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DIGITAL STEEL

THE STEEL INDUSTRY RESEARCH MAPPING PROJECT

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ABSTRACT

The Australian steel fabrication industry is facing hard times. Cost pressures, import competition, and skills shortages are major issues of concern. Many businesses are considered to be in 'survival mode'. Much of this has been attributed to the rising value of the Australian dollar – but there are other forces at work.

This research reports on ways in which the Australian steel fabrication sector can improve productivity, national and international competitiveness, and energy efficiency by obtaining greater access to knowledge generated through research in Australian universities and research organisations to achieve innovation outcomes.

The research involved 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.

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

KEY WORDS

Innovation; Science and Technology; Knowledge Transfer: Industry Economics: Industry-University Collaboration.

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Summary

This Paper is a summary of a much larger report prepared for the Commonwealth Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education.

The research reports on ways in which the Australian 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 research involved 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 but openness to the adoption of new knowledge and practice is an important dimension.

The research did not address options for 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.

The research 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.

The research identified the following:

- There is not a great deal of research taking place in technologies related to steel fabrication. 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. This reflects the position that "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. This reflects a strong science oriented, theory based, investigator initiated research culture.
- Materials Science discoveries and inventions may be picked up in larger companies (nationally and internationally) and new start-ups – but not by struggling SMEs without a strategic vision and strong entrepreneurial capability.
- 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 Europe.
- Fields of Research (FORs) and research focus do not align easily with the manufacturing requirements and capabilities. Industry/user program and project needs might require knowledge drawn from several FORs, across different faculties and universities. 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.
- 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.
- 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.

- Universities are hard to connect with. Many have poorly developed websites, gatekeeper barriers, and limited resources for industry engagement. Institutional commitment to building relationships in research and 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.
- There is, nonetheless, 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. The two large steel makers and fabricators (BlueScope and Arrium) have extensive linkages with several universities in Australia and overseas. Overseas steel producers are implementing similar strategies in Australia.
- It is generally recognised that the most effective form of knowledge transfer is through the employment of skilled and knowledgeable graduates (Howard Partners 2005). Larger companies have postdoctoral positions, graduate recruitment programs and offer cadetships for promising students. 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.
- 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). However. The application and adoption of new technologies and manufacturing processes requires new knowledge and skills.
- 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. Public sector developers (including universities) have the opportunity to drive an outcomes focus and deliver great buildings using steel.
- 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. Opportunities exist to apply new technologies and materials to extend the service use-value of steel to users and consumers. This requires much greater collaboration along the value chain.
- 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.

The research findings formed the basis for a number of specific recommendations relating to:

- Building research capability in technology integration, application and education.
- Creating avenues to fund research that achieves greater integration of the science and engineering domains.
- Promoting the Steel Fabrication sector as a high technology industry with a future built around digital technologies.
- Building capability in the fabrication sector in management capacity, innovation, marketing, and communication.
- Establishing a Steel Construction and Infrastructure Alliance across the professions.
- Promoting an understanding and culture of university-Industry relationships focussed on outcomes and creation of value for all parties through effective partnerships.
- Stimulate the demand for high quality steel for construction and manufacture through government procurement policies for public buildings and design competitions.

- Support the development of knowledge precincts, hubs and clusters that have relevance to the steel fabrication sector.
- Establish an Institute for manufacturing process science and engineering (The Digital Steel Institute).

The recommendations are addressed in extended detail in the full report to the Department of Industry, Innovation, Climate Change, Science, Research, and Tertiary Education.

Success of implementation of these initiatives should be evaluated over time, in the following areas:

- Widespread adoption of new technology and value chain integration.
- Increased production, sales and profitability.
- Increased export and international engagement.
- Enhanced collaborations and partnerships between industry, universities and research organisations.
- Increased employment.

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 was to provide 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 research will provide a basis from which industry can engage with the research and development community more effectively.

1.2 The problem, and the opportunity to be addressed

The research brief was 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 research 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 was intended that the project would 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)

1.3 Research requirements

The main focus of the project was on research and development (R&D) activities that could assist steel fabricators improve their competitiveness. A key requirement of the 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 be focussed on developments in, but not limited to, the following manufacturing processes:

- Assembly – covers formation, building and erection of steel structures.
- Automation – use of digitally enabled automated processes and procedures in factory operations.
- Casting – making complex shapes.
- Coating – protective layers sprayed for corrosion and other forms of protection.
- Cutting – including sawing, oxy-cutting, plasma cutting, laser cutting and water jet cutting.
- Forming – bending presses to produce a camber are sometimes incorporated into beam lines.
- Joining – bolted and riveted connections and welding.
- Machining – milling and other techniques to achieve the desired tolerances.
- Robotics – the use of computer-controlled machines to perform manual tasks.

