A review of Triple Helix Linkages in New Zealand Earthquake Engineering Networks and comparison with the Australian Cooperative Research Centre Model

Peter Butcher
University of Southern Queensland and
The Open Polytechnic of New Zealand
peter.butcher@openpolytechnic.ac.nz

David Thorpe
University of Southern Queensland
thorped@usq.edu.au

Keywords: Triple Helix, New Zealand, Cooperative Research Centres

Abstract

This paper addresses factors that influence the relationships between industry, government and academia in New Zealand in terms of the earthquake engineering industry and identifies strengths and weaknesses of the model in comparison with Cooperative Research Centres (CRC) in Australia and discusses:

- How are value conflicts from university-industry-government interactions addressed and resolved?
- How does the Australian CRC model operate and what parallels and differences exist between that model and the New Zealand situation?
- What can be learnt from the CRC model that can be applied to the New Zealand situation?

A case study approach is used to evaluate triple helix elements and identifies key attributes which support or otherwise, effective operation and economic performance in the two sectors.

ISBN: 978-81-904262-9-9

1 Introduction

Government, academia and industry have long been seen as a means through which complex problems can be identified, quantified and addressed. Usually such problems are beyond the scope of any particular stakeholder to address and resolve which encourages cooperation in order for success to be attained (Ackoff, 1981; Van de Ven, 2000).

The attractiveness of a collaborative arrangement between government, academia and industry includes:

Government funding is a significant attraction to both academics and industry associations. In effect government already pays for academics through tertiary institution employment and support for facilities and also have the ability to track and account for funding and its application.

Government also identifies global societal needs and those with special strategic value such as tourism and has a role in creating an environment within which disadvantaged groups can be nourished and benefit given accordingly.

In general, (at least in most western countries) governments are reasonably stable with fewer annual ups and downs than often occurs in business.

Academia in the context of universities and polytechnics clearly has the research capability and motivation, as well as experience, in delivering educational benefits through courses and workshops to large segments of a population.

Academia is able to explore concepts that are too risky for business especially as there is a surfeit of relatively cheap and smart labour available in academic settings as students seek to learn and gain experience.

Academia therefore has a responsibility to interact with and support the community at large.

Industry is the engine that largely creates the tax base for government revenues and provides the general economic viability of a community, city and country.

Industry is also the basis of the problems and opportunities for application that can be the focus of government and academic collaborations. For example Small and Medium sized Enterprises[(1)] are an aspect of industry that account for the vast majority of businesses around the world, but unfortunately, typically do not have the scarce resources (either in people or money) necessary to explore concepts and remove uncertainties beyond day to day survival. As such, they are prime clients for government and academic collaboration.

A variety of linkages exist to support government, academia and industry collaborations, for example government and academic linkages include various funding programs, as well as forums and means of information exchange.

Government and industry linkages also include industry liaison and lobbying groups that represent large numbers of clients in an industry, as well as government programs to leverage the collective nature of business.

Academia and industry linkages include special educational programs as well as sponsored projects and other mechanisms by which students can learn and from which business can benefit.

In many cases, however, linkages formed are either insufficient to deal with problems and project complexity or stakeholder attributes overwhelm the ability of the linkages to affect government, academia and industry collaboration.

In part there exist fixed modes of thinking that not only inhibit effective communication but also can result in stalemates or worse situations (Mitroff and Linstone, 1993; Corbitt and Al-Qirim, 2004). Barriers are numerous and often difficult to address.

2 Background to the New Zealand Earthquake Engineering Industry (2)

The Earthquake Engineering Industry in New Zealand could by Hemlin's definition, be categorized as a "CKE", (Creative Knowledge Environments) being:

> "(*of an)* environment, context and surroundings, the characteristics of which are such that they exert a positive influence on human beings engaged in creative work aiming to produce new knowledge or innovations, whether they work individually or in teams, within a single organisation or in collaboration with others" (Hemlin et al, 2006)

The Earthquake Engineering industry, represented largely through the Earthquake Engineering Business Forum is "creative" inasmuch its membership includes academics, industry professionals and government agency representatives who as individuals provide impetus to new ideas from any sector especially in terms of new opportunities or initiatives, who practice a focused management and working style which encourages innovation, autonomy and diversity among members so that an element of creative tension exists.

