

# **Strength of Partnership as a Key Factor in Collaboration between Universities and Industry for Production of IP: A Study of Applications to the BHERT Awards**

**Leon Mann**

Centre for R&D Leadership, Faculty of Medicine, Dentistry and  
Health Sciences

The University of Melbourne

**Intellectual Property Research Institute of Australia**

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Intellectual Property Research Institute of Australia

The University of Melbourne

Law School Building

Victoria 3010 Australia

Telephone: 61 (0) 3 8344 1127

Fax: 61 (0) 3 9348 2353

Email: [info@ipria.org](mailto:info@ipria.org)

[www.ipria.org](http://www.ipria.org)

## Abstract

The study reported in this Working Paper examines the association between strength of relationship between partners in R&D collaborations and the amount or quality of innovation. Three hypotheses were tested: First, the stronger the relationship between partners in collaboration, the greater the innovation. Second, the longer the duration of the collaboration, the stronger the relationship and the greater the innovation. And third, the fewer the number of partners in the collaboration, the stronger the relationship and the greater the innovation.

The three hypotheses were tested with data from a sample of 84 R&D collaborations submitted for annual awards to the Business-Higher Education Round Table, 1999-2004, in three categories: general collaborations (n=53), international collaborations (n=12), and collaborations involving a Cooperative Research Centre (n=19). There was evidence to support all three hypotheses, although in the case of CRCs, the predicted effect of number of partners was not found. The findings demonstrate the importance of social-structural factors— number of partners, duration of partnership, strength of relationship— as contributors to innovation as well as the importance of taking type of collaboration into account when analysing these factors. The findings have implications for policy and practice, and especially for the facilitation of effective R&D partnerships between universities and industry.

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## **I) INTRODUCTION**

This Working Paper reports a study of factors associated with the production and commercialisation of IP from Research and Development projects involving partners from industry and higher education.

Several questions guided the overall study. How does the strength of the partnership relate to the quantity and significance of the IP? Is the partnership strength and innovation quality different when there are complex partnerships involving multiple partners located in different sites and countries? Is there evidence that trust based on previous successful partnership helps create a platform for new, more ambitious and successful collaborative initiatives? How long does it take to establish a strong partnership, and is there evidence that long-term collaborations produce superior innovation? The focus of this Working Paper is the key proposition that the strength of the partnership between partners in collaborative R&D is significantly related to innovation and the production of IP.

Collaboration involves a partnership, alliance or network aimed at a mutually beneficial, clearly defined outcome ( McGauchie, 2004). There are different forms of collaboration between firms, including joint ventures, R&D contracts or technology exchange agreements, and strategic alliances. Increasingly, universities and public research organisations have become partners with industrial firms in an array of R&D collaborations. In Australia, many industry-university collaborations are supported by Commonwealth or state grants (such as R&D Start, COMET, etc) and many involve public research organisations such as CSIRO, DSTO, and the Cooperative Research Centres (CRCs). The McGauchie Committee Review (2004) focused on collaboration between universities and the four major public funded research agencies in Australia: CSIRO, DSTO, the Australian Nuclear Science and Technology Organisation, and the Australian Institute of Marine Science.

Many collaborations between industry and universities include one or more of the public research agencies. Partnership and collaboration between industry and universities becomes more complicated when a range of organisations with a variety of missions, interests, and organisational cultures are involved. Accordingly, it is important to identify and take into account different kinds of inter-organisation partnerships and structures when examining the relationship between strength of collaboration and innovative outcome.

### **The Collaboration Imperative**

In many countries, there has been a growing recognition of the importance of research collaboration between universities and industry for national innovation. In the United Kingdom, Lambert (2003) authored a landmark report in which he argued for greater business-university collaboration for improved national innovation performance and knowledge transfer. He identified lack of clarity over the ownership of IP as a major impediment to research collaborations (Lambert 2003, p.4). He recommended, *inter alia*:

- the introduction of a new funding stream for business-relevant research;
- the encouragement of new forms of formal and informal networks between business people and academics
- the development of model contracts;
- an IP protocol to speed up commercialisation;
- the development for universities of a code of governance and good management for research and innovation; and
- a greater role for Regional Development agencies in facilitating knowledge transfer.

The final point in the Lambert Report speaks to the issue of the necessity of building a strong partnership between industry and universities for national innovation performance:

Companies and universities are not natural partners: their cultures and their missions are different. Universities and governments also find it hard to work together. Academics value their freedom and independence, resent their reliance on public funding and feel their efforts are not properly appreciated. ...There are benefits to be gained for business, the universities, and the economy as a whole by improving communications and developing a more trusting approach by all those involved. (Lambert, 2003, p.14)

In Australia, there have been several reports commissioned by the Department of Education, Science and Training (DEST) and by the Australian Research Council on the importance of fostering effective university-industry partnerships in research and innovation, noting some of the many issues that interfere with good collaboration (Cripps, et al., 1990; Turpin, et al,1999; McGauchie, 2004).

### **Barriers to collaboration and obstacles to successful collaboration**

A distinction must be made between factors that act as *barriers or blocks* to an interest in collaboration between organisations from different sectors, and the factors that act as obstacles to successful collaboration following the establishment of a research partnership. We consider the collaboration barrier and obstacle factors together because they are closely linked. A factor that is a *barrier* to university-industry collaboration (for example, a university researcher invited to participate in a collaboration who questions the value of industry research) can also become an *obstacle* to successful collaboration if not resolved (the university researcher, having joined the project, loses interest after the first experimental results confirm little scientific value, although potential commercial value).

### **Barriers to an interest in collaboration between industry and universities**

Turpin, Aylward, Garrett-Jones, Speak, Grigg, and Johnson (1999), in their Report on university-industry research partnerships, noted a “faculty culture” in which many university researchers question the value of industry-based research. In the DEST

Review of closer collaboration between universities and major publicly funded research agencies, McGauchie (2004) identified four barriers to collaboration: structural requirements imposed through legislation, regulation, procedural rules and constraints (such as security policy); differences in organisational culture and values, including the management of Intellectual Property; differences in career-related promotion/advancement practices across organisations; and geographical location and physical separation.

McGauchie (2004) noted also that the management and application of IP are seen as significant barriers to university partnership in R&D collaborations. The issues include IP ownership, contract disputes, over-valuation of IP, and the over-emphasis on revenue returns on investment.

### ***Obstacles to successful collaboration, and why many collaborations fail***

A survey of Business-Higher Education Round Table (BHERT) members by Mann, Chatfield, Bain and Pirola-Merlo (1996) examined reports from 17 universities and 10 companies in response to the question, “What do you regard as the critical success factors in three of the best industry-university linkages you have experienced...and what are the greatest obstacles to collaboration?” The most frequently reported success factors in collaboration from the industry perspective were: good planning, personal contact, understanding the partner’s needs, and good researchers. From the university perspective, the success factors were: personal contact; understanding the partners’ needs, integration of expertise, and flexibility.

With regard to obstacles to the collaboration, the most frequently cited by both industry and university respondents was the failure to understand the partner’s needs. Respondents pointed to the different aims of industry (commercial objectives) and universities (academic objectives), and to disagreements between industry-university partners over rights to intellectual property and publishing. The second most frequently identified obstacle was difficulty in maintaining the collaboration, with industry respondents pointing to the inflexibility of university bureaucracy and the

non-reliability of university collaborators, while university respondents pointed to the competing pressures of research and teaching and difficulties in meeting project milestones that occur at inconvenient times in the academic calendar. The third most common obstacle identified by industry respondents was poor planning, while for university respondents it was gaining access and close proximity to equipment, infrastructure, and personnel.