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.

1.4 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

The Report relied 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. The extensive Triple Helix literature, particularly the work of Henry and Loet Leydesdorff was constantly in mind (Etzkowitz and Leydesdorff 2002; Etzkowitz 2007, 2008).

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. These capabilities are being developed in an increasingly digitised environment that provides context for the research commitment.

2.1 Adoption, application and use of digital technologies

Adoption and use of ICT applications has, in effect, changed the orientation of steel fabrication 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.

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.

It is expected that the “factory of the future” will be digitally driven, machine based, and seamlessly connected from the ordering process (probably on-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 provide an indication of this future scenario. Innovations in cold-formed steel for low rise structures is seen as a major opportunity. There are major issues, however in how new knowledge is transferred to industry for application and use.

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 Computerised Numerical Control (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.

The Institute advises that leading fabrication firms, equipped with state-of-the-art automated CNC fabrication equipment, 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.

The discussions and consultations for this project also indicated that there should be greater integration of the steel fabrication supply chain, enabled by information technology. Many have a vision for seamless integration across organisations and supply chain elements. Others 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.

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

2.2 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.

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

Code	Field of Research
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

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).

According to the ERA assessments, research excellence in the relevant FORs is spread widely across the university sector in the fields of 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.

Nonetheless, 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.

Research income

A profile of research income across relevant FORs for the period 2008-2010 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 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.

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.

ARC grants for steel fabrication related research

The Australian Research Council (ARC) has provided limited support for steel fabrication related research. Only 10 projects have been funded over the period 2010-2012. Most grants have been in the field of Civil Engineering (FOR 905).

Research outputs

Across the system, research outputs (books, book chapters, journal articles, and conference papers are concentrated in a relatively small number of disciplines. 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.

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, covering commercial sales and/or capital gains resulting from the commercialisation of research outputs, services, and intellectual property indicates a total of $50m had been generated over the period 2008-2010. This represents 0.6 per cent of research income.

Over the same period 50 patents had been registered in Australia, 42 in the US, 11 in Europe, 7 in Japan and 96 in other locations.

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.

2.3 Fabrication capabilities in Australian universities and research organisations

In Figure 1 below FOR codes are mapped to the manufacturing capabilities identified in the project brief and other capabilities identified as being relevant to the project. This assessment was validated in conversations and discussions with senior staff in Universities and Research Centres.

Figure 1: 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

Figure 2 was used as a basis for constructing a “capability map” across the university and research system and identification of specific capabilities within institutions.

Research excellence provides the foundation for a broader assessment of research capability relevant to steel fabrication and the extent of industry engagement with industry. Initial material relating to engagement was obtained from university websites and publications as well as contacts and referrals within the sector. This was followed by extended discussions and consultations with Pro Vice-Chancellors (Research), Directors of Industry Engagement, Deans, and Heads of relevant Schools/Centres/Departments.

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 2 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 collaboration and access to industry research funds.

Figure 2: Map of Steel Fabrication Research Capabilities at Australian Research Institutions

	Automation	Robotics	Additive Manufacture	Assembly	Coating	Casting	Cutting	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 across institutions in automation, robotics, coating, forming, joining, energy efficiency, architecture and design, and building and construction management (where universities offering AIB accredited courses are included). Only a few institutions, however, provide all capabilities relevant to steel fabrication. Universities that have a broad range of capability 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 (DMTI). The DMTI provides an example of the way in which capabilities can be aggregated and made available to an important industry sector. All universities and the DTMI

contributed to the research for this project through interview, consultation, and round table discussion. Site inspections were also undertaken.

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.

Summary comments on specific areas of capability follow. More detailed descriptions have been provided in the Appendix to the Report to the Department.

Automation and robotics

At the same time, the analysis in Figure 2 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. Sophisticated machinery and equipment used in steel fabrication comes with embedded OEM systems and there is a large supplier market of proprietary factory automation software and CAD/CAM systems. The challenge lies in integration of systems and training people to work with them to achieve their potential.

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). Eleven 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). Academic staff educated at The University of Sydney School of Engineering occupy prominent research and teaching positions in Australian universities and overseas.

Cold-formed steel has the ability to produce lightweight, strong, structures and is being used extensively in storage racks and warehouses, where there are risks of failure under load and seismic instability. It is also being used more widely in building and construction and there are several discovery research projects underway.

The popularity of cold-formed steel in construction has stimulated research into its wider use in low-rise construction (homes, retirement villages, prisons, country hospitals, and schools). Steel framed housing accounts for only 10-13 per cent of residential construction, but the proportion could be significantly higher through more innovative building techniques. In the United States, cold steel framing is being used for buildings up to 12 floors.

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. NASH has been working with The University of Melbourne and Swinburne University. NASH, with many SMEs among its members, has the capacity to bring this component of the fabrication sector into the research environment.

Assembly is also impacted by the adoption of steel detailing technologies and the use of Building Information Modelling (BIM). BIM technology has the potential to create major changes and improvements for design and construct delivery. The rapidly evolving field of BIM Management is driven by an ability to incorporate as much project information as possible in the one multi-layered virtual model.

Discussions and consultations for the research indicated that universities are taking an interest in BIM, principally in building and construction management programs, which tend to be located in business schools and management faculties. There appears to be little integration and cross fertilisation with engineering, architecture and design disciplines.

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 2013. 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.

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.

Automation and robotics have substantial potential in the casting sector. This relates to the low cost of robots (enabling early return on investment), increased system flexibility, workplace safety, facilitated product handling, ease of maintenance and conformance to safety standards related to heat and gas exposure. However, this project did not identify research projects being conducted in these areas.

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 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. There are strong collaborations with motor vehicle manufacturers, particularly the Ford

Motor Company. This research will continue notwithstanding a recent decision by Ford to close down motor vehicle manufacturing in Australia in 2016.

There are very few people doing research in structural steel in Australia. 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.

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.

Cutting

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.

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.

- ***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 battleships and 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. 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.

- ***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.

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/

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 has been leading collaborative research in coating technology with several universities as part of its development of the Colorbond® 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.

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.

Design, architecture

Architecture and engineering faculties have traditionally not been close in Australian universities. However, 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.

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. It may also provide a link with ICT research capability, where this is aligned with Business School missions.

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.

2.4 Access to facilities, machinery, and equipment

Several universities have acquired modern machinery and equipment for the purposes of research and education. These resources are also used in collaborative partnerships with industry. The recently opened Advanced Manufacturing Precinct at RMIT provides a leading example.

There is also substantial capability available to industry at the Advanced Manufacturing Centres at Swinburne and The University of Queensland, and at School of Materials Science and Engineering at The University of NSW.

A detailed description of capability across universities and research organisations was provided as an Appendix to the main report to the Department.

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. International producers are also establishing connections with Australian Universities to access capability. There is some strong *developmental* activity within SMEs.

Chinese company Baosteel has recently opened a Joint Research and Development Centre with four Australian universities (The University of Queensland, The University of New South Wales, Monash University and the University of Wollongong) The Centre will conduct research and provide innovative technologies in areas of interest to Baosteel.

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 majority of research work is in the areas of ironmaking and steelmaking, rolling and metalworking, metal coatings, polymer coatings and product applications.

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. The company has been collaborating with RMIT University to adapt Colorbond® steel to suit a South East Asia climate environment. High temperatures and tropical rain bring down a lot of atmospheric pollution.

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.

OneSteel’s research activities in most areas rely on *external* research organisations and many co-operative ventures are in place. 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.

Small to medium enterprises

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. Engineers and designers bring knowledge and skills to business through their education background and continuing contacts and informal alumni networks.

2.6 Gaps and shortfalls

The research identified the following gaps and shortfalls in industry relevant research:

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. Prominent researchers include Professor Peter Hodgson at Deakin University and Professor Geoff Brookes at Swinburne University.

In March 2012, Professor 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 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 (see http://www.deakin.edu.au/research/stories/2012/03/01/lee-hsun-lecture-award).

In February 2013 Professor Geoff Brooks was awarded the Association for Iron and Steel Technology's (AIST) John F Elliott Lectureship for 2013. The award honours the late Professor John Elliott of the Massachusetts Institute of Technology, a major figure in the history of process metallurgy. Professor Brooks is the first Australian born and trained engineer to receive this honour, which acknowledges his contribution to developing the science behind metal production, particularly that relating to steelmaking. The award involves delivering a lecture to engineering students at up to five leading international universities throughout the year (see http://www.swinburne.edu.au/chancellery/mediacentre/media-centre/news/2013/02/metallurgy-honour-for-swinburne-professor).

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.

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 little 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.

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 sustained 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.

Limited knowledge about university capability

Businesses and government often complain that they do not know the scope and scale of research and knowledge capability in universities and research organisations. They point to the absence of a 'front door' or single point of contact for industry. 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 now updating their websites to include a specific section on 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".

The research for this project indicated, however, that university websites are poorly constructed to communicate information that would be useful for industry, 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.

But it is by no means certain that improved websites and capability registers will enhance the level of engagement. 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 marketing "capability" using a consultancy/professional services model. These entities operate through a Technology Transfer Office or are assigned to a designated person/unit 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 generally the source potential new clients. There is also a process of checking and assessment concerning whether unsolicited clients meet the firm's business criteria.

3 Demand side issues

Previous parts of this Paper have focussed on the supply side. This section of the Paper draws attention to demand side issues.

3.1 Address low demand for steel in construction

The use of steel in commercial and residential construction in Australia 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.

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.

One of the issues encountered during the consultations process for the research was an absence of dialogue on steel fabrication matters across professional domains. There was evidence of considerable rivalry between professions.

There is also a plethora of professional organisations and industry bodies that seek to represent the interests of elements of the steel fabrication sector. This generates a multiplicity of views and makes it difficult to ensure that there is a coherent policy message in relation to the steel fabrication sector.

The Australian steel fabrication sector would benefit from an industry led Forum that brought together engineers, architects, industrialists and others concerned with and interested in the analysis, design, construction, research and other aspects relating to the innovative use of steel.

3.2 Raise the profile of design in the Australian innovation system

The opportunity for design innovation through the use of steel is not well developed and the link between design and technological innovation is not well developed. This contrasts with the increasing significance of design in innovation systems that has been established in the US, the UK, Europe and now Asia.

In late 2012 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). The Taskforce noted that 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.

An Emerging Australian Advantage: Design

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.

3.3 Create environment for strategic engagement

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. However, 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.

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 pursue collaborations in an *ad hoc*, piecemeal manner rather than developing a relationship strategy and structure (Perkmann and Salter 2012; Wright 2008).

The consultations for this project indicate that universities have been reluctant to approach industry engagement through a transactions/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.

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 strategic collaboration around capabilities through partnerships and joint ventures. The research for this project has identified a number of long term strategic collaborations between businesses and universities.

3.4 Strengthen university involvement in business networks

In Australia University Vice-Chancellors and senior executives are being invited to join the boards of business associations and councils as a basis for strengthening relationships between the university and industry. Senior staff are generally active in professional associations. These relationships are particularly strong where a Vice-Chancellor comes from a business background. Several Vice-Chancellors and Deans of Engineering and Business have close relationships with the steel fabrication sector.

Universities also offer Adjunct and other forms of honorary appointment as a way of tapping into industry capability for research and teaching. Properly managed, these appointments can have beneficial outcomes for a university and a business.

3.5 Develop SME research engagement models

It is clear form the research for this project, together with information form many reports and reviews, that small to medium enterprises have limited capacity to engage with research organisations – principally due to lack of scale, limited finance, and limited 'absorptive capacity.

Over the last several years there have been a number initiatives designed to engage SMEs more effectively with universities and research organisations, principally through, but not limited to the CRC program. Four broad models for SME engagement can be identified:

- SME clubs – inform SMEs about research activities taking place within a CRC, and to give them the opportunity, where appropriate, to participate either in the research work, and/or in the commercialisation of a technology.
- Incorporated consortia – a trust formed to represent the interests of a large number of SMEs who wished to be involved in the research of a CRC. A trust structure with limited liability, is a familiar commercial instrument to business and offers uncomplicated exit.
- Alliance models – an alliance is a way of building 'critical mass' for membership of a CRC. Experience indicates that alliance models require the pre-existence of a strong network (where there is a high level of trust), and financial input of third parties – either government or possibly an industry association.
- Contract models – a contract model can provide for SMEs to enrol as associate members of a CRC and to undertake contract work such as producing prototypes for laboratory evaluations and field trials. There is a view that the work is 'too close to market' at the expense of research commitment.
- Industry association models - an industry association becomes a member of the CRC, or an active participant. It becomes the conduit through which the transfer of research problems and outputs between the CRC and SMEs is undertaken. By engaging with the industry association, an SME is able to access the latest research or present problems needing solutions.

4 Establishing institutional and organisational capacity for collaborative research

The research and consultations for this project indicated strong support from within the academic and business community for establishment of a research, teaching, and training 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 key feature of such an institution would be effective *engagement* between industry and research.