The term "earthquake engineering" covers a broad range of disciplines involved in the specialist science and practice of reducing the impact of earthquakes on our communities. The various components of earthquake engineering include steel and reinforced concrete buildings and structures, bridges and roads, a wide range of types of planning, emergency management, geosciences and social sciences, reconstruction financing including insurance, and property valuation.

The economic and social impact of earthquakes is huge, and thus there has been an increasing international trend to take initiatives that reduce the impact of such calamities. For example, "in the event of a single major earthquake in Wellington, (New Zealand) EQC[(3)] estimates its claims settlements would total up to $6.8 billion (the 90% confidence level)." (Source: Earthquake Commission (EQC) Ministerial Briefing Paper 2002, www.eqc.govt.nz) and

> "A less damaging event could be "an earthquake on the Wellington[(4)] fault" (which) will cause probably as much as $150 million losses." (Source: W.D. Smith, A.B.King & W.J.Cousins, GNS[(5)], March 2004).

The Earthquake Engineering Industry in New Zealand operates largely under the auspices of the New Zealand Earthquake Engineering Business Cluster, which competes or cooperates as appropriate on national projects and assertively competes as a unified body on international projects.

Their emphasis is on using the engineering and technical skills developed by New Zealand engineers and marketing them in international environments subject to earthquake impacts.

The major early catalyst for the development of the New Zealand earthquake engineering industry was the 1931 Napier earthquake. This led to improved building design, approval, construction and certification processes, the establishment in 1945 of the Earthquake Commission, and a growth in government-funded research and development initiatives.

New Zealand is at the forefront of innovations and new developments in the earthquake industry. An example is New Zealand's Earthquake Commission (EQC):

> "…no other scheme in the world is like EQC, and New Zealand is the envy of other countries which are subject to severe disaster events. In recent times, EQC had been approached for information and advice by officials acting on behalf of the governments of Indonesia, China, India, Taiwan, Israel, Turkey and South Pacific nations." (Source: EQC Ministerial Briefing Paper 2002)).

Another example is the world famous lead-rubber-bearing seismic base-isolation system invented by Dr Bill Robinson, then a government scientist and now Director and Chief Engineer of Robinson Seismic Ltd.

During 1997/98 the Earthquake Engineering NZ Business Cluster (EENZ) was formed as a business organisation that could provide a vehicle for assisting with facilitating the collaborative development of export markets and be complementary to the professional development focus of the New Zealand Society of Earthquake Engineers (NZSEE). It provides an identifiable entity enabling the harnessing of the experience and skills of earthquake engineers throughout the country from large multi-national firms to individual specialists, from both the private and public sector and from academia and government.

The business of EENZ members is to deliver practical and economic solutions that reduce the consequences of earthquakes on communities. The key focus of EENZ is on overseas work that would not otherwise be generated by individual members.

EENZ estimates that cluster initiatives can generate an additional $NZ16-$NZ25 million in export income in the next 3–5 years in addition to individual company efforts. This represents a 15–25% growth over 3–5 years in export income. (Source: EENZ 2003/4 Strategic Plan)

A joint Earthquake Engineering (NZ) and Natural Hazards (NZ) Cluster Task Group last year projected a 50–100% lift in foreign-exchange earnings by their cluster members, with earnings projections of $NZ25 million to $NZ40 million, in 10 years time.

Currently, total export income from New Zealand consulting engineering companies is about $NZ100 million a year. (Source: ACENZ, April 2004).

2.1 What is the Earthquake Engineering Industry in New Zealand?

We can consider the "Earthquake Industry" as:

> *"… any industry or organisation which has a contribution to the study and analysis of earthquake phenomena including the commercialisation of research into earthquakes and the delivery of product and services to clients operating in existing or potential earthquake prone environments…"*

Included within this definition are areas such as those involved in measures that mitigate earthquake risk and damage and includes insurance, valuation and property issues; civil defence and emergency management and education relevant to earthquake-prone environments pertinent to the industry, not only for the New Zealand market but also for export markets.

New Zealand earthquake engineering has long been recognised as being of an exceptional international standard. This has developed through high class research and teaching at universities, strong professional commitment by key practitioners, including the former Ministry of Works, through the innovative design applications of consultants and through participation of New Zealand professionals in the development of international building and design codes.

New Zealand leads the world in the development of base isolation devices within critical facilities as a means of damage control and the evolution of structural capacity design principles (which build a strength hierarchy into building systems to ensure building collapse avoidance at reasonable cost).

The development in New Zealand of a rational basis for lifeline engineering and more recently the passing of the Civil Defence and Emergency Management Act with its promotion of hazard identification and pre-event mitigation by local communities, demonstrate ongoing international leadership shown within this sector.

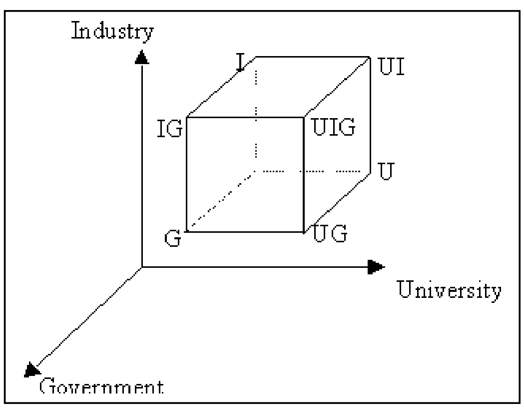
In late 2005, Government passed The Building Act, designed to significantly raise the quality of new building construction in New Zealand and further extend the range of existing buildings and structures that are classed as earthquake prone. This measure, aimed at reducing New Zealand's earthquake risk over time, will certainly enlarge the market for earthquake engineering services in New Zealand for the next few years with the further development of structural-strengthening techniques to existing buildings that can be retrofitted at reasonable cost.

3 Triple Helix Relationships in the New Zealand Earthquake Engineering Industry

The most commonly quoted visualisation of the triple helix is that outlined by Leydesdorff in his many articles on UIG relationships. In particular the models (Figures 1a and 1b) below.

In these examples the triple helix is shown either as a solid rectangle with axes of university (U), industry (I) and government (G) or as a DNA like series of strands.

Equally Leydesdorff and others have visualised it as a planar view of three spheres showing an overlay of relations as in Figure 2 below.



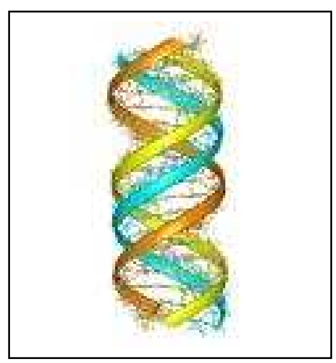


Figure 1a (above left): Basic representations of Triple Helix
Figure 1b (above right): Further representations of Triple Helix

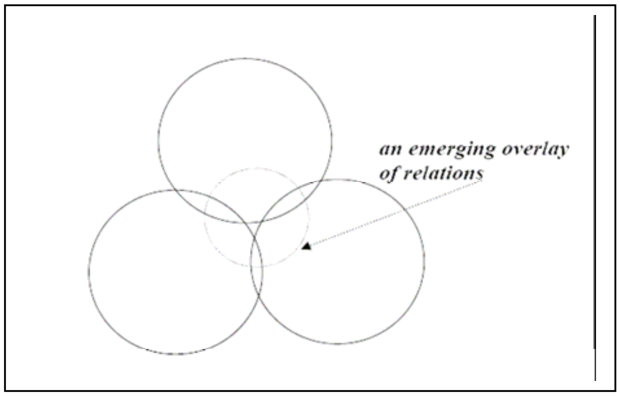


Figure 2: Further visualisation of a triple helix relationship

It seems to the author that this approach is easier to assimilate especially when redrawn in 3 dimensions.

3.1 Visualising the triple helix as a 3-segment ball

In demonstrating University-Industry-Government (UIG) relationships in the New Zealand Earthquake Engineering industry, it is useful to visualise such relationships as a three dimensional ball (3-d ball). This enables:

- Addressing different levels or magnitudes of UIG relationships
- Viewing the relationship as distinct **and**/**or** inter-related components
- Viewing the relationship 3-dimensionally, