and introduction of new process and materials technologies in Australian steel fabrication has the potential to improve productivity and significantly enhance industry performance.

As indicated, take up has been slow. This reflects uncertainty in the industry, but more significantly, a lack of people trained and educated in the use of new technologies. Skills require competencies in the use of new equipment as well as knowledge of the software and systems that sit behind it that establishes the capability to program the machinery to meet processing requirements and link the equipment to broader automated systems. It is a combination of trades based skills with applicable knowledge.

During the consultations for the project it was pointed out that research is required to ensure that technologies are suitable for the Australia production environment and that there was effective integration of materials science knowledge in the development and application of manufacturing processes technologies.

4 The way forward

The steel industry employs about 90,000 people, of whom approximately 10 per cent are engaged in manufacture. The rest are engaged in fabrication and other activities involved in the fabrication of steel to meet user requirements. The risk, of course, is that if manufacture moves offshore, there will be more pressure for fabrication to be undertaken offshore and imported in the form of completed modular packages.

There will always be a demand for steel. Australia is a small producer and consumer. But it has a strong research capability and there are many innovative companies – large enterprises, including BlueScope, and small to medium enterprises that have developed a distinctive capability around technology and are now significant exporters.

As with many of Australia's industries that are going through restructuring brought about by global competitive pressures, the future lies in securing greater efficiency in the use of resources, productivity, and most importantly, in innovation.

In an environment of design and construct contracts and global procurement for the resources sector, it is vital that end users take full account of the outcomes that can be generated by the (innovative) use of steel and full life cycle costs. Steel is also a resource that is fully re-usable. Current policy environments do not, however, provide incentives for end users to seek energy and environmental accreditation in the use of materials and fabrication methods.

On the basis of the findings referred to above, there are three broad areas where research can assist in modernisation, productivity improvement and enhanced competiveness in the steel fabrication sector:

1. Product and processing (inside the gate) capability – adoption and application of knowledge, technology, skills, new 'niche' areas. Plenty of supply, issue of demand.
2. Management capability – creating sustainable businesses through business development, marketing, relationships, partnerships and collaborations. There are some 'beachheads' already in the field, but there is still much to do.
3. Value chain integration – creating stronger links between end user requirements – some level of action.

4.1 Production and processing innovation

It was Peter Drucker who wrote in *The Practice of Management* (first published in 1954) that managers not only have to be concerned with the present, they must also be concerned with what is likely to happen in the future. In addition to finding out about market trends and changes in industry structure, they also have to find out about the *innovations* that will change customer wants, create new ones, extinguish old ones, create new ways of satisfying wants, change the concepts of value, or make it possible to give greater value satisfaction (Drucker 1993).

With flat domestic demand, import competition and limited resources steel fabricators do not have capacity to commit large expenditures on research and development. Businesses have to, for the time being, have to make do with what they have. A response to this situation calls for capabilities relating to creativity, ingenuity and initiative. Innovation is sometimes regarded as using existing resources in new ways to create wealth (Howard Partners 2006). It may involve developing new products and entering into new markets.

Fabrication businesses must move from a supplier, orders driven way of doing business to one that addresses changing and emerging trends in demand. Demand driven strategies require understanding the market and looking for changes that invite an innovation response. It means participating in networks, attending conferences and workshops and engaging with teaching and research organisations.

There is a great deal of scope for improved automation and integration of the fabrication process. In emerging businesses design, detailing, engineering, and production is an integrated, seamless operation carried out in the one enterprise. This is essential for modular construction, and is being practised by Chinese companies involved in this segment of the market.

Demand and market driven strategies require detailed planning and commitment. Adoption and implementation of information and communication technology based applications have the potential to increase productivity and performance in service delivery. They also require transformation of business structures, new skills and a commitment to change management.

4.2 Management capacity and capability

It was apparent during consultations that many steel fabrication businesses should think about the way the business operates, the way it manages resources and the way it delivers value to its clients and customers. There is little opportunity to withdraw from the delivery of what are seen as 'core products' given the level of investment that has been committed, but there is often opportunity to think about how they are delivered.

Successful businesses see innovation as a need to constantly change, adapt, and redefine the nature, purpose, and direction. This transformational process reflects a business view of innovation as a way to use resources in new ways to create wealth (Drucker 1994). Those resources might be currently under the control of a business, or they may be acquired from another business where they are seen to be under-performing or lacking potential in other contexts.

Business driven innovation may involve one or more of the following:

- Changing the way in which physical and other assets are used, either on their own or in combination, in the creation and delivery of products and services.
- Achieving a substantial shift in the way people work and think about the business through attitudinal, behavioural, and cultural change strategies and programs.
- Entering into new lines of business related to core competencies and capabilities through investments, partnerships, and collaborations.
- Sale or divestment of under-performing business assets.

Inevitably business driven innovation means challenging the way in which the 'business' is conducted. It involves a commitment to sustaining and value by responding to changing business drivers and meeting a broad range of stakeholder expectations.

For many businesses the only way they can become sustainable, and continue to deliver value is through continuous updating of their business models in the light of changes in market conditions, shifts in end user tastes and preferences, and more demanding performance expectations. This transformational innovation represents a paradigm shift in the purposes, processes, and behaviours for many businesses.

4.3 Value chain integration

The Australian Steel Institute has pointed out that the steel value chain has very strong linkages from producer to distributor to fabricator as customers and suppliers, each of whom works seamlessly with the various other associated links including, engineers, architects, design detailers, painters, galvanisers, erectors and others to ensure that a solution is delivered to the end-users' satisfaction (Australian Steel Institute 2011).

The Australian Steel Institute (ASI) also has long established links with a number of key industry bodies that supports the steel industry including; Engineers Australia, the Architects Institute of Australia, the Australian Industry Group, the Building Products Innovation Council, and other key associations who interact with the steel industry.

While it is apparent that the links in the steel fabrication value chain are strong between Australian steel producers and distributors (in many cases one and the same) and to fabricators, the linkages with other elements in the value chain and particularly to final end users are not as strong as they could be. While there are strong linkages with industry and professional organisations, the linkages may not be as strong as they might be with universities and research organisations, and between businesses for the purposes of collaboration and partnership.

The Institute, in collaboration with relevant professions should explore the opportunity of engaging with university engineering, architecture and built environment departments about the environmental strengths and sustainability of steel structures. There also needs to be a greater connection between the end users of steel, particularly the design and construct companies responsible for advising clients on construction solutions. Engagement is complex due to the plethora of industry and professional associations working in the area of building – sometimes with competing agendas.

The Institute is keen to promote a culture of 'whole of lifecycle' approach to building solutions which is consistent with clean energy and sustainability policies being developed and implemented.

Addressing these issues will require resources. The proposed Institute for manufacturing process science and engineering could take up the initiative in this regard.

5 Industry capacity to 'absorb' new knowledge, technologies and practices

It is often thought that businesses have difficulty in their capacity to 'receive', 'adapt', and 'adopt' discoveries and innovations generated through the public research system. In other words, the market is perceived to fail in revealing the opportunities available from public research for application and use in business. Researchers and research organisations have limited incentives and reward to 'market' their discoveries and inventions to business.

5.1 The problem of 'absorptive capacity'

The poor 'receptor' capability and capacity to absorb new knowledge on the part of Australian business for discoveries and inventions has been seen as an inhibitor in Australia's industrial progress.

A paper prepared by DIISRTE saw Absorptive Capacity in terms of a firm's intent and ability to recognize opportunities presented by new knowledge. It argued that firms need a foundation of in-house knowledge that allows them to recognise and evaluate new knowledge. But recognition alone is not enough; it needs to be allied with an effective strategy/capability for exploitation/ implementation.

The paper suggested that firms may develop Absorptive Capacity through explicit measures, such as hiring trained staff, R&D activities or establishing strategic alliances. Absorptive Capacity may also develop as the by-product of other business activities, for example through learning associated with problem solving, innovation, and collaboration for other purposes.

A firm's capacity to absorb information depends not so much on the amount of knowledge and information that is available, but on its capacity to receive. Rarely is information or knowledge available in a way that firms can immediately adopt and apply. It will require translation into a form and format that is quite often situation specific.

Externally available information and knowledge often requires translation into a form and format that can be received, understood and acted upon by a firm's decision makers. This is essentially a communication issue. Communication occurs when messages have been received, understood and acted upon by the intended receiver. Quite often this requires translation into a language, format and style that a receiver can comprehend.