While the two sectors have similar and overlapping ideas about factors important for successful collaboration, there is a clear difference in emphasis, with industry much more concerned with good planning at the beginning to ensure clear agreement on time-lines and budget, whereas universities are also interested in maintaining flexibility in the agreement. Clearly, a strong relationship between industry and university partners in collaboration is dependent upon the partners communicating and arriving at a mutual understanding of how they will work together. We assume that legal instruments and contracts, without establishment of prior trust, cannot guarantee effective cooperation between partners. Hence, personal contact and understanding the partners' needs are high in the list of success factors recognised by industry respondents and university respondents. (See discussion of the "trust-building" and "ground rules" perspectives on R&D collaborations, below).

In their report for the Australian Research Council, Cripps, Yencken, Coghlan, Anderson and Spiller (1999) focused on technology transfer and commercialisation practices in university-industry research. They noted several major issues affecting the success of university-industry collaborations, for example: the importance of the parties having a shared understanding of the research objectives; the time required for relationships to develop, and the greater success of longer term relationships; the level of commitment of senior researchers in providing leadership; the focus of business on research outcomes and completion of work; and the role of the university research/legal office in providing a better service to researchers, especially during the contract negotiation phase of a collaboration. Cripps *et al* (1999) also noted that

industry partners often found contract negotiations with universities complex and time-consuming.

In sum, government reviews in UK and Australia point to the importance of university-industry collaboration for national innovation performance, but invariably note the barriers to establishing a collaboration, and also the obstacles to maintaining an effective collaboration.

## **II) THE PRESENT STUDY**

The present study builds on previous Reviews and Reports. The Working Paper addresses the question of what enables university researchers and industry representatives to establish and maintain effective collaborations to produce IP. The contribution of the study is that it examines data from a large sample of projects and draws conclusions about the significance of a strong partnership and the effects of different types and structure of research collaboration, number of partners, and duration of collaboration for successful innovation and production of IP (cf Dodgson, 2000).

### **Study methodology**

The study draws on a sample of 84 R&D collaborations between industry and universities in Australia between 1999 and 2004. Beginning in 1998, the Business-Higher Education Round Table of Australia (BHERT) established an annual program of awards to recognise achievement in collaboration between industry and higher education in R&D. Applications were invited in several categories: collaborations that had been established within the previous three years; collaborations that had been established for more than three years; collaborations involving an international partner; collaborations involving a Cooperative Research Centre; and, more recently (from 2004 onwards), collaborations with a regional focus.

In each year, BHERT received approximately 20 detailed applications for the awards. Each application contained information about the nature of the industry-university partnership (e.g., number of partners, when established) and the kinds of IP achieved. (e.g., patents, license agreements, technical reports, and new products). Some of these collaborations involved Cooperative Research Centres (CRCs), comprising a large group of industry and university partners with a strong industrial research focus, and a mission to produce commercial IP and spin-off companies. Some involved public research agencies, such as the CSIRO. Others were small-scale partnerships based on a professional link or friendship between two people, one located in a university and the other in a small company.

### **Evaluation of collaborations on strength of relationship**

Each submission for a BHERT award requires applicants to describe the project/program and address how the project meets the five criteria used by the judging panel to rate the excellence of the project. The five criteria are: innovation; strength of the relationship between collaborating partners; outreach inclusion (for example to other groups, other companies, and overseas); national economic and social benefits; and cultural impact on the partner organisations. Innovation and strength of relationship were identified as follows in the application form:

**Innovation:** Has the project or program produced new products or services?  
How innovative is it in its concept or idea, design, delivery or content? What new barriers has it surmounted? What new challenges has it surmounted?  
What new challenges has it identified?

**Strength of relationship:** (a) What is the extent of involvement of the partners? (b) How has this grown over the life of the project or program? (c) How do the partners work together in a productive partnership? (d) What other spin-offs have there been from the project or program for participating organisations?

The judging panel, with members drawn from R&D organisations, higher education, and government agencies, rated each submission independently on a scale of 1-5 on each of the five criteria. The panel secretary recorded the ratings. The panel then met to compare ratings and decide on the award-winning programs/projects. In making that decision, the panel weighted innovation (the signature criterion) and strength of relationship (the enabling mechanism) most heavily.

When assessing the strength of the relationship between collaborating partners, the panel looked for evidence of a strong relationship between partners working together as a team to define and scope the project, and contribute useful ideas and resources (in contrast to sponsored or outsourced research, which was the case in several applications). The evidence included regular contacts and meetings, shared resources, and joint collaboration on other projects and activities. The panel also took into account whether the links had strengthened over time, whether obstacles had been overcome, and even, as a minor piece of evidence, whether partners had made the effort to co-sign the submission.

With regard to innovation, the panel was interested in the quality and quantity of the IP generated. The panel took into account the novelty and usefulness of the new product, program, or service, and the inventiveness of the concept, design and delivery, as well as evidence of commercial success and other beneficial outcomes. This included a record of new products, technical reports and journal articles, and securing IP rights through patents, trademarks, and licensing agreements.

The aggregated panel ratings of the strength of relationship and of innovation for each project application can be used to test a range of hypotheses. These include the simple prediction that the strength of the relationship between partners is significantly related to the quantity and quality of IP. Other hypotheses that can be tested by the BHERT data include the prediction that the greater the number of partners, the more difficult the challenge of maintaining effective collaboration, and accordingly the lower the quality of IP (alternatively, it could be argued that multi-partner

collaborations are necessary for some kinds of breakthrough technological innovations), and the longer the duration of the collaboration the stronger the relationship and the better the innovation.

To sum up, the data for hypothesis testing are ratings used as surrogate indicators of both the strength of the relationship (a panel rating of 5 signifies a very strong relationship in which each partner contributes) and the quality of innovation (a panel rating of 5 signifies a highly innovative project that has produced or is producing substantial intellectual property). In addition, to illustrate the links between strength of relationship and innovation, several examples of award-winning collaborations will be described in the body of the Working Paper and in the Appendix.

### **Three types of collaboration in the present study**

The 84 collaborations were grouped into three main categories for purposes of this study:

- General (n=53). Partnerships between Australian universities and Australian companies; Sixty-eight percent of the collaborations in this category (36/53) were partnerships between one university and one company. An example is the partnership between the University of Technology, Sydney and MicroMedical Industries Ltd in the development of the VentrAssist Implantable Rotary Blood Pump. The remaining collaborations in this category involved three or more partners and as many as eight. An example is the partnership between Central Queensland University and six companies—HortiCal Pty Ltd, The Harvest Company Pty Ltd, Horticulture Australia Ltd, Integrated Spectronics Pty Ltd, Applied Horticultural Research Pty Ltd, and Colour Vision Systems Pty Ltd—in the development of a new class of fruit.
- International (n=12). Partnerships between Australian universities and overseas companies. An example is the partnership between Australian National University and Volvo (Sweden) in the development of a video-based sensor device for tracking driver attention and vigilance. Several

collaborations in this category involved as many as six partners. An example is the research partnership between Curtin University of Technology, five Australian companies and one French company (Sanchez Technologies) in LNG Micro-Cell Technology. There were no cases involving an overseas university and an Australian company

- CRCs (n=19). Partnerships in which a Cooperative Research Centre (CRC) was the main participant. An example is the partnership formed under the organisational structure of the CRC for Polymers between three universities— Monash University, RMIT, and UNSW, two public research organisations— CSIRO and DSTO, and one company - Olex, to research and develop a new product, Pyrolex Ceramafiable. Another example is the AJ Parker CRC for Hydrometallurgy, which listed three universities and twelve companies, a CSIRO division, a mining industry association, and a government department (the Department of Minerals and Energy) as partners in the collaboration. Several CRCs were also involved in international collaborations. The rule was to assign them to the CRC category rather than the international category

It is sensible to analyse the data on collaborations by different categories. The challenges differ between a small-scale collaboration involving a university department and a local company in the same city, and a multinational organisation located in Sweden in partnership with a university centre located in Canberra. CRCs, established under a government scheme to link university and industry research, have their own structures, procedures, and challenges.

### **III) FINDINGS OF THE STUDY**

#### **i) How strong is the relationship? How innovative are the outputs?**

**Table 1 (a)** presents the mean strength of relationship and innovation ratings for the sample, as well as the range from lowest to highest in each category.

**Table 1 (a)**

**Strength of Relationship and Innovation Ratings and Correlations between Strength of Relationship and Innovation by Type of Collaboration**

Type of collaboration	Relationship	Innovation	Correlations
<b>GENERAL n =53</b>	<b>3.7</b> <b>range 2.4 – 4.8</b>	<b>3.5</b> <b>range 2.3 – 4.8</b>	<b>r = .37</b> <b>p&lt; .01</b>
<b>INTERNATIONAL n = 12</b>	<b>4.0</b> <b>range 3.3 – 4.8</b>	<b>3.8</b> <b>range 3.0 – 4.6</b>	<b>r = .43</b> <b>p&lt; .10</b>
<b>CRCs n = 19</b>	<b>3.6</b> <b>range 2.0 – 4.5</b>	<b>3.9</b> <b>range 1.7 – 4.8</b>	<b>r = .77</b> <b>p&lt; .01</b>

**Table 1(a)** shows that mean ratings were quite high- in the mid to high 3s- for strength of relationship and innovation. However, mean strength of relationship did not differ greatly across the three categories (General 3.7; International 4.0; CRCs 3.6). The CRC ratings might seem odd, but note that stricter criteria was used in assessing CRCs on strength of relationship, as CRCs are established on the foundation of negotiations and agreements between multiple partners. There were, however, some small differences in mean innovation ratings across categories, with general (3.5) lower than international (3.8) and CRCs (3.9).

**ii) Does duration of collaboration make a difference?**

In the analysis in **Table 1(a)**, the 53 general collaborations were pooled into a single category. BHERT had invited applications in two sub-categories: Projects or Programs in train for less than three years and for more than three years. The BHERT rationale was that greater innovation should be expected from collaborations that have existed a longer time.

**Table 1 (b)**

**Strength of Relationship and Innovation Ratings in General Collaborations less than and more than three years duration**

Type of collaboration	Relationship	Innovation	Correlations
<b>GENERAL LESS THAN 3 YEARS n = 21</b>	<b>3.4</b> range 2.8 – 4.5	<b>3.3</b> range 2.3 – 4.3	<b>r = .01</b>
<b>GENERAL MORE THAN 3 YEARS n = 32</b>	<b>3.9</b> range 3.0 – 4.8	<b>3.7</b> range 2.7 – 4.8	<b>r = .45</b>

**Table 1(b)** presents a finer analysis of the 53 general collaborations, splitting them into partnerships that have existed for fewer than three years (n=21), versus partnerships that have existed for more than three years (n=32). The analysis in **Table 1(b)** provides evidence that duration of the collaboration is indeed an important factor in strength of relationship and innovation. The older (and, therefore, better established) collaborations rated higher than the newer on strength of relationship (3.9 versus 3.4) and on innovation (3.7 versus 3.3). This is an important finding, as it underlines the point that it takes time for partnerships to build strength and deliver innovations.

### iii) Looking for excellence

The BHERT awards refer to “outstanding achievement” in collaborative R&D. The mean ratings in **Tables 1(a) and 1(b)** are a field of mid to high 3s, conveying an impression of general competence rather than indications of excellence and achievement. Another way to analyse the data is to identify the number/percentage of high rating collaborations in each category to give focus to the top end of the continuum. Tables 2(a) and 2(b) show the number (percentage) of collaborations rated 4 or better in each category.

**Table 2 (a)**

Percentage of 4+ ratings of relationship strength and innovation by types of collaboration

Type of collaboration	Relationship strength	Innovation	Relationship and Innovation
<b>GENERAL</b> n= 53	21 / 53 = 40%	12 / 53 = 23%	9 / 53 = 17%
<b>INTERNATIONAL</b> n= 12	8 / 12 = 67%	4 / 12 = 33%	4 / 12 = 33%
<b>CRCs</b> n= 19	5 / 19 = 26%	10 / 19 = 53%	5 / 19 = 26%

**Table 2(a)** shows that 40 percent of general, 67 percent of international, and 26 percent of CRC-linked collaborations rated 4 or better on strength of relationship, and 23 percent of general, 33 percent of international, and 53 percent of CRC-linked collaborations rated 4 or better on innovation. The final column shows the number/percentage of collaborations rated 4 or better on *both* strength of relationship and innovation. Altogether, 18 of the 84 applications rated four or better on *both* relationship and innovation: 17 percent of general, 33 percent of international, and 26 percent of CRC applicants. Thus, as expected, the international and CRC-linked collaborations had a greater number of “stars” than the local, small-scale collaborations, presumably because of the additional care, preparation, and investment involved in establishing cross-national and CRC partnerships.

**Table 2 (b)**

**Percentage of 4+ ratings on relationship strength and innovation in general collaborations less than and more than 3 years duration.**

Type of collaboration	Relationship strength	Innovation	Relationship and Innovation
<b>GENERAL LESS THAN 3 YEARS</b> n = 21	4 / 21 = 19%	2 / 21 = 10%	1 / 21 = 5%
<b>GENERAL MORE THAN 3 YEARS</b> n = 32	17 / 32 = 53%	10 / 32 = 31%	8 / 32 = 25%

**Table 2(b)** splits the general collaborations into less than three years and more than three years. The analysis shows that only one of the 21 (5 percent) newer collaborations rated 4 or better on *both* relationship and innovation, while eight of the 32 (25 percent) older collaborations rated 4 or better on both. These collaborations were invariably award winners and Honourable Mentions. The important message from the analysis in table 2(b) is that strong relationship and high innovation is seldom found in early collaborations. It takes time for partnerships to mature and deliver innovative outcomes. Much can be learned from analysing the strength of such partnerships and the kind and quality of innovation produced. Examples will be given below in Section V, and in the Appendix.

To conclude, the highest rated collaborations occurred among the CRCs and international collaborations. This first finding makes sense, as CRCs are large R&D organisations that put structures and processes in place to manage the complex relationships necessary to undertake major innovative projects. For international collaborations to survive there must also be sound structures and procedures in place. When organisations separated by national boundaries even attempt a complex collaboration, they must prepare and reach agreement on the scope of the project, and on how partners will work together. Companies and universities in two different countries are not likely to attempt joint R&D unless they have the fundamentals of a sound working partnership. Indeed, in some industries, such as biotechnology and pharmaceuticals, a strategic alliance between laboratories and firms in international

and global technology networks is the entry requirement for radical innovation (cf. Dodgson 2000).

Furthermore, the duration of the collaboration is a significant factor, contributing to the strength of relationship and to the level of innovation. This finding points to the importance of tracking collaborations longitudinally from the time of establishment to understand the stages and critical periods the partners encounter, as they learn to work together, overcome obstacles, and build confidence and trust.

### **Testing the relationship between strength of relationship and quality of innovation**

The prediction was that the stronger the relationship, the higher the innovation, on the premise that good coordination and communication are prerequisites for performing innovative work. The assumption was that a good relationship between partners is a necessary but not sufficient condition for creative collaborative R&D. In general, that was the case, with some exceptions. There were two cases in which a weak relationship resulted in substantial innovation. However, in both cases the partnership was not a genuine collaboration, but sponsored research in which a company outsourced a project to a university.

**Tables 1(a) and 1(b)** show that the stronger the relationship, the greater the innovation (as rated by the panel). The correlations are significant or approach significance in each category: for general collaborations ( $r=.37$ ,  $p < .01$ ); for international collaborations ( $r= .43$ ,  $p < .10$ ); and for CRC-linked collaborations ( $r = .77$ ,  $p < .01$ ).

The effect of the duration of the collaboration on the link between partnership and innovation is quite striking. As **Table 1(b)** shows, there is virtually no correlation between strength of relationship and level of innovation in the sample of  $n=21$  newer collaborations ( $r=.01$ ). However, the correlation between strength of relationship and amount of innovation in the sample of older collaborations is significant ( $r=.45$ ,

$p < .01$ ). A conclusion from these findings is that the first year or two of collaboration is a time of relationship building, when the promise of innovation is still to be realised. As the collaboration matures, the partnership strengthens, and the level of innovation increases. This establishes a dynamic link in which a stronger partnership provides the platform for greater innovation, and successful innovation provides the reinforcement for stronger partnership. Because the sample is small, we have not analysed the international and CRC linked collaborations by duration of collaboration. However, we assume that the same dynamic link between stronger partnership and greater innovation over time would also hold for these collaborations.

In interpreting correlations between two variables, such as strength of partnership and level of innovation, it is important to keep in mind that the link is not perfect. One is not the mirror of the other. There were many examples of projects with good partnerships and sound innovation. However, there were also exceptions, such as substantial projects where a solid partnership had produced only modest innovation, at least at the point where it was assessed by the BHERT panel. It is tempting to postulate a direct, causal relationship between strength of partnership and innovation, but there are other pathways and possibilities. For example, the relationship, as suggested above, could be reciprocal, with a sound collaborative partnership laying the foundation for quality innovation, which in turn builds the scaffolding for a stronger partnership, and so on. Alternatively, the relationship could be due to extraneous factors, such as a dedicated University Research and Innovation Office, which acts as broker to nurture a sustainable partnership between a university laboratory and a local R&D company. Close analysis of innovative projects on a case-by-case basis is needed to tease out the nature and direction of the pathways between strong partnership and quality innovation.

In conclusion, a strong collaborative partnership is a significant factor contributing to innovative R&D performance, although there are many factors that contribute to innovation, such as the quality of project leadership, the skills and expertise of the researchers (designers, production, marketing etc), adequacy of resources, reliability

of management support, and the innovation culture of the organisation (cf. Mann, 2005).

In the next section, we examine whether the number of partners in the collaboration makes a difference to the strength of the relationship and the quality of innovation.

### **Complex collaborations: does number of partners make a difference?**

The number of partner organisations in a collaboration is of interest, because it is reasonable to expect that the greater the number of partners, the more difficult the task to build strong relationships and maintain sound communication and coordination. While every collaboration is a challenge, we would expect that a dyadic partnership between a university and a company would be easier to establish and maintain than a multi-partner collaboration involving, say, two universities and three companies. **Table 3** presents data on the number of partners in the collaboration, and the effects on strength of relationship and innovation.

**Table 3**

**Number of partners and ratings of strength of relationship and innovation by type of collaboration**

Type of collaboration	Number of Partners	Relationship strength	Innovation
<b>GENERAL</b> n= 53	<b>Two (n = 36)</b>	<b>3.8</b>	<b>3.7</b>
	<b>Three plus (n = 17)</b>	<b>3.4</b>	<b>3.3</b>
<b>INTERNATIONAL</b> n = 12	<b>Two (n = 6)</b>	<b>4.1</b>	<b>4.1</b>
	<b>Three plus (n = 6)</b>	<b>3.9</b>	<b>3.5</b>
<b>CRCs</b> n = 19	<b>Two-Five (n = 9)</b>	<b>3.4</b>	<b>3.8</b>
	<b>Six-Ten (n = 8)</b>	<b>3.7</b>	<b>3.9</b>
	<b>Eleven plus (n = 2)</b>	<b>4.1</b>	<b>4.1</b>

Most of the general collaborations (36/53 = 68 percent) were single university-single company partnerships. The other 17 ranged from three to six partners. Most of these multi-partner collaborations (14/17) involved a single university with several companies or government departments, councils, professional associations or industry bodies. Only 3/17 multi-partner collaborations involved several universities and several companies.

Half of the international collaborations (6/12) involved two partners, the other half three or more partners. Finally, consistent with their organisational structure, CRCs always involved more than two partners, and approximately half (10/19 = 53 percent) involved more than six and as many as 18 partners.

There is evidence that number of partners had an effect on the strength of the relationship and the quality of the innovation, especially among the general and international collaborations. As **Table 3** shows, in the sample of 53 general collaborations, the two-partner collaborations had higher ratings of strength of relationship and innovation than the multi-partner collaborations (3.8 versus 3.4, and 3.7 versus 3.3 respectively). Similarly, in the sample of 12 international collaborations, the two-partner collaborations had higher ratings of strength of relationship and innovation than the multi-partner collaborations (4.1 versus 3.9, and 4.1 versus 3.5 respectively). Only in the sample of 19 CRC collaborations was there a different pattern. As table 3 shows, there was a trend for large multi-partner CRCs to have higher ratings on strength of relationship and innovation than the smaller CRC partnerships. The dynamic at work in the CRC collaborations may have something to do with the kind of industry sector to which the CRC belongs, and the ability of the industry to speak with one voice. For example, the award winning A.J. Parker CRC for Hydrometallurgy, with 18 partners, was a research arm for the Australian mining industry.

To sum up, three hypotheses were tested by data analysed from the BHERT sample of 84 R&D collaborations for 1999-2004. First, the stronger the relationship between

partners in a collaboration, the greater the innovation. Second, the longer the duration of the collaboration, the stronger the relationship and the greater the innovation. Finally, the fewer the number of partners in the collaboration, the stronger the relationship and the greater the innovation.

There was evidence for all three hypotheses, although in the case of CRCs the opposite of the predicted effect of the number of partners was found. The findings, together, demonstrate the importance of social-structural factors as contributors to innovation— number of partners, duration of partnership, strength of relationship- as well as the importance of taking into account the type of collaboration when analysing these factors. The findings, although not surprising, have implications for both policy and practice, and especially for the most frequent collaborations, the partnership between one university and one company.

In the following section, examples will be given to illustrate a strong relationship and how it relates to excellence in innovation in each of the three categories of collaboration

#### **IV) Some limitations of the BHERT applications data for testing hypotheses about collaboration and innovation**

The evidence and examples presented in this Working Paper support the main hypothesis of a significant link in which strong partnership goes together with excellent innovation across all types of R&D collaboration. However, several caveats are in order.

First, the data for testing and illustrating the link between strength of partnership and quality of innovation is drawn from applications to the annual BHERT round of awards for outstanding collaboration in R&D between universities and industry. However, the sample is not representative of the many R&D collaborations that take place between Australian industry and universities. While virtually all Australian universities are members of BHERT and are therefore eligible to apply for the award,

very few Australian R&D companies are members. Moreover, not all universities or member companies make the effort to apply for the award. Therefore, the sample represents only a small percentage of the large number of collaborative R&D projects undertaken between industry and universities each year. The applications are likely to come from the top end of the spectrum, not across the entire distribution of collaborations. The weakest collaborations are unable to muster the interest to apply. Therefore, any application of the findings to the universe of R&D collaboration must be made with caution.

Second, the award applications do not tell the whole story of the nature of the collaboration, the obstacles encountered and overcome, and the- sometimes painful experience in managing and allocating ownership of IP. The submissions were written by investigators putting a case to win a prestigious annual award. They were not written to provide data for a study of the relationship between partnership and innovation. Thus, there are limitations in the accounts that provide the data that are the basis for testing the key hypotheses.

Third, many of the new collaborations were essentially projects-in-progress. The nature of the relationship in new collaborations is at an earlier stage than in mature, well-established collaborations of over five years. Correspondingly, the amount of IP and commercial outcomes produced by new collaborations is less. This is not a retrospective study in which completed collaborations are examined for the strength of the collaboration and the amount and quality of IP produced. Thus, for some collaborations in the study, the story is more about the promise of innovation than about IP achieved and applied.

Fourth, panel ratings of the information in each submission were used to identify the strength of relationship and quality of innovation. While there is confidence in the panel's judgment and the reliability of its ratings (as evident by very high correspondence between independently made ratings), there is also the potential for "same-source bias" in ratings of the two key variables- relationship strength and

innovation quality. Put simply, there may be a predisposition for raters to assume that an outstanding innovation must be due to a strong relationship between partners, and therefore be influenced by a kind of halo-effect when making their ratings of the relationship. The problem of using same-source ratings when testing an association between two variables is the risk of an inflated estimate of the true association. While the correlation between strength of relationship between partners and quality of innovation was positive and significant, some of that association could be due to “same-source bias” by the raters.

A final point is that university-industry collaborations are a major challenge, require careful management, and many do not succeed. In the BHERT awards sample, we were looking at submissions and therefore data from collaborations that were still standing. Much of the evidence to provide a stronger test of the association between partner relationship and innovation may have been sitting in university and company filing cabinets containing records of failed and prematurely terminated research collaborations. Access to accounts of flawed and failed collaborations would provide a richer basis for understanding the factors conducive to strong relationships and excellent innovation.

## **V) Examples of strong collaboration and high quality innovation**

In this section, three award-winning R&D projects (all double 4 pluses) are briefly described to illustrate what the partners do to create strong partnership and, in turn, innovation. The projects are examples of different forms of R&D collaboration producing different kinds of IP. For example, the VentrAssist Implantable Rotary Blood Pump project with UTS and MicroMedical Industries Ltd as partners is an example of a partnership that grew in small steps with support from government funding schemes into a mature collaboration yielding substantial IP. The Vision-Based Human-Interaction Machine Project, initiated when Volvo (Sweden) approached ANU to conduct basic research on vision-based sensors, grew in to a

successful spin-off company with Volvo and ANU as equity shareholders. The Pyrolex project is an example of a multi-partner collaboration established under the structure of a CRC. The project was initiated when Olex, the industry partner, saw the need for a superior cable that would perform under extreme temperatures. The three projects, although structured differently, illustrate the importance of strong relationships for the production of high quality innovation.

**VentrAssist Implantable Rotary Blood Pump: University of Technology Sydney and MicroMedical Industries Ltd. (Chatswood NSW)**

This collaboration won a BHERT award in 2001. The project was the development of VentrAssist, a ventricular assist device implanted in parallel with the left ventricle to help pump the blood of patients with congestive heart failure. Two US patents and one Australian patent were granted by 2001, with others pending. The novelty of the innovation is in the design, which puts motor magnets in thick, tapered impeller blades so that once the impeller begins spinning it glides on blood fluid bearings. VentrAssist is a cheaper, more reliable and longer lasting device than other rotary pumps, which use contact or magnetic bearings.

MicroMedical initiated the collaboration in 1996 when it approached UTS and suggested a joint ARC SPIRT grant. Applications to AusIndustry for an R&D START grant and to ARC for an APAI (Australian Postgraduate Award Industry) followed. At UTS, Dr. Peter Watterson, Senior Research Fellow, and Dr Geoff Hansley, Principal Research Fellow in the Faculty of Engineering, led the Motor team and Pump team respectively while Dr John Woodard, CEO, led the team at MicroMedical Industries. The three researchers were named as the co-inventors on patents for the VentrAssist device. Eight UTS staff worked on the project together with 26 staff from MicroMedical, which established a VentrAssist Division to develop the pump.

In 1996, the combined MicroMedical and UTS teams brainstormed the initial design. UTS staff worked to solve the problem of how best to incorporate the motor into the impeller. The first prototypes produced by UTS worked. The R&D START grant followed in 1998 and MicroMedical began substantial investment in the device. While UTS fine-tuned the motor and the magnets, MicroMedical moved the lab from Surry Hills (near UTS) to larger premises in Chatswood and took over development, manufacture, and testing of the design.

Dr Watterson observed: “The collaboration between the partners has been so close that at times people’s employer origins have been forgotten. Dr Tansley, though a UTS employee, worked 90 percent of the time at the MicroMedical laboratory.” He also observed that, “When MicroMedical moved its laboratory from Surry Hills to Chatswood the partners could no longer walk to meet each other. However, UTS members travelled by train to attend regular meetings”. The initial ARC collaborative grant contract stipulated equal ownership, but this was changed later due to MicroMedical’s greater financial investment in the pump development. In 2001, the two parties signed a mutually agreeable licence agreement.

Keys to this successful collaboration include: complementary expertise (UTS’s knowledge in advanced engineering and MicroMedical’s in technology transfer and product testing and development); growth of a strong partnership over five years in small steps from a successful ARC collaborative grant, to a START grant, to application and commercialisation; the benefits of proximity and co-location of the partners for frequent communication; a focused and enterprising company with the vision to undertake the project and find a suitable university partner with the required expertise; and a university partner which responded sensibly to negotiations about IP ownership.

**Vision-based human machine interaction. International Collaboration Award winner 2000.**

The collaboration between ANU and Volvo began in 1998. At first, it involved an 18-month research contract from Volvo to ANU to do the basic research on the possibility of building a vision-based interface suitable for motor vehicles. The initial project milestones were met, which provided confidence building and the steps to more funding.

The innovative device, a video-based sensor (faceLAB, trademark), tracks the driver's head, pose, gaze direction, and eyelid closure. This is important for transportation safety and useful in active information awareness systems. A spin-off company, Seeing Machines Pty Ltd., was established with ANU and Volvo as equity shareholders, and both were represented on the company board. For Volvo the spin-off of Seeing Machines through the investment of the IP was a first. In the past, Volvo had kept its IP entirely within its own organisation. The commercial objective was to supply production versions of the in-car driver safety system for Volvo cars and trucks within three to five years.

The partnership was a complementary arrangement. The basic R&D was undertaken at ANU, while the applied testing was done at Volvo (Gothenburg, Sweden), and commercialisation of the R&D was done through Seeing Machines. The challenge in the partnership is what Alex Zelinsky, formerly of ANU and now Chief Technology Officer at Seeing Labs, calls the "tyranny of distance"- the distance between research labs in Canberra and Gothenburg. The answer to the problem was firm agreement on definitive milestones and review points, established at the outset. The progress of the project was closely monitored through monthly meetings via telephone or teleconferencing, a daily exchange of email, and six-monthly site visits.

The collaboration is similar to a Silicon Valley start-up model in which the IP of the partners (ANU and Volvo) is transferred into a spin-off company in exchange for

minority equity. The originators of the IP (staff at ANU) were granted majority equity. They left ANU to take up founder positions in Seeing Machines Pty Ltd.

This is an example of both the trust building and ground rules perspectives on collaboration (see below), perhaps essential when collaboration occurs at a distance, and especially when a highly professional international company is the industry partner. To what extent was the strength of the relationship responsible for the quality of the innovation? The path seems to be that the relationship was instrumental to field testing the technology, but most important for commercialising the technology. In sum, the partnership was less important for bubbling ideas, and more for taking the next step to application and commercialisation.

#### **Ceramifying Polymers –the Pyrolex project: Collaboration involving a CRC Award winner, 2004**

In July 1999, seven organisations began working on a new plastic material that in a fire would transform into a ceramic that would maintain its shape and structural integrity. The aim of the project was to produce a material for cables in buildings, hospitals, and factories that would continue to operate even in the case of fire at extreme temperatures. Olex, the Australian company that manufactures cables for the local and overseas market, saw the need for such a product.

The research partnership involved researchers from the Cooperative Research Centre for Polymers, three Australian universities (Monash University, UNSW, RMIT), two public research organisations (CSIRO and DSTO), and Olex as the industry partner. Each partner contributed expertise to support the collaboration. Researchers at Monash University were involved in ceramics materials engineering, researchers at UNSW on polymers materials science, and researchers at RMIT contributed polymers composite expertise. At DSTO and CSIRO, researchers conducted small-scale fire testing and fire performance evaluation of the new material. At Olex, research engineers were involved in the concept design and specification, while operations managers, production engineers, and marketing staff participated as the

project moved from concept, to factory trials, to full-scale production, and finally to marketing and distribution. The CRC for Polymers, led by Dr Ian Dagley, provided the overall organisational structure and direction for the project, including coordination and research management, and oversaw the transfer of the new technology into patents and commercialisation.

The IP produced by November 2004 included four patent applications, a new range of fire performance cables, and a new product known as Pyrolex Ceramafiabable, released on the market by Olex in July 2003. The new cable has been used in large public buildings and construction projects, including Melbourne Central, Austin Hospital, and the Melbourne Cricket Ground. Global licenses were negotiated, and a spin-off company, Ceram Polymerik, was established to exploit the technology in non-cable applications (such as roof tiles, door seals, and building panels). Pyrolex is a breakthrough in cables technology and is a substantial innovation with clear life-saving and commercial benefits.

Other indicators of a successful collaboration are the prospect of developing future IP. This is demonstrated in a willingness of the partners to work together again on new projects, in the establishment of a spin-off company, extending the new technology into new applications, and what Ian Dagley observed is the cultural impact on the partners. Olex has been reinforced in supporting R&D, is looking for new research opportunities, and has gained a greater awareness of IP management issues. The university partners and public research organisations have developed a greater understanding of the needs of industry in producing a commercial product, the challenges of translating a promising new concept from laboratory to production, and the importance of timeliness in finding solutions.

To what extent was the nature and strength of the relationship a contributing factor in the development of excellent IP? At one level, the answer is simple. The project and its IP would have been impossible without the collaboration between partners who contributed different, but complementary, knowledge, skills, and resources. Ian

Dagley, in his account of the project, maintained that the research would not have been possible without a CRC, because a high level of collaboration was required between many organisations to provide the best team available in Australia to conduct and commercialise the research. Dr Dagley also pointed to the crucial role of Olex as an industry partner that identified the need for a radical new technological solution to the problem of cable degradation and possible collapse in the case of fire. Olex was committed to commercialising a new technology, and had the production and marketing capability to bring the new product to market.

In Dr. Dagley's opinion, the CRC structure was crucial to the success of the collaboration, as it provided the team with expertise in research project management, patent development and commercialisation, and marketing. In his opinion, the potential obstacles to effective collaboration were not differences in values or interests, but the challenge of maintaining effective communication and coordination of the research project between partners spread across organisations and states.

The factors conducive to effective collaboration for innovation in the Pyrolex project include: a multifunctional team with the necessary range of expertise and specialist knowledge drawn from some of Australia's leading research organisations; integration of scientific and technological knowledge, production engineering, marketing and distribution, and legal knowledge for IP development and protection; a strong leadership and management structure (the CRC) to coordinate the project and maintain clear communication between dispersed partners; an experienced project leader with a strong scientific and industry orientation; and a commitment to adequately resource the project (over \$1million per annum) from 1999-2003.

We note that the collaboration was spread across partners located in three states and six locations. The strong leadership and management structure identified above is perhaps the most important factor contributing to the success of the Pyrolex project.

## **VI) Summary of factors in successful collaborations**

The previous section describes three award-winning collaborations, one in each category: general collaborations, international collaborations, and CRC collaborations. An additional five collaborations are described in the Appendix. While each collaboration is unique, several common themes or factors occur in all accounts.

First, the initial idea or concept that prompts the partners to join together is clever, original and worth pursuing. This is the motivation and incentive to pool resources, work together and strive for the application and commercialisation of IP. Second, the partners bring complementary skills, knowledge and expertise. Each partner brings something useful to the collaboration. Third, the dyadic “one-on-one” partnership is the most common model, perhaps because it is the simplest to establish and maintain. Fourth, the collaboration is led by senior researchers with standing, authority and commitment, who are there for the long haul and have built sound personal and professional relationships with partners. Fifth, the collaboration develops incrementally over time in knowledge-building and confidence-building steps through a sequence of joint projects and successful grants. This process usually takes at least three years. Finally, the collaboration involves rich multi-strand links between partners, such as shared labs, joint supervision, graduate employment, overlapping board memberships, start-up companies, and close teamwork. The partners in most general collaborations were located in the same city, enabling frequent face-to-face meetings and discussion.

More can be said about the nature of the relationship in successful collaborations. The data analysed in this Working Paper are limited to ratings and examples of strong partnerships. An important question to explore is what is required to create a successful collaboration. Another question is the difference made if the collaboration is initiated by a university partner rather than an industry partner. Does this have an effect on the style and strength of the relationship?

Many people who have worked together in successful collaborations favour the “trust building” perspective. This perspective emphasises long-term relationships (a history of many projects together), shared experience of meeting expectations, sharing explicit and tacit knowledge, flexible arrangements, and renegotiated arrangements as the partnership grows or the R&D environment changes. The examples in this appendix are consistent with the “trust building” perspective.

Another perspective, favoured by many IP lawyers and funds managers, is the “ground rules” perspective. This perspective emphasises contractual and legal arrangements for management of information and technology transfer and commercialisation of outputs. The penalties for the breakdown of the relationship include sanctions and litigation.

While many university partners in collaborative R&D prefer a looser arrangement based on trust and flexibility, the commercial imperative inherent in most industry activities provides the impetus for a ground rules perspective. The question of which approach is more conducive to innovation and production of IP is of great importance. There is evidence in the BHERT data that the trust-building perspective is especially important in the early stages of successful collaboration between a university research group and a company, while the ground rules perspective becomes more important in the later stages as the value of IP and technology transfer becomes more apparent. In examples of the complex R&D collaborations involving international partners and CRCs, we see evidence of trust building as well as a ground rules perspective. The underlying conclusion is that trust building is a necessary but not sufficient condition for the production and commercialisation of IP.

## **VII) Conclusion and recommendations**

The study of factors underlying successful collaborations is important for making decisions about the best form of collaboration for a given project, the selection of partners, and the design and establishment of procedures to assist partners to achieve

successful outcomes. The study reported in this Working Paper provides evidence that a set of social factors contribute to the strength of R&D collaboration and in turn to the production of innovative IP. Accordingly, a greater understanding of how relationships between partners in R&D collaboration are developed and strengthened is of importance for understanding the conditions for the production of new ideas and knowledge.

The type of collaboration makes a difference in the analysis of relationships. It is important to compare like with like in examining the type of collaboration. As found, both magnitude and strength of association between variables differ across different types of collaboration, and indeed within types of collaboration as a function of number of partners and duration of the partnership

Perhaps the most useful type of collaboration to analyse is the basic two-partner collaboration between a university research group or department and a company. This is the most frequent kind of university-industry collaboration, and, therefore, helping to make these basic collaborations grow and function smoothly is a wise investment in inter-institution partnerships. One of the most striking findings is that these simple two-partner collaborations have some way to go in their first three years before they build the close relationship and quality of innovation found in many older collaborations. The absence of correlation between strength of relationship and innovation in the 21 newer collaborations, and the finding that only one rated highly on both relationship and innovation, suggest that it would be useful to find ways to support early collaborations and assist their development.

Our findings suggest that confidence and trust building take time (years and not months), that keeping the partnership simple (two rather than three or more partners) is an advantage, that complementary skills and expertise provide a basis for partners to work together and respect each other's contribution, and that a step-wise growth from smaller to larger projects creates the momentum for later innovation.

I conclude with four recommendations:

**Recommendation 1:** Workshops should be set up for new research collaborations funded by government schemes, such as the ARC Linkage, CRC and START programs.

There is an implicit assumption that when a team assembled from different organisations has put together a successful application for a CRC or for an ARC Linkage grant, its members will have the requisite skills to deal with the strains that often occur in the early, formative stages as the parties learn to work together and share their knowledge and background IP. One suggestion is that, as a condition of receiving an award or a grant, all partners, unless exempted, should be required to participate in a workshop covering principles of working together in productive partnerships, negotiation and conflict resolution principles, stakeholder analysis, and establishment of ground rules of how the collaboration will work. The establishment of a Research Collaboration Unit, either in a government department or by an industry-university consortium, to provide advice to intending and new collaborations on how to get started, refresher workshops for collaborations as they move into a new phase or take on additional partners, and a consulting service for struggling collaborations would increase the likelihood of effective collaboration and innovation.

**Recommendation 2:** Government support should be provided for education and training of postgraduate students in science and technology in the skills and knowledge needed for effective communication, negotiation, multifunctional team performance, leadership, collaboration, innovation, and commercialisation.

New initiatives have occurred in bringing together university and industry partners (especially when linked by membership in Cooperative Research Centres), to develop programs in research leadership/management with an emphasis on building “soft” collaboration skills and “hard” innovation and commercialisation skills. The

programs include the Certificate in Research Management at Southern Cross University and the planned Summer School in Research Leadership at the University of Melbourne.

**Recommendation 3:** The Cooperative Research Centre scheme must be protected.

CRCs are complex organisations that knit industry, universities, and usually public research agencies in collaborative research with an applied focus. The CRCs are essentially field laboratories for setting the standard for sustained good collaboration, so that the links between strong partnership and innovative outputs are readily observed, and can be used as a model.

**Recommendation 4:** Incentives must be provided to establish collaborations.

The study reported in this Working Paper is limited to an analysis of factors in existing collaborations. There is wide support in Australia, the U.K, and elsewhere, to foster greater interest in collaborations involving universities and business, and universities and public research agencies. The McGauchie Committee report (2004), on collaboration between universities and publicly funded research agencies in Australia, makes strong recommendations for inter-organisation co-location and freeing up of highly prescriptive IP management regimes to help stimulate collaboration. The McGauchie (2004) review argued strongly for the co-location of research groups in technology parks, campuses, and research precincts as one of the most effective drivers of collaboration. The expectation is that when research groups are located in the same place, it is easier to coordinate, communicate, and exchange valuable ideas and information. This has been the case in studies of multidisciplinary scientific collaborations in the US. Cummings and Kiesler (2005) analysed 62 National Science Foundation research projects and found that projects spread across multiple institutions had less successful outcomes- fewer papers and fewer patent applications- than traditional projects based on one campus. Nevertheless, dispersed

groups that develop deliberate coordination strategies and communication practices can work at a distance effectively (Cummings and Kiesler 2005).

## **APPENDIX Five university-company collaborations**

### **Australia's only digital cellular telephone: Queensland University of Technology and Voxson International Ltd (Eagle Farm, Brisbane) 1999 award winner**

The GSM digital cellular telephone was the first in the world to have dimensions less than 100 cm<sup>3</sup>, weigh less than 100 grams, and operate for longer than 100 hours on one battery. These factors placed the GSM at the forefront of the new digital mobile phone technology. The partnership had begun seven years earlier, in 1992-1993, when Voxson provided final-year Electrical and Electronic Systems Engineering students from the Queensland University of Technology with work experience in the company laboratories. By 1999, all of Voxson's R&D team were graduates of QUT. The partnership was led by Miles Moody, Professor of Electrical Engineering at QUT, and at Voxson by Lucas Longinnou (CEO) and Simon Button (Head of R&D), both QUT graduates. Since 1993, over thirty-one QUT staff and students have worked with and for Voxson. Voxson has been a major supporter of establishing a cutting-edge digital wireless information services laboratory at QUT.

The key to this collaboration is the unique partnership, which Moody described as a "symbiotic relationship", in which QUT and Voxson operated as feeder school and place of employment for the best graduates working in digital mobile phone technology.

### **Vaccines to prevent or treat cervical cancer: University of Queensland (Centre for Immunology and Cancer Research) and CSL Ltd. 1999 award winner**

This project was a world first in the development of vaccines to prevent cervical cancer based on non-infectious papillomavirus virus-like particles (VLPs). The VLPs are similar to the genuine virus, and therefore stimulate an immune response, but are safe for humans, highly immunogenic, and able to provide mucosal immunity. VLP technology is, therefore, an unconventional approach to the development of vaccines for conventional viruses. The University of Queensland team developed and added value to the VLP intellectual property. The collaboration with CSL Limited Products

generated by the Centre's researchers led to four patents, while products generated by CSL produced five patents, two of which were held jointly with the Centre. The technology was then licensed to Merck and Co (USA) for commercial development. The collaboration began in 1990, based on Professor Ian Frazer's research at University of Queensland and as a collaboration with Dr Ian Gust at CSL. In 1999, the collaboration involved 30 people at the Centre and at CSL. Representatives of the two groups met monthly to discuss progress. The project management team used email for ongoing communication and discussion. CSL upgraded its email system to facilitate a "virtual management team".

The key to this collaboration is found in a close partnership between two scientists- Frazer at UQ and Ian Gust at CSL- which was advanced through the complementary skills and expertise of the partner organisations. UQ provided the fundamental research and CSL developed the critical technologies to produce research materials, expression systems, and fermentation processes for the joint project, and negotiated the licensing agreement with Merck and Co.

### **Enhanced and automated container handling equipment for improved waterfront efficiency –University of Sydney and Patrick Stevedore Holdings**

This collaboration won a BHERT award in 2000. The partnership began in 1995, as a partnership between the Australian Centre for Field Robotics at University of Sydney (a Commonwealth Key Centre) and Patrick Stevedore Holdings, on two projects- enhanced quay cranes and automated straddle carriers. The quay crane involved a novel reeving system and advanced control system that improves cycle times by as much as 40 percent. The automated straddle carrier aimed to automate quayside operations.

The relationship between the Centre and the corporation was founded on a number of projects, and not only the crane and straddle carrier. The relationship began when Professor Hugh Durant-Whyte, Director of the Centre for Field Robotics at University of Sydney, undertook consulting work for Patrick. This grew into an ARC

Linkage grant, with the Centre at the University of Sydney and Patrick as partners in developing the crane system. Patrick then invited the Centre to examine the possibility of an automated straddle carrier. Patrick undertook to fully fund the initial study. The Centre and Patrick obtained a START grant from the IRD Board to construct and demonstrate a prototype automated straddle carrier, which was successful. Patrick then approved work on a pre-production unit and brought in Kalmar Industries of Finland (the world's leading manufacturer of straddle carriers) to undertake the work. Kalmar then joined the project and became an equity investor in Patrick Technology and Systems, a company established to commercialise the automated straddle carrier and related systems.