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:

- A focus on materials and manufacturing technologies
- Strong ICT capability in production technologies
- Application and adoption
- A capacity to scale up and strengthen capability across universities

Several organisational and institutional options were canvassed including:

- A designated hub, or hubs, of capability linking research and industry
- A new cooperative research centre (CRC) for steel.
- A research association model
- An institution modelled on the Fraunhofer institute for production technology (ipt).
- Extending the role of the CSIRO future manufacturing flagship
- Establish a new collaborative centre of excellence (institute) for steel manufacturing process science and engineering.

These are discussed in turn.

4.1 A designated hub, or hubs, of capability linking research and industry

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. Fundimg is allocated on a competitive basis.

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. The financial returns from university involvement in technology parks and innovation precincts in Australia are not good.

Clusters and precincts can be important for business development, networking and collaboration among businesses, and between businesses and researchers. Venture investors like to have prospects in one place. A strong retail presence will work towards keeping people in the cluster. Success tends to be evolutionary, built around trust and working to specific objectives rather than the result of a formula or recipe.

4.2 A new Cooperative Research Centre (CRC) for Steel.

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 Science 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.

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.

An application for a CRC in the area of manufacturing innovation is being prepared, involving the participation of the CSIRO and a number of universities. It is not clear whether the proposed centre will address research and adoption issues identified in this research. It is noteworthy, however, that steel fabrication is an important industry in regional communities.

The CRC Program is very competitive and the option remains open to prepare an application for a Steel CRC in the next round.

4.3 A Research association model

There are several possible models that have achieved success in Australian and New Zealand 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.

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.

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

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.

4.5 Extending the role of the CSIRO Future Manufacturing Flagship

The CSIRO 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 the research for this project 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. Additional funding could be provided to lift the Flagship profile in steel industry research.

4.6 A new collaborative Centre of Excellence (Institute) for Steel Manufacturing Process Science and Engineering

A 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. They provide a model for thinking about university-industry-government collaboration in terms of building an organisation that can address applicable research, research translation and adoption, as well as industry modernisation in the steel fabrication sector.

During discussions about possible models, 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.

From this perspective, research funding should strike a balance between these areas of scholarship.

A commitment to ongoing viability and sustainability would require that the Budget should be $4-5m per year over 7-8 years ($28m to $40m). The design of these institutions is addressed in the extended Research Report.

5 Conclusion

There have been many reports, papers and articles that promote and advocate greater interactions between universities and business. Perceptions about industry take up of university research 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.

Australian universities generally take the view that they have been established principally for the purposes of teaching and research – not to promote economic or industry development. However, universities will embrace industry engagement where it makes a contribution to achieving objectives set internally by governing boards, is consistent with the criteria of funding agencies, and is financially attractive. At the end of the day, engagement with industry has to be a 'good business' proposition.

For success and sustainability in the steel fabrication sector, businesses must find new customers, develop new products, with better materials. They must find pathways to market for an Australian solution. Research will be undertaken where it can be related to making high value products and improved manufacturing processes around a strong business case. The larger steel fabricators and a small number of SMEs do invest in research, and understand the benefits. But collaborative research with universities is necessarily long term and sometimes difficult to negotiate.

The research for this project indicates that research capability relating to steel fabrication is thinly spread, but there are important collaborations with larger businesses. There are also potential models to explore for engaging with small to medium businesses.

Building research capacity and capability takes time, commitment, resources *and* organisation. Cooperative and collaborative models such as the Cooperative Research Program provide stability and long term commitment. A Steel CRC would provide a sound basis for building research capability – but an organisation that reflects the unique characteristics of research, development, and application in the steel fabrication sector would be more appropriate (as discussed in Section 4).

The research for this project demonstrates that effective research collaboration involves a strong commitment on the part of executive leadership within both universities and companies – large ad small. Collaborations must also be centred around the existence of a capability within a university and a capacity to absorb on the part of business. Often this means having skilled and educated engineers, with a willingness to follow and adopt new ideas and knowledge at senior levels within businesses.

The issues that must be addressed in building capability for sustained university collaboration with industry in the steel fabrication sector can be summarised as follows:

- *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.
- *Maintaining capability*: Although research in the traditional areas of manufacturing engineering and technology is not well 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.
- *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.
- *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.

It is critical that these issues are addressed in a way that involves the active participation of industry, industry and government. The Triple Helix Framework provides some foundation, and its focus on institution building makes an important contribution to achieving outcomes that create value for all participants.

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