Academic papers published in scholarly journals generally require 'translation' into forms and formats that can be understood and acted upon by non-academic recipients. But knowledge is most effectively transferred through interactions involving the knowledge, capabilities and experience of *people.* In this respect, collaborations through placements, partnerships and networks are an important means of transfer.

The Enterprise Connect Researchers in Business Program has been an important means for knowledge transfer between the CSIRO and industry, where the Organisation is looking to place 100 researchers, but has not been taken up extensively in Universities.

5.2 From transfer to translation

Translation (and translational research) has come into prominence in relation to the 'absorption' of new knowledge in the health services industry—as primary and secondary health care providers want access to the results of the most recent (publicly funded) research. However, general practitioners and clinicians in community and public hospital settings do not simply 'apply' knowledge generated through medical research. In the past they have 'absorbed' knowledge through a range of channels—some highly reliable and others sometimes dubious.

To ensure that knowledge generated through research is brought into practice health services authorities are making significant investments in *translation*—to put information and knowledge in a form and format that practitioners can receive and apply. Similar initiatives are being implemented by the mining and infrastructure related industries.

Translation has also received some attention in agriculture and environment industries where frameworks are being developed to identify industry and firm level knowledge and information that is relevant for practice and translating this in a way that can be received, adopted and applied by managers. People are being appointed and processes being established to ensure that firms cam identify, translate and adopt information and knowledge relevant to a firm's mission and business development strategy.

5.3 Education and training

The most effective way of transferring knowledge form an academic to a business context is through the knowledge of people educated and trained in universities and vocational training institutions.

In 2008 the Bradley Review of Australia's tertiary education system concluded that for successful and sustained innovation (the adoption and application of new ideas, practices, and technology) businesses require *university graduates* with an appreciation of practice, *and technicians* with an appreciation of theory.

Bradley argued that current and future employers and employees need *both* education and competency skills. Australia's tertiary education system is responding to this requirement – albeit slowly – but not at the same pace as our East Asian competitors.

Unfortunately, Australian Business has not been strong in advocating an approach that addresses these requirements.

6 Facilitating ongoing interactions

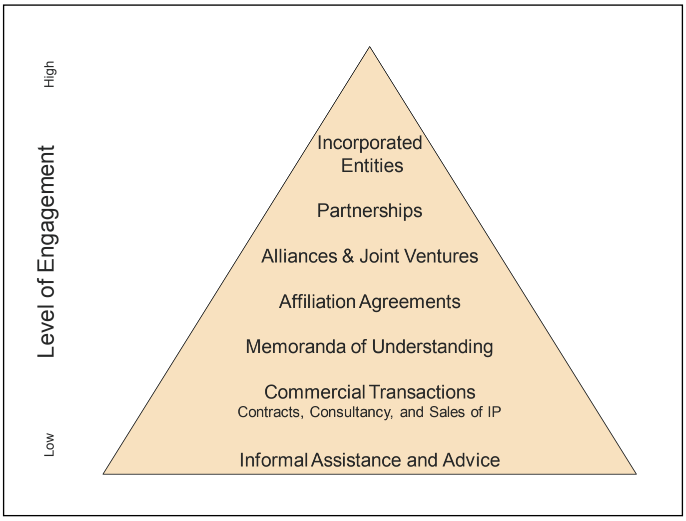
This Section of the Report addresses the requirement to develop and distribute a template that can be used to update the report to facilitate ongoing interactions between researchers and business (via email to relevant R&D groups in the Australian Innovation System).

Before considering the design and structure of a 'template' it is important to provide some background about the nature of university-business interactions.

6.1 Move from a transactional to partnership paradigm in university-business relationships

Interactions between universities and business (and government) can be represented as a hierarchy of interactions, understandings and agreements. The hierarchy has as its base a low level of engagement, represented by informal assistance and advice, and at its apex formalised corporate entities that give permanent effect to joint ventures. This is illustrated in figure 10.

Figure 10: The University-Business Engagement Pyramid



Source: Howard Partners, 2011

University staff are generally actively involved in their professional and broader communities. They are members of boards, associations and committees at the local, national and international levels. This level of engagement, whilst important, is difficult to capture and quantify in universities and research organisations. Some universities are assessing this form of engagement in performance agreements and reviews.

At the next level, universities and research organisations enter into contracts for commissioned research and consultancy, and execute licensing agreements covering access to intellectual property. Relationships become progressively closer through formalised memoranda of understanding, affiliation agreements, strategic alliances and joint ventures, and finally to incorporated entities, such as a Cooperative Research Centre established under the corporations law, or new institutions entirely.

The progressive movement from transactions to partnerships involves occurs on the basis of high levels of trust developed between parties. It is an axiom in the corporate world that people do business with people they trust.

Successful collaborations involve not only researchers at the middle level of an organisation but also executive level input from all parties and endorsement by CEOs and Vice Chancellors. It is impotent that brokerage and intermediary activities can generate confidence at this level.

Interactions and relationships are often formed on the basis of initial and informal personal contacts and through networks, by academics looking for funding for a research opportunity, or by businesses or their agents looking for solutions to a business problem. Many expect these relationships to be formed on the basis of a simple agreement between a researcher and a purchaser in business or government.

This reflects a transactions mindset and conveys the knowledge warehouse or supermarket view of the University, where purchasers can figuratively roam the shelves for solutions to their business and technology problems. People in business and government often complain that there is often no 'sales catalogue', 'shop front' or single entry point for the procurement of academic services—advice, analysis, research, short term and bespoke teaching and training, for example.

The reality, of course, is that universities are not set up to merchandise knowledge in a transactional context. Moreover, knowledge is a very difficult product to handle, particularly if it is context dependent - or has not actually been created. Nonetheless, a few universities have established entities to take on the role of merchandising "capability" using a consultancy/professional services model. These entities operate through a Technology Transfer Office or are assigned to a designated person in the University Executive Team.

It is worth pointing out that finding the 'front door' of a large professional services firm also presents major challenges for new clients. In these businesses personal contacts and active relationship marketing by the firm's principals often source potential new clients. There is also a process of checking and assessment concerning whether unsolicited clients meet the firm's business criteria.

Recent articles published in the *MIT Sloan Management Review* identify ways that businesses can create more productive relationships with Universities. Businesses are criticised for too often trying to purse collaborations in an ad hoc, piecemeal manner rather than developing a relationship strategy and structure (Perkmann and Salter 2012; Wright 2008)

It is essential that discussion and debate about knowledge transfer move from a transactional basis of 'buying and selling knowledge products' to one that involves collaboration around capabilities through partnerships and joint ventures.

6.2 Ensure that interactions and relationships are consistent with core mission

Universities have been established principally for the purposes of teaching and research. Many universities regard industry engagement as peripheral to this core mission, but will embrace it where it makes a contribution to achieving objectives set internally by governing boards, and by the criteria of funding agencies.

The Australian Government does not specifically fund universities for industry development and engagement ('third mission') activities. Only Victoria and Queensland have consistently funded universities for industry and economic development purposes.

Universities have also been reluctant to approach industry engagement from a consultancy model, although it is the case that many research centres underwrite the full cost of basic research from consultancy income. Industry requirements for research consultancy must generally be couched in a way that meets legitimate research criteria.

Across the sector there are many academics that undertake 'private consultancy' outside their professional obligations to the university. Many universities support this, provided a staff member meets requirements under a workload agreement and risks to the university are known and covered.

6.3 Communicate information about industry engagement and partnership opportunities

Only a few Universities refer to industry engagement on their home websites. Student recruitment and research interests and capabilities are given top billing. This reflects the overarching business driver to secure income from student enrolments and secure a reputation for scholarly research activity.

Many universities are updating their websites to include a specific section in industry engagement, and a number include detailed information about faculty/research centre/school capability and the CVs of academic staff. Some have a tab for "Find an Expert".

Generally, however, university websites are poorly constructed to communicate information that would be useful for business, are out of date, and links are no longer operative. In some universities industry engagement is channelled through the research page that is effectively equated with securing funding for the university's research interests.