Ten staff were involved in the project - six from the Centre and four from Patrick. A scale crane was designed and a worldwide patent granted. A pre-production full-scale automated straddle carrier was developed. Daily contacts were maintained, especially during the initial phases of the straddle project. Graduates of the Centre have been employed in key development positions in Patrick Systems and Technology. Patrick sponsored and supervised student projects in waterfront technology and is represented on the Centre's Board.

As Professor Durrant-Whyte observed:

The relationship between the Australian Centre for Field Robotics and Patrick has developed from initial consulting, through collaborative R&D, to a major collaboration in which the activity of each organisation is shaped significantly by the collaborating partner.

The key to this collaboration was the incremental development of a close relationship between Professor Durrant-Whyte and the Technical Development group at Patrick Stevedore Holdings over more than five years. Each step provided the confidence and momentum to take the next step. Successful collaboration on ARC SPIRT grants and IRD START grants provided the platform for taking the next step of testing the field

and commercial viability of the new technology. The ready movement of graduates, undergraduates, supervisors, and research staff between the partner organisations helped reinforce their close ties, and facilitate the accumulation of knowledge and experience.

**Development of Advanced Combustion Systems; University of Adelaide and Fuel and Combustion Technology (FCT) Port Adelaide, SA Award winner 2001**

Gyro-Therm burners use precessing jet technology, which was invented at Adelaide University. The Precessing Jet (PJ) nozzle creates a new way of mixing fuel and air together. The technology is unique in its ability to increase heat transfer while also reducing NO<sub>x</sub> emissions. Gyro-Therm technology has an international patent. It provides a 50 percent reduction in NO<sub>x</sub> emissions and a 5 percent increased output and/or fuel efficiency in gas-fired rotary kilns. The partners designed the combustion systems for the torch and community cauldrons, and for the main cauldron flame used in the Stadium at the 2000 Sydney Olympic Games.

The collaboration between Adelaide University and Fuel and Combustion Technology (FCT) Pty Ltd took the invention from university laboratory-scale to full-scale commercial application.

The collaboration began in 1988 when University of Adelaide Professor R.E (Sam) Luxton and Graham Nathan of the Department of Mechanical Engineering's Turbulence, Energy and Combustion group were seeking an industry partner to help commercialise the IP following their joint discovery and patenting of the PJ technology.

At the same time, Adelaide Brighton Cement was seeking to develop new technology for its plant. As fuel costs are the single largest operating expense in production of cement, PJ technology was of interest to the company. In 1991, Luxton and Nathan began negotiations with ABC. In that same year, ABC conducted the first full-scale trials on PJ technology and was impressed. The success of the trials provided the

foundation for a licensing agreement, signed in 2003, giving ABC full commercial rights to the PJ technology in return for an annual payment and a royalty on each burner. The annual payment provided the Turbulence, Energy and Combustion group at Adelaide University with a guaranteed funding stream. From 1994-2001, ABC, then Fuel and Combustion Technology, which bought out ABC, paid \$2.5m to the Turbulence, Energy and Combustion Group's R&D program and paid royalties on 26 commercial gas-fired combustion systems. The collaboration involved 11 staff and 20 students at the university and 14 staff at FCT.

Dr Graham Nathan observed in 2001:

“The strong relationship between the two organisations, developed through the commercialisation and development of the PJ technology, provide the foundation from which the partnership has extended to other areas. Adelaide University brings technical expertise, R&D facilities and experience in resolution of industry problems to the partnership, while Fuel and Combustion Technology brings expertise in combustion engineering, project management and commercial undertakings. The decade-long association has matured to the stage where the two groups act as a seamless partnership. Fuel and Combustion Technology staff contribute to some R&D programs at the University, and University of Adelaide staff contribute to commercial installations and designs...”

A Chief Design Team, with representatives from the University of Adelaide and FCT, coordinated the design of the combustion systems for the 2000 Olympic Games. The complementary expertise of the partner organisations contributed to the design, testing and commissioning. “The team-based approach”, observed Graham Nathan, “has been a vital component in the success of our joint projects, as it has enabled the designers to capture the best ideas from across the two organisations while allowing greater access to resources and skills...The collaboration has allowed the two

organisations to evolve into organisations with complementary skills, facilities, and expertise.”

The key factors in this successful collaboration are: complementary expertise; a partnership between a university and a company located in the same city both interested in the application of a smart new technology; a close and successful relationship between the two organisations built over ten years; a realistic and constructive licensing agreement for use of the technology; the commitment of Nathan, who together with Luxton, his PhD supervisor, invented the gyro-term technology; and, finally the ability of the partner organisations to work together as a genuine team.

#### **Lupron --a drug for rebuilding the immune system –Prize winner 2004**

The partnership between Professor Richard Boyd of the Department of Immunology, Monash University, and Norwood Abbey Ltd., an Australian Stock Exchange-listed firm involved in research, product development, and marketing of innovative medical products, began in 2000.

Boyd’s research at Monash University on thymus rejuvenation for treating cancer and infectious diseases evolved over 20 years. It is widely understood in medical science that the thymus (and therefore the immune system) degenerates with aging, or can be destroyed by major infections such as HIV/AIDS, and by chemotherapy and radiotherapy. The Boyd Lab conducted an extensive research program on how to rejuvenate the thymus, and, therefore, how to rebuild the immune system to assist in the treatment of cancer, infectious diseases, autoimmune conditions, transplantation, and other problems of immune deficiency. Research on animals and human clinical studies found that temporary inhibition of sex steroids helps restore thymus functioning and helps rejuvenate the immune system. Boyd named the drug used to inhibit sex steroids “Lupron”, an analogue of Luteinizing Hormone Releasing Hormone.

Norwood Abbey was a somewhat unusual industry partner in the BHERT sample of collaborations, inasmuch as it began life as a company involved in the management of IP, patents, and licensing arrangements, and not as a research organisation. At first, the partnership between Monash University and Norwood Abbey was limited to finding funding for the Boyd Laboratory. As the partnership developed, Norwood Abbey's role grew to include development of clinical and licensing programs, program management, IP advice and management, and establishment of an international scientific advisory board to provide guidance to the project. This enabled the Boyd Lab to run extensive clinical trials on immune system regrowth in Australian hospitals

The resulting IP from the partnership included: 100 patent applications filed in the US, Europe, Japan, and other countries; two patents; a commercial licensing agreement between Monash University and Norwood Abbey; an exclusive license agreement between Norwood Abbey and TAP Pharmaceutical Products Inc for use of Lupron in the US; and the establishment and listing in 2004 of Norwood Immunology (a spin-off company to develop the medical project) on the United Kingdom AIM Stock Market. Norwood Abbey and Norwood Immunology have a team working on the development of the clinical program, patenting, and licensing activities for the project. The collaboration extended to collaborative links with researchers in other countries and clinical studies in several Australian and overseas hospitals. The licensing deal with TAP Pharmaceutical Products Inc brought investment into Australia, as well as access to expertise and markets.

Richard Boyd observed that adapting an academic laboratory to one with a more commercial focus was initially an obstacle. However, he also noted that the partnership had been “exceptionally productive because all the parties were fully committed to making it work”.

The collaboration between Monash University and Norwood Abbey is a fusion of innovative basic research conducted by a university, and astute commercial backing

and patent law protection provided by a company. This is a mature collaboration, in which highly valuable IP is protected and prepared for the market.

The factors that made the collaboration work included: a university researcher who was comfortable dealing with commercial partners; a company that expanded its role beyond IP management, funding, and legal arrangements to assist in project development; a university with an Innovation Office that provided advice and helped facilitate the commercial partnership; and, as Richard Boyd observed, trust between partners that developed over time.

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