The few universities that have established websites that have a tab on their front page for industry engagement include:

- The University of Sydney http://sydney.edu.au/sydnovate/
- University of Wollongong http://www.uow.edu.au/engage/index.html
- Macquarie University http://www.mq.edu.au/business_community.php
- Monash University http://www.monash.edu.au/industry/
- Swinburne University http://www.mq.edu.au/business_community.php
- RMIT university http://www.rmit.edu.au/industry
- Deakin university http://www.deakin.edu.au/industry-and-community
- Queensland University of Technology http://www.qut.edu.au/industry-and-partnerships
- University of South Australia http://www.unisa.edu.au/Business-community/
- The University of Western Australia http://www.uwa.edu.au/business
- Murdoch University http://www.murdoch.edu.au/Business-and-Industry/
- Charles Darwin university http://www.cdu.edu.au/business-government

Many universities provide a home page link to community, but these tend to publicise events rather than identifying industry engagement and partnership opportunities. Some universities provide access to industry partnerships through the research page (for example, The University of Queensland at http://www.uq.edu.au/research/index.html?page=4143 , but the page is 'not found').

Most universities feature a tab for Alumni and Donors.

6.4 Provide easy access to researcher profiles

A number of universities provide access to research profiles through their websites. Many provide a pro forma for the preparation of profiles.

Universities should be encouraged to develop and expand this practice. There is limited value in tasking a third party to consolidate research profiles, although this may be a role for a steel industry organisation or one of the current lead universities in steel related research or with a new institutional arrangement.

A web page with links to researcher CVs should be all that is required. URL links to relevant research centres, as contained in Appendix 2, is possible development of this option.

Of more concern is the difficulty of obtaining consistent and reliable information about publicly funded research grants. The Australian Research Council does not provide a search facility, using key words, for successful grants. Information can be obtained by laboriously searching each grants announcement. To find grants for steel related research over a five year period, for example, may require 15 separate searches.

6.5 Continue to support innovation intermediaries

Over the last several years there has been a growing interest in the role of innovation intermediaries and 'innovation carriers' who work at the interface between the creators and suppliers of knowledge.

The Australian Government provides support through Enterprise Connect and has supported pilots of other models, including the InnovationXchange and Techfast operated by the Australian Institute for Commercialisation. A problem has been that people involved in this work do not have a good understanding of how the research sector works, the priority given to teaching and scholarly research, and how best to support academic researchers in building business relationships.

Enterprise Connect business advisers have well established contacts with Universities and work well with staff in Technology Transfer Offices or their equivalents. However, navigating through the complex structures of universities and building relationships with academic and administrative staff can be a daunting and time consuming task. Some universities are making it easier by providing contact points for industry engagement activity.

It is important that intermediaries not only engage with academic staff but also with people with the responsibility, and resources, to make decisions in relation to commissioned research and consultancy. These are generally Faculty Deans, Research Offices, and Industry Engagement Offices.

The focus on intermediary activity so far has been on the demand side of knowledge transfer, under the rubric of demand led innovation, rather than building capacity in the supply side – within universities and research organisations – where people have a better knowledge of research and teaching capability and can communicate effectively with research staff as well as with business.

6.6 Recognise and support University industry engagement activities

Most of the research-intensive universities have established technology transfer offices to protect and commercialise Intellectual Property generated through research. The University of Queensland's UniQuest is seen as one of the more successful models and receives strong support from within the University (Johnston, Howard, and Grigg 2003).

Among other universities delivery models are constantly changing and being repositioned as Vice-Chancellors try to find a formula for securing a financial return from commercialisation activity. There is acknowledgement, of course, that universities seek protection of Intellectual Property for purposes other than making money (Merrill and Mazza 2010)

Many technology transfer offices market and coordinate consulting and advisory services, such as ANU Edge at the ANU.

ANU Edge

ANU Edge delivers knowledge services informed by the world-class research and practice at The Australian National University. It is dedicated to the application of university research and knowledge excellence to satisfy real-world needs.

As part of Australia's national university and leveraging an international network of partners in government, industry and academia, ANU Edge is ideally positioned to identify and translate research output with the potential to provide real-world benefit. These methodologies can be developed and delivered as world class solutions to industry, government and NGOs in Australia and the Asia Pacific region.

Services have been targeted around a demonstrated ANU capability in strategic planning and innovation. Currently, services are available in three areas.

- Roadmapping – understanding future trends and capabilities to position for growth.
- Scenario Analysis – identifying risks and opportunities based on complex variables.
- Open Innovation - developing and managing Open Innovation systems.

ANU Edge is always seeking new avenues to develop, customise and deliver knowledge services.

http://anuedge.anu.edu.au

ANU edge was recently brought within the structure of ANU Enterprises.

A number of universities coordinate consultancy services through their Research Offices, but do not actively market them. Academics also engage in consulting activity in their own right through the 'one day a week rule' that allows staff to allocate 20 per cent of their time to consulting and community engagement activity. Universities have developed policies and procedures for paid outside work activity. These differ significantly across the system. Enterprise Agreements also cover the amount of time available for teaching, research and engagement activity.

Universities become concerned when staff are generating significant amounts of income from their private consulting activities. The concern centres on deflection of time from university related work, non-recovery of university costs (including use of facilities and materials) and the risks imposed to the university through failure to meet contract deliverables. Academic staff have a responsibility to ensure that approaches from industry to undertake consultancy work are channelled through the university's management systems.

At the same time, many universities are taking a greater interest in building business and industry engagement for the purpose of securing partnerships and securing funding for teaching and research. Many have made appointments to positions of Pro Vice-Chancellor Innovation or Industry Development with specific responsibilities to build closer links with business for collaborations in teaching and research that can meet both university and business requirements. In some universities the responsibility is held by the Vice Chancellor.

Monash University has established an *Industry Engagement and Commercialisation Group* to build and nurture long-term relationships with industry and other organisations. Its task is to seize opportunities and forge collaborations that allow innovation to drive business success. The Group is headed by a Pro Vice-Chancellor and includes managers tasked with responsibilities for:

- Research Partnerships
- the Monash Innovation Institute
- Monash Consulting Services,
- Partnerships and Precinct Development
- Industry Engagement
- Commercialisation.

The Group also includes Business Development Managers located in Faculties.

In some universities KPI for Executive Deans and Heads of School relates to engagement, industry partnerships and business development.

6.7 Conclusion

There have been many reports, papers and articles that promote and advocate greater interactions between universities and business. There is a policy concern that industry is not effectively utilising the results of publicly funded research.

Perceptions often hide the reality of an extensive and complex pattern of engagement. Too much policy attention has been focussed on technology transfer through commercialisation – the sale and licensing of Intellectual Property and formation of start-up companies – a model that is based on the experience of medical and biomedical research. A UK study has indicated that universities receive *40 times* more income through collaborations and partnerships than they do through commercialisation (Perkmann, 2012)

The reality is that knowledge transfer through collaboration and engagement is far more difficult, requiring high-level competencies and capabilities within both universities and industry. They rely less on external third parties and more on the commitment of university executives and research leaders. At the end of the day, research collaboration must make good business sense for all involved and work towards achieving what are sometimes disparate missions and objectives.

Initiatives that promote understanding by both business and universities about their role and function can only assist in developing productive interactions.

7 Overcoming barriers to innovation

This Section identifies ways that industry might encourage innovation in the steel fabrication sector by addressing demand side issues, reduction in the amount of 'layering' in policy advocacy, and work towards greater collaboration across professional domains.

7.1 Address low demand for steel in construction

The use of steel in commercial and residential construction is well below that in the rest of the developed world. The attributes of steel as a construction material, and as part of the solution to greenhouse gas emissions is not well promoted or understood.

With greater utilisation will come opportunities for innovation and an expanding role for universities and research organisations. The Australian Steel Institute is to be commented for the role that it plays in representing the interests of steel producers, who are its major benefactors and supporters. But it has limited resources to promote and advocate on behalf of the many hundred SME steel fabricators and other participants in the supply chain.

In Singapore, by contrast, the Singapore Structural Steel Society was formed with the objectives of constituting an association of engineers, architects, industrialists and others concerned with and interested in the analysis, design, construction, research and other aspects of structural steels. As a result of the Society's effort, there has been an upsurge of interests in Singapore towards the consideration of structural steel as an alternative material of construction.

The Society has also been very active in bringing together all those involved in research, teaching, design, fabrication, manufacture and construction of steel structures in this region.

In the UK, the British Constructional Steelwork Association (BCSA) is the national organisation for the steel construction industry that, promotes the use of structural steelwork and ensure that the capabilities and activities of the industry are widely understood.

The Australian steel industry would benefit from an organisation that brought together "engineers, architects, industrialists and others concerned with and interested in the analysis, design, construction, research and other aspects of structural steels". The Steel Industry Innovation Council could promote this initiative.

7.2 Address policy layering in steel fabrication industry representation and advocacy

Relating to the points made above, there are numerous professional organisations and industry bodies that can, or could, represent the interests of the steel fabrication industry. This generates a multiplicity of views and makes it difficult to ensure that there is a coherent message in relation to the steel fabrication sector.

Professional Organisations include:

Academy of Technological Sciences and Engineering (ATSE)
The Australian Institute of Steel Detailers (AISD)
Australian Council of Built Environment Design Professions
Australian Institute for Building
Australian Institute of Architects
Design Institute of Australia
Australian Foundry Institute
Engineers Australia
The Australasian Universities Building Education Association (AUBEA)

There is a multiplicity of industry organisations that would have some concern with innovation and modernisation in relation to steel fabrication industry.

Australian Steel Institute
Australian Manufacturing Technology Institute Limited
The Australian Certification Authority for Reinforcing Steels ("ACRS")
Australian Packaging and Processing Machinery Association
Australian Automation and Robotics Association
Australian Pipeline Industry Association
American Institute of Steel Construction
Australian Construction Industry Forum (ACIF)
Australian Green Infrastructure Council
Australian Sustainable Built Environment Council
Australian Institute of Public Works Engineers
Bureau of Steel Manufacturers, Australia
Steel Stewardship Forum
Building Products Innovation Council
Construction Forestry Mining Energy Union - Construction and General Division
Consult Australia
Green Building Council of Australia
Housing Industry Association
Materials Australia
National Association for Steel Framed Housing
Australasian Railway Association
Standards Australia
Welding Technology Institute of Australia

This extensive network of policy voices creates a 'layering' effect in representation and advocacy. Moreover, the methods and approaches of the lobbying and representation industry makes it difficult to secure a coherent and evidence based view in relation to future and proposed policy actions and initiatives.

7.3 Coordinate across professional domains

One of the issues encountered during the consultations process for the project was an absence of dialogue on steel fabrication matters across professional domains. There was evidence of considerable rivalry between professions.

There is little merit in suggesting forums and coordinating arrangements where people have limited time and resources. It would be more useful to utilise some of the existing forums and ensure that all professional interests have the opportunity to be involved.

7.4 Actively promote the structural and environmental credentials of steel on an evidence base

The structural and environmental credentials of steel are not well promoted. Australia does not have a body such as the UK, US and Singapore organisations that promote and provide knowledge in relation to steel construction and fabrication. Steel is generally understood to be a commodity, and the language is generally in commodity terms – tonnes produced, for example.

Steel should be understood as a diversified product range, with differentiated characteristics and capable of delivering substantial economic and aesthetic value to end users.

7.5 Prepare a steel fabrication industry strategic plan

The Steel Industry Innovation Council should consider supporting preparation of a steel fabrication strategic plan, involving all segments and elements of the steel fabrication sector.

8 Proposed activities that will encourage relationships between research and business

This Section of the Report addresses that part of the project brief that requires consideration of activities and initiatives that will assist industry identify and target capabilities and researchers. In addressing this issue, it is important to be aware that capabilities and researcher availability may constituted in a way that makes contact, communication and engagement easy.

Building communication and contact will, if it is to be sustained, require changes in the structure of the research and higher education industry itself. Many of these are in progress, but there is a wave of structural underway and still to come that has the potential, if managed appropriately, and with substantial industry input, to deliver outcomes that deliver benefit for all parties.

One of these changes, for example, is the internationalisation of the industry, reflected in global research collaborations and on-line education. Other changes include the institutional restructuring involving the integration of research, education and training, as foreshadowed in the Bradley Review of higher education in 2008.

8.1 Establish capability for knowledge transfer and translation

The ways in which applicable knowledge is created and moves between universities and research organisations to industry and business is not fully understood appreciated (Howard Partners 2005a). Since the publication almost 20 years ago of *The New Production of Knowledge* (Gibbons et al. 1994) there has been a growing appreciation that that knowledge is created in a dynamic process, involving universities and research organisations, practice in business and industry contexts, and a broad range of consultancy, advisory, advocacy and private research organisations ('think tanks', for example).

Knowledge is transferred and translated through three broad institutional arrangements: markets, organisations and networks (Howard 2004, 2011). There has been very little investment in building institutional capacity for knowledge transfer in any of these domains:

- University technology transfer offices, which transfer knowledge through sale or licensing of intellectual property, are generally poorly resourced.
- There is little guidance around governance, management, and financial issues in university research centres and university-industry partnerships and collaborations.
- Building and sustaining leadership capacity in knowledge networks is also an area that has received little attention (Howard Partners 2005b).

Effective knowledge transfer requires strong institutional capacity and capability that, in turn, requires investment and commitment. Some of this investment should occur in universities and some should occur in business and professional organisations.

8.2 Support integration of research, education and training

The Bradley Review made the point that in a knowledge based service economy the traditional institutional divisions of role and function between universities, technical and further education institutions, and post compulsory secondary education colleges and schools are becoming blurred. It suggested that the education, skills and training requirements in the new economy differ markedly from those which applied in the "old economy" where some students went to a VET institution to get an industry recognised qualification and others went to university to get an education.

The Review Report suggested it is no longer helpful to see stark contrasts between higher education and VET in the level and types of qualifications they deliver. Bradley noted that traditionally higher education has concentrated on delivering longer study programs with a strong element of general education and adaptable skills largely for professional occupations, whereas VET has focused on more immediate vocational outcomes in trades and paraprofessional occupations. However, these differences are shifting.

> The Review concluded that for successful and sustained adoption and application of new ideas, practices, and technology, that business, government and non-government organisations require university graduates with an appreciation of practice, and technicians with an appreciation of theory. Current and future employers and employees need both education and competency skills (Bradley et al. 2008).

The Review noted that there had been some convergence—with growth in the vocational and professional focus of higher education, and VET responding to the demands of industry for higher-level skills by re-focusing on middle-level and advanced training. However, in submissions to the Review there was strong support from universities, public VET providers and State Governments for continued differentiation in the roles of VET and higher education. In Australia, there appears to be little business interest in the polytechnic models of Europe and Scandinavia that are associated a strong innovative culture and close inks between academia and industry.

Employers, by contrast, argued in their submissions to the Review for an integrated post-secondary skills environment where the differences between the sectors do not restrict the capacity of individuals to move between them. They suggested that the distinction between higher education and vocational and technical education is eroding in the minds of employers and employees. Businesses and Industry Associations have reaffirmed this view in consultations for this Study.

The Bradley Review Report did not address structural change in the tertiary sector or how a tertiary education system could be aligned with economic and industry objectives. It did note however, that various efforts to strengthen the connections between higher education and VET have been made in Australia over the last twenty-five years with limited success, due to structural rigidities as well as to differences in curriculum, pedagogy and assessment.

The Bradley Review considered that a better interface between higher education and VET is now imperative and vital for a fully effective tertiary system. But in the four years since the release of the Bradley Report these structural rigidities continue in the tertiary education system, largely driven by funding, the research imperative and intergovernmental roles and responsibilities - to the detriment of Australia's industrial future.

Only a few 'dual sector' institutions have fully embraced integration of tertiary education and competency training – RMIT University is an exemplar, whilst proposals to establish a model of a polytechnic institution in Canberra through structural adjustment funding were strongly opposed on grounds other than a compelling education, training and industry rationale.

8.3 Encourage and support industry supply chain integration

The discussions and consultations indicated that should be greater integration of the steel fabrication supply chain, enable by information technology. Many have a vision for seamless integration across organisations and supply chain elements. The BuildingSmart has been an important initiative in promoting this vision.

The BuildingSMART Initiative

BuildingSMART's role is to work with key industry organisations to support the transition of the sector to a knowledge based digital economy, by addressing key issues such as GHG reduction, enabling Local Government planning and approval processes, and improving the quality & performance of the physical built environment.

BuildingSMART has proposed an economic study that has the objective of determining the productivity benefits of the adoption of digital modelling in the Built Environment sector. The BIM working group is now seeking wider sponsorship for the costs of the study from industry. BuildingSMART are planning to introduce web site tools to assist firms and individuals in adoption of digital modelling technologies and change management support.

Many are more sanguine about progress, recognising the many institutional blockages that need to be addressed. It could, however, be an area that is addressed by the proposed Institute for manufacturing process science and engineering.

8.4 Promote a broader view of scholarship in manufacturing process science and technology

During discussions there was reference to Ernest Boyer's *Scholarship Reconsidered* (Boyer 1997; Braxton, Luckey, and Helland 2002) as a basis for building research capability for the steel fabrication industry. This means:

- Re-affirming Australia's commitment to the scholarship of discovery based on research initiated curiosity driven inquiry
- Building a scholarship of integration that supports cross-disciplinary research focussed on solving problems and capturing opportunity for society, industry, and public policy.
- Developing a scholarship of application that addresses issues in the translation and transfer of knowledge into application, adoption and use.
- Supporting a scholarship of teaching that promotes teaching excellence.

Funding should strike a balance between these areas of scholarship – and reflected in an Institute for Manufacturing Process Science and Engineering.

8.5 Raise the profile of design in the Australian innovation system

The link between design technology and innovation was the subject of a Paper prepared for the Council of Humanities, Arts and Social Sciences (CHASS) *Between a Hard Rock and a Soft Space*. It drew attention to the historical link between design and technology dating back to the industrial revolution and celebrated in the Great Exhibition of 1851 (Howard 2008). The significance of design in innovation in innovation systems is well established in the US, the UK, Europe and now Asia.

More recently, the non-government members of the Prime Minister's Manufacturing Taskforce drew attention to the importance of design in innovation (Prime Minister's Manufacturing Taskforce 2012).

AN EMERGING AUSTRALIAN ADVANTAGE: DESIGN

As discussed, design is a critical enabler of productivity and innovation, and has been shown to play a significant role in the growth of firms and sectors. Building on a strong engineering tradition, Australia can and must succeed in design if its manufacturing industries are to create the differentiated products and services that consumers want and are prepared to pay for.

Aspects of Australian industrial design, particularly those stemming from a strong engineering base, are world class. Similarly our related marketing and branding capabilities are world class.

Until recently, Australian industrial design has primarily been focused on efficiency concepts such as lean manufacturing and resource productivity. However, today design is evolving as a broader and more compelling concept for business.

Design should be seen as a ubiquitous capability for innovation. The non-government members of the Taskforce propose that the Commonwealth Government commission an independent panel to advise on the changes needed to maximise the potential of design thinking on innovation in Australia. This review would consider implications for design research, design education, design practice, national design collaboration and the absorptive capacity of firms, and would involve open engagement of the entire design community.

The non-government members of the Taskforce also consider that that the design thinking approach form significant elements of the curriculum of the proposed Australian Leadership Institute.

8.6 Provide support for precincts, hubs and clusters

The record of success of clustering initiatives through innovation precincts and technology parks in Australia is mixed. Many are simply real estate plays. Despite serious efforts, the Silicon Valley model of innovation has not been successfully replicated. It took 15 years for the Australian technology Park to work. The Mawson Lakes precinct was underwritten by a levy on the sale of land from what was the multi-function polis.

The lesson is that knowledge clusters require the committed support of universities and research organisations, lead tenants, and technology investors.

The Non-Government Members of the Prime Minister's Manufacturing Taskforce drew attention to the CSIRO, Monash and Victoria Government initiative at Clayton, Victoria.

HOW CSIRO AND MONASH MAY DEVELOP THE AUSTRALIAN MANUFACTURING AND MATERIALS INNOVATION PRECINCT IN CLAYTON, VICTORIA

In response to Australia's need for a more connected, globally recognised and sustainably competitive manufacturing industry, Monash University and CSIRO are working together through a strategic relationship agreement to develop the Australian Manufacturing and Materials Innovation Precinct (AMMIP) in Clayton, Victoria.

Clayton forms a natural location for the AMMIP, as it is within the South East metropolitan region of Melbourne, which houses a significant number and range of advanced manufacturing companies, the Australian Synchrotron and the Melbourne Centre for Nanofabrication.

The vision for AMMIP is to act as a hub for a wider network of interconnected industry and research based facilities (eg. National Food Innovation Hub, Queensland Manufacturing Institute, design innovation collaboration with Queensland University of Technology, Swinburne University National Faculty of Design and Advanced Manufacturing Centre on its Hawthorn campus, RMIT's Advanced Manufacturing Precinct), that can translate know-how and promote the development of existing Australian manufacturing companies, as well as the growth of new companies across Australia, including in regional centres.

CSIRO is committed to the success of AMMIP and its ability to provide innovative technologies and boost the competitiveness of Australian manufacturers, and is therefore actively seeking capital investment in-excess of $10 million from non-government sources (eg. application to Science Industry Endowment Fund, Universities, industrial investment) to assist with the realisation of AMMIP.

Through its 'hub and spoke' collaboration model, AMMIP will bring together advanced manufacturing facilities from around the country creating scale and connection and an environment in which the proposed Manufacturing Technology Innovation Centre (MTIC) could be hosted. Whilst the MTIC could be housed at AMMIP, its crucial industry-led focus would still be maintained through the proposed establishment of a Board of Governance with leading multinational corporations, representatives of leading SMEs, Enterprise Connect, Queensland Manufacturing Institute, universities and State Governments.

Finally AMMIP is also proposing to house a new 'open access' Factories of the Future initiative. The Factories of the Future would be a facility made available to industry on an open access basis to provide advanced prototyping and production capability to Australian Industry.

The facility will be supported by research and development from the relevant research agencies and designed to be a reconfigurable multi-user facility for manufacturing companies for design innovation, micro automation, advanced processing and additive manufacturing with industry, complemented by technical advice and R&D services to assist firms' process and product development and business model innovation needs.

The non-Government members noted that in order to act as a hub and bring together the wider capability network, AMMIP must be successful in working in a virtual way across Australia. This would require the implementation of broadband networks and new tools for collaboration at a distance that will transform the way people work.

8.7 Introduce technology 'voucher' schemes

Technology voucher schemes support a transactional approach to knowledge transfer. This can work for universities and research organisations that have developed a consulting capacity and capability but is more problematic in relation to capability that is not 'transfer ready'.

The Victorian Government has implemented a Technology Implementation Voucher Program. Vouchers will be awarded to undertake substantial testing or applied development activities in order to develop, adapt or adopt industrial biotechnology, small technologies and advanced information and communication technology based innovations for new practice or new markets. A business could use a Technology Implementation Voucher to work with a supplier to:

- Develop or manufacture a prototype or prototypes to demonstrate commercial feasibility, open up markets and/or improve current products or processes
- Test different applications of the technology within new markets
- Undertake pilot scale trials to demonstrate the benefits from incorporating technology into products or production processes
- Carry out applied development and testing of technologies that can improve productivity and/or profitability

Reflecting the maturity of the ICT market in Victoria, the program will support ICT applications for projects that involve new technology development or exploration and/or testing the application of existing technologies in innovative or novel ways.

The non-government members of the Prime Minister's Manufacturing Taskforce proposed a voucher scheme (Prime Minister's Manufacturing Taskforce 2012).

IMPROVING RESEARCHER RESPONSIVENESS – MAKE IT EASIER FOR SMEs TO ACCESS KNOWLEDGE

Innovation Vouchers would increase the engagement between knowledge providers and SMEs. While the immediate focus is to raise the SMEs productive and innovative capacity, a wider goal is to increase linkages between SMEs and providers by creating new spaces that encourage collaboration.

Vouchers would also be used to enable the identification of good providers. To minimise the transaction costs for SMEs and knowledge providers, brokerage support would be available to connect SMEs and relevant researchers. Red tape involved in administration should be minimal. Vouchers would be redeemable for activities intended to introduce new technologies, products, processes or services, or significantly improve those currently existing. The value of the vouchers could vary, with vouchers for innovation activities such as:

- Accessing facilities for specialised measuring equipment, e-research, supercomputers, or nanofabrication as well as accessing design expertise.
- Accessing process improvement expertise and other technical assistance by drawing on the expertise of staff in the research or technology diffusion facilities.
- Accessing skills analysis, workforce planning and development expertise as it relates to building firm capability.
- Trial production runs or processes to demonstrate technical concepts.
- Validation or demonstration of the technical capabilities of the product, process or service, including scale-up, stability or reproducibility of a process.
- Implementation of new technology and Implementation of new business models.

The purpose of vouchers is to refocus research effort on helping businesses to solve their practical problems through direct relationships.

8.8 Establish institutional and organisational capacity to build and sustain capability for research and knowledge transfer in manufacturing technologies

There is strong support from within the academic and business community for establishment of a research, teaching, training and engagement organisation that has a specific focus on the adoption, application and use of science and technology relating to the manufacturing process science and technologies. This support was premised on broad fabricating industry involvement and end user interest.

A commitment and sustainability would require that available resources should be $4-5m per year over 7-8 years ($28m to $40m).

The institutional and organisational options that have been canvassed during consultations are summarised below. Further information about each model is provided in Section 9.

9 Sustaining research capacity and capability: An Institute for manufacturing process science and engineering (The Digital Steel Institute)

Opportunities and options to build and sustain research capability in the fabrication sector were discussed extensively through the Project consultations processes. There was a strong view that a designated and dedicated organisation was required that connected industry with the research and teaching community and was focussed on the transfer and translation of research into practical application. There was also a view that such an organisation should be receptive to ideas, insights and methods that have been developed in industry.

The organisational capability should encompass:

- Focus on materials and manufacturing technologies
- Strong ICT capability in production technologies
- Application and adoption focus
- A capacity to scale up and strengthen capability across universities
- Replace present Advanced Manufacturing Centre

Constitutional and organisational options that have been canvassed during consultations are outlined below. Where options draw on international practice, further information is provided in Attachment 4.

9.1 A designated hub, or hubs, of capability linking research and industry

This model picks up elements of the UK ESRC collaboration programs including Industrial Doctorate Centres and the Collaboration Awards in Science and Engineering.

Within this broad option there are a number of possible models:

- A Hub established under the ARC Industrial Transformation Research Program.
- A model that picks up elements of the UK ESRC collaboration programs including Industrial Doctorate Centres and the Collaboration Awards in Science and Engineering.
- A National Network for (Steel) Manufacturing Innovation – modelled on the US National Network for Manufacturing Innovation.

Industrial Transformation Research Hubs are intended to encourage R&D projects that could help solve industry-facing problems. In these hubs it is envisaged that managers, researchers and industry workers will work together to address everything from the need to reduce pollution in manufacturing processes to enable businesses to compete locally with a high Australian dollar.

Up to 20 research hubs will be established nationwide with initial funding for up to five years. This funding term gives our researchers and industry partners the flexibility to undertake comprehensive research programs that will help tackle our big industry challenges, as well as short-term projects that may help answer emerging issues or questions. The Government will invest up to $1 million per year in each hub with this investment being matched by industry partners.

The UK ESRC Collaboration Programs offers Collaboration Awards in Science and Engineering (CASE). Industrial CASE provides funding for PhD studentships where businesses take the lead in arranging projects with an academic partner of their choice. These aim of these awards is to provide PhD students with a first-rate, challenging research training experience, within the context of a mutually beneficial research collaboration between academic and partner organisations e.g. industry and policy making bodies.

Industrial Doctorate Centres (IDCs) are a subset of EPSRC' Centres for Doctoral Training (CDTs). These user-oriented Centres provide the same training environment and features as CDTs whilst also incorporating a strong industrial focus. There are currently 19 IDCs. They include:

- Industrial Doctorate Centre in Advanced Forming and Manufacture, University of Strathclyde

- Industrial Doctorate Centre in Machining Science, University of Sheffield
- Engineering Doctoral Centre in High Value, Low Environmental Impact Manufacturing, University of Warwick
- Innovative and Collaborative Construction Engineering, Loughborough University

Further information about the scope of activity in IDCs is provided in Attachment 4.

In his FY2013 budget, President Obama proposed the creation of a National Network for Manufacturing Innovation (NNMI) to help accelerate innovation by investing in industrially relevant manufacturing technologies with broad applications, and to support manufacturing technology commercialization by bridging the gap between the laboratory and the market.

The National Network for Manufacturing Innovation

The NNMI proposal calls for the establishment of up to 15 Institutes for Manufacturing Innovation (IMI) funded through a one-time infusion of $1 billion in mandatory funding to the Department of Commerce's National Institute for Standards and Technology (NIST) and carried out over a period of 10 years. Each IMI would be comprised of stakeholders from industry (including large companies and small- and medium-sized manufacturing enterprises), academia, federal agencies, and state government entities.

Each IMI is to be competitively selected, serve as a regional hub for manufacturing innovation (as well as part of the national network), and have a unique focus area (e.g., an advanced material, manufacturing process, enabling technology, or industry sector). The NNMI would be managed collaboratively by NIST, the Department of Defense, Department of Energy, National Science Foundation, and other agencies.

THE NNMI model reflects elements of the Australian Government's initiative for a Manufacturing Innovation Centre announced in the 2012-13 budget.

Further information on these models is at Attachment 4.

The findings outlined in this Report point to the need for a model that is more specific to the issues relating to the steel fabrication sector (and perhaps metal fabrication more generally). These include, for example:

- The thin spread of capability and research funding in areas relevant to the steel fabrication sector.
- The requirement for the Industrial Transformation Hubs to be researcher initiated, under ARC guidelines, and the limited pool of industry partners
- The need to address specific strategic and structural issues related to improving performance, productivity and competitiveness in steel fabrication.

A number of technology hubs and innovation precincts have emerged around Australia through specific initiatives and the natural clustering and agglomeration of technology businesses in and around universities and research organisations. Many 'clusters' reflect state and local government land-use zoning decisions, and are underpinned by strong property development and real estate interests. They include the Monash Science and Technology Precinct, the Geelong Technology Precinct, the Mawson Innovation Precinct and the ATP Innovations at the Australian Technology Park.

Clusters and precincts are important for business development, networking and collaboration among businesses, and between businesses and researchers. Venture investors like to have prospects in one place. Success tends to be evolutionary, built around trust and working to specific objectives rather than the result of a formula or recipe. Silicon Valley is unique, brought about by exceptional circumstances and is difficult, if not impossible, to replicate (Saxenian 1996), although many have tried. The financial returns from university involvement in technology parks and innovation precincts are not good.

9.2 The Cooperative Research Centre (CRC) Model

The merits of the CRC model were raised extensively during the consultations process. The CAST CRC had achieved success in working with SMEs and scaling projects up into investable programs.

A number of people in the research sector suggested a model similar to the Defence Materials and Technology Centre (DMTC). DMTC is a collaborative venture that brings together defence industry, universities and government research agencies to develop new materials and manufacturing technologies that will enhance Australia's defence capability. It is Australia's first Defence Future Capability Technology Centre – a Federal Government initiative based on Co-operative Research Centre (CRC) model.

Operational funding of approximately $86 million is drawn from several sources including a $30 million contribution from the Federal Government and a combined $9 million from the state governments of Victoria, Queensland and New South Wales. Collaborative industry and research sector partners provide the balance.

The opportunity to give the Advanced Manufacturing CRC a greater focus on steel fabrication was discussed during consultations for the Project.

On 28 November 2012 Senator the Hon Chris Evans, Minister for Tertiary Education, Skills, Science and Research announced the 16th CRC selection round. The focus of selection is to be innovative manufacturing, social innovation and sustainable regional communities. The Minister announced

> The innovative manufacturing priority area will be interpreted broadly but should address the challenges faced by industry in the manufacturing sector. The challenges may include the development of capabilities and products in knowledge-intensive manufacturing or niche high tech areas, and enhanced processes and products that reduce emissions, consumption and costs. Other areas could include capitalising on upstream processing. Proposals should be focussed on end users maximising opportunities through innovative sustainable practices that will underpin growth and competitiveness over the longer term.
>
> The social innovation priority area will be interpreted broadly but might focus on new and sustainable solutions to societal challenges faced by end users in areas such as education, health or community wellbeing and development. Innovations may include products, models, processes or services that seek to strengthen society at a local, national and global level. The priority area will address public good as a key objective of the CRC program and also align with the government's broader social inclusion agenda.
>
> The sustainable regional communities priority area will be interpreted broadly but might address any of the challenges-economic, environmental or social-faced by Australia's regional communities. Proposals could be focussed on securing future prosperity and maximising opportunities for regional communities through sectors with long term competitive advantages, investment in climate and biosecurity resilience, agriculture, infrastructure, health, jobs, education and increased participation. Proposals could also contribute to sustainable regional communities through investigation of trade opportunities and value-adding to raw products, digital applications, investment in clean energy, water and carbon efficient technologies as well as community leadership and resilience.

An application for a CRC in the area of steel fabrication process innovation, new products that meet end user needs and address sustainability issues at a regional level could fit these criteria. Steel fabrication is a major employer in regional and local communities.

9.3 A Research Association Model

There are several possible models that have achieved success in various contexts:

- AMIRA (Australian Minerals Research Association),
- The Rural Research and Development Corporation
- The NZ Heavy Engineering Research Association (HERA)

The AMIRA model has achieved success in the mining sector. It is a research-commissioning organisation, supported by the major mining companies. It is not certain whether the model could be extended to the steel fabrication sector with a large number of SMEs and limited research collaboration.

Australia has experienced considerable success with the rural research and development and marketing corporations. They have a strong commitment to industry supported strategic research and, through research application and marketing, have enabled significant restructuring and modernisation of their industries. Wine, Red Meat and Grains are stand out examples. These corporations have been sustained through strong industry support, representation, and a compulsory levy on producers and optional levies on processors.

The NZ Heavy Engineering Research Association (HERA) was established in 1978 as an industry owned, non-profit research organisation dedicated to serving the needs of metal-based industries in New Zealand.

While the emphasis of its activities is on heavy engineering, HERA also services wider metals industry interests such as light-gauge steel, stainless steels, light alloys and metals-based composites.

The Mining industry has also achieved beneficial industry wide outcomes through AMIRA (Australian Minerals Research Association).

In New Zealand, the Heavy Engineering Research Association (HERA) was established in 1978 as an industry owned, non-profit research organisation dedicated to serving the needs of metal-based industries in New Zealand. While the emphasis of its activities is on heavy engineering, HERA also services wider metals industry interests such as light-gauge steel, stainless steels, light alloys and metals-based composites.

HERA obtains its income from an industry contribution in the form of a levy on steel and welding consumables, Public Good Science funding for contract research programmes, direct funding from industry for specific programs, consultancy work, seminar and course fees, subscriptions from members and sales of publications.

The Australian Steel Institute sees merit in this model.

9.4 An institution modelled on the Fraunhofer Institute for Production Technology (IPT).

The Fraunhofer-Gesellschaft's research work is oriented toward applications and adoption of research. Funding is obtained from both from the public sector (approximately 30 per cent) and through contract research earnings (roughly 70 per cent). This encourages the Institutes to operate in a dynamic equilibrium between application-oriented fundamental research and innovative development projects.

There are 60 Fraunhofer Institutes. The task of the Fraunhofer IPT is to transfer research findings into economically viable and unique innovations in the field of production. It promotes and conducts applied research, implements research results in an industrial context, and provides relevant and effective consulting services for the direct benefit of industry, thereby contributing significantly to the competitiveness of companies.

Research and consulting services are provided on the basis of scientifically recognized procedures and using state-of-the-art facilities. Fraunhofer IPT also aims to achieve technological and opinion leadership in its key focus areas with respect to contract research at both a national and international level.

Many organisations consulted saw merit in this model. However, given Australia's investment in CSIRO, and the direction being taken by the CSIRO Future Manufacturing Flagship, there is doubt whether such an Institute is warranted.

9.5 Extending the role of the CSIRO Future Manufacturing Flagship

The Future Manufacturing National Research Flagship (FMF) is Australia's largest multi-disciplinary research program focused on manufacturing innovation. It was established to assist Australian industry meet the challenges of an increasingly globalised, competitive and resource constrained future, the FMF is also poised to help its research partners capture emerging global opportunities.

The current focus areas for the Flagship are:

- Sustainable Materials – assisting manufacturers to become more competitive and sustainable by developing and putting into use sustainable materials technologies with smart functional

properties that maximise value and performance whilst minimizing the negative environmental impacts of product-lines (low waste, low embodied energy) throughout their life-cycle.
- Factories of the Future - supporting manufacturers become more productive, agile and resilient by developing and putting into use, new, efficient, clean and scalable manufacturing technologies that leverage digital and information sciences through low cost micro- and assistive-automation, robotics, additive and sustainable (closed loop) manufacturing to deliver a triple bottom line advantage.
- Transformative Industries – supporting the development of new supply chains for future market needs through transformative technology platforms and new business models

Many of the issues raised in this Report would fit within this overall strategy.

The Flagship operates on an annual budget of $70m, of which $30m is externally sourced. External funding is secured primarily through commercially contracted research with industry, with varying levels of co-investment. About 80 per cent of the Flagship's resources are directed towards research projects with industry partners. The remaining is invested in early stage strategic research.

Specific funding for steel industry research and innovation could be supported within the Flagship. It would be necessary however, for CSIRO to establish a presence in other cities and regions.

Additional funding could be provided to lift the Flagship profile in steel industry research.

9.6 Establish a new collaborative Centre of Excellence (Institute) for Steel Manufacturing Process Science and Engineering

Centre of Excellence (Institute) for Steel Manufacturing Process Science and Engineering would aggregate capability across current centres and university faculties. It would provide critical mass and ensure that the full range of technological capabilities is available for the fabrication sector.

It would be modelled on centres that have been established recently with strong industry involvement. It would focus on research translation and application – drawing on knowledge created in an academic environment and professional knowledge generated in industry. These include:

- The Centre for International Finance and Regulation
- The Australian Centre of Excellence for Local Government.

Both Centres have strong links to universities and collaborations with industry. They are not in the first instance research centres but have strong research and industry connections.

Centre for International Finance and Regulation

The Centre for International Finance and Regulation has been established to assist government, regulators and industry to meet emerging challenges and opportunities in the field of global finance. It will link and support international policy makers, regulators, industry and academia to anticipate, prevent or contain future financial disruptions.

The Federal Government committed $12.1 million over four years to establish the Centre, with the NSW Government providing an additional $6 million. A further $6 million has come from corporate sources and universities. The Centre will also receive $17.5 million of in-kind support from partner institutions including New York University, and further funding is expected to be provided as the Centre develops.

Foundation partners are:

- Six leading Australian universities, each with prestigious international research reputations in finance, law and economics
- Two Sydney-based, internationally distinguished capital markets research and development centres – the Capital Markets Cooperative Research Centre and the Securities Industry Research Centre of Asia-Pacific
- Two of the leading finance research centres in the world, NYU's Salomon Centre and Volatility Institute, and UCLA's Fink Centre – through these institutions the Centre will have an active collaboration with three Nobel Laureates
- Industry participants that have already committed to support the Centre include the Commonwealth Bank of Australia, Macquarie Group and KPMG

The Centre, to be located at UNSW's CBD campus, will also play an educative and consensus-building role, combining world-class discovery and collaborative research with effective outreach.

The Australian Government contributed $8 million in funding for the Australian Centre of Excellence for Local Government. The Centre's mandate is to enhance professionalism and skills in local government, showcase innovation and best practice, and facilitate a better-informed policy debate. The centre aims to:

- Build on existing local government programs and networks

- Encourage innovation and best practice across local government
- Foster good governance and strategic leadership
- Support action to improve local government workforce capability to address skill shortages and attract and retain skilled staff
- Promote new and improved training and development programs
- Stimulate and inform debate on key issues for local government in coming decades.

NICTA, in its current form is also a possible model. It has the advantage of strong State Government buy-in.

These models of university-industry-government collaboration provide a framework for thinking about an organisation that can address applicable research, research translation and adoption and industry modernisation in the steel fabrication sector.

The Centre of Excellence (Institute) for Steel Manufacturing Process Science and Engineering would aggregates capability across current centres and university faculties. It could involve, potentially, 10 universities and two research centres as collaborating partners –

- ANU (Materials and Manufacturing Group)
- Deakin University (Centre for Frontier Technologies)
- Monash (Department of Materials Engineering)
- RMIT (Advanced Manufacturing Precinct) and work on Materials Engineering
- Swinburne (Advanced Manufacturing Research Centre)
- UNSW (Centre for Sustainable Materials Research and Technology)
- UQ (Centre for Advanced Materials Processing and Manufacturing – APPAM)
- UTS (Centre for Built Infrastructure Research) and ARC Centre for Autonomous systems
- USyd (Centre for Advanced Materials Technology)
- Wollongong (Faculty of Engineering, DMTI)
- CSIRO (Future Manufacturing Flagship)
- ANSTO (Institute for Materials Engineering).

Other capabilities exist, including UniSA (forming and BIM), JCU (structural and extreme weather) Curtin (forming), and UWS (structural steel).

As with the Finance and Local Government Centres and NICTA, the Centre of Excellence (Institute) for Steel Manufacturing Process Science and Engineering would be established on the basis of competitive tender. The inclusion of universities and research organisations and industry partners would be a matter for tenderers to include in their applications. It would be expected, however, that the Institute would have national coverage.

The Budget should be in the order of $4-5m per year over 7-8 years.

The preferred model for the Centre of Excellence (Institute) for Steel Manufacturing Process Science and Engineering must give broad fabricating industry interest and involvement, and end user interest.

The Institute must also establish an interface with the Centre for Manufacturing Innovation.

Appendix 1: People and Organisations Contacted and Consulted

University staff

Professor Riadh Al-Mahaidi, Director, Smart Structures Laboratory, Faculty of Engineering and Industrial Sciences, Swinburne University of Technology
Professor Daine Alcorn, Deputy Vice-Chancellor Research and Innovation, RMIT University
Professor Andrej Atrens, Head, Division of Materials, The University of Queensland
Professor John Beynon, Executive Dean, Faculty of Engineering, Computer and Mathematical Sciences, The University of Adelaide
Professor Geoff Brooks, Leader, High Temperature Processing Group, Faculty of Engineering and Industrial Sciences, Swinburne University of Technology
Professor Mick Cardew-Hall, Pro Vice Chancellor, Innovation, The Australian National University
Professor Mike Clements, Professor of Industry Engaged Learning, Industry Engaged Learning, Swinburne University of Technology
Dr George Collins, Deputy Vice-Chancellor (Research and Development), Swinburne University of Technology
Professor Christopher Cook, Dean, Faculty of Engineering, University of Wollongong
Professor Alan Crosky, Senior Lecturer, School of Materials Science and Engineering, The University of NSW
Associate/Professor Matt Dargusch, Mechanical Engineering, Centre for Advanced Materials Processing and Manufacturing, The University of Queensland
Professor Gamini Dissanayke, Professor of Mechanical and Mechatronic Engineering, Centre for Autonomous Systems, University of Technology, Sydney
Dr Matthew Dolan, Lecturer, School of Engineering, The Australian National University
Ms Daphne Freeder, Manager, CMOS Centre for Organisational Studies, University of Technology, Sydney
Professor Emad Gad, Faculty of Engineering and Industrial Sciences, Swinburne University of Technology
A/Professor Helen Goldsworthy, Faculty of Infrastructure Engineering, The University of Melbourne
Dr Steve, Gower, Director, Research Collaborations and Partnerships, Research and Innovation, RMIT University
Professor Peter Hodgson, ARC Laureate Fellow, Director, Institute for Frontier Materials, Deakin University
Professor Mark Hoffman, Head, School of Materials Science and Engineering, The University of NSW
Professor Andrew Holmes, University Laureate Professor and CSIRO Fellow, Bio21 Institute, The University of Melbourne
Professor Ron Johnston, Executive Director, Australian Centre for Innovation, The University of Sydney
Professor Saulius Juodkazis, Centre for Micro-photonics, Faculty of Engineering and Industrial Sciences, Swinburne University of Technology
Dr Stephen Kajewski, Head of School, Civil Engineering and Built Environment, Queensland University of Technology
Professor Ajay Kapoor, Professor of Engineering Design, Faculty of Engineering and Industrial Sciences, Swinburne University of Technology
Dr Shahin Khoddam, Senior Lecturer, Department of Mechanical Engineering, Faculty of Engineering, Monash University
Associate/Professor Xiazchou Liao, School of Aerospace, Mechanical and Mechatronic Engineering, The University of Sydney
Professor Ian Mackinnon, Director, Institute for Future Environments, Queensland University of Technology
Professor Yiu-Wing Mai, Professor of Mechanical Engineering, School of Aerospace, Mechanical and Mechatronic Engineering, The University of Sydney
Dr Peter Murphy, Associate Director, Mawson Institute, University of South Australia
Professor John Norrish, Chair in Materials Welding and Joining, Faculty of Engineering, University of Wollongong
Professor Andrew Parfitt, Pro Vice Chancellor, Division of Information Technology, Engineering and the Environment, University of South Australia
Professor Veena Sahajwalla, Director, Centre for Sustainable Materials Research and Technology (SMaRT@UNSW), The University of NSW
Professor Bijan Samali, Professor of Structural Engineering, Director - Centre for Built Infrastructure Research, School of Civil and Environmental Engineering, University of Technology, Sydney
Associate/Professor Shankar Sankaran, Course Director, Project Management, School of the Built Environment, Faculty of Design, Architecture and Building, University of Technology, Sydney
Professor David St John, Director, Centre for Advanced Materials Processing and Manufacturing, The University of Queensland
Dr Rod Thomas, Senior Business Development Manager, Industry Engagement and Commercialization, Faculty of Engineering, Monash University
Professor Brian Uy, Foundation Director, Institute for Infrastructure Engineering, University of Western Sydney
Dr Scott Wade, Senior Lecturer, Faculty of Engineering and Industrial Sciences, Swinburne University of Technology

Professor John Wilson, Executive Dean, Professor of Civil Engineering, Faculty of Engineering and Industrial Sciences, Swinburne University of Technology
Dr Zhigang Xiao, Lecturer, Engineering, School of Applied Science and Engineering, Monash University
Professor Irene Yarovsky, Professor of Theoretical Physics, School of Applied Sciences, RMIT University
Dr Jianqiang Zhang, Senior Lecturer, School of Materials Science and Engineering, The University of NSW

Research organisations and collaborations

Dr Paul Di Pietro, Deputy Head, Institute of Materials Engineering, ANSTO
Dr Yvonne Durandet, Materials Processing and Laser Applications, Industrial Research Institute, Swinburne University, CAST CRC
Ms Kellie Dyer, Adoption and Commercialization Manager, CRC for Rail Innovation
Dr Mark Easton, Program Manager, Department of Materials Engineering, Monash University, CAST CRC
Professor Lyndon Edwards, Head, Institute of Materials Engineering, ANSTO
Mr Michael Egan, Corporate Manager, SME Engagement, CSIRO
Dr Barrie Finnnin, Theme Leader, MMTM, Future Manufacturing National Research Flagship, CSIRO
Mr David George, Chief Executive Officer, CRC for Rail Innovation
Mr Bruce Grey, Managing Director, Advanced Manufacturing CRC
Ms Rosie Hicks, Chief Executive Officer, Australian National Fabrication Facility
Dr Anita Hill, Chief of Division, Process Science and Engineering, CSIRO
Dr Mark Hodge, CEO, DMTC Ltd
Mr David Lind, Director, Business Development and Commercialization, Future Manufacturing National Research Flagship, CSIRO
Dr Swee Mak, Director, Future Manufacturing National Research Flagship, CSIRO
Mr Andrew McLellan, Commercialization Manager, Advanced Manufacturing CRC
Professor John Norrish, Director, DMTC Ltd
Ms Helen Ujvary, Facilitator, SME Engagement, CSIRO
Dr Stephen van Duin, Program Leader - Maritime Platforms, University of Wollongong, DMTC Ltd

Business and industry

Mr Andrew Barker, Metalworking Representative, Sales Team, Ron Mack Machinery
Mr Henri Baumann, Director, Sovereign Design Group
Mr Gerhard Bindlechner, Operations Manager, Henrob
Mr Stuart Blacket, Managing Director, Henrob
Mr Greg, Bosward, Territory Manager, Headland
Mr Scott Bourne, Market Manager, Structural and Merchant Bar, Onesteel
Mr Robby Clark, Sales Engineer, Fabrication and CNC Machine Tools, Headland
Mr Ross Davies, Relationships Manager, Sustainability, BlueScope Steel
Mr David, Eden, Construction Manager, Construction + Development, Brookfiled Multiplex
Mr Ben George, Sales Manager, Industrial Machine Sales
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Mr Trevor Stuart, Business Adviser, NSW Business Chamber, Enterprise Connect
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Mr Richard Tooher, Business Adviser, Wynnum and District Chamber of Commerce, Enterprise Connect
Ms Amanda Wood, State Director, South Australia, Enterprise Connect
Mr Peter Yates, Chief Executive Officer, Industry Capability Network

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Mr James Cameron, Policy and Advocacy Manager, Australian Institute for Building
Mr Robert Hunt, Chief Executive Officer, Australian Institute for Building
Mr Oliver Kratzer, Managing Director, Australian Design Council, Ideal Industrial Design and Product Development
Mr David Parken, Chief Executive Officer, Australian Institute of Architects
Mr Clayton Roxborough, Managing Director, Steel Detailers Association, Steelcad
Mr Chris Velovski, Managing Director, Steel Detailers Association, EDC

Industry associations

Mr David Birrell, Chief Executive Officer, Australian Steel Association
Dr Peter Key, National Technical Development Manager, Australian Steel Institute
Mr Don McDonald, Chief Executive, Australian Steel Institute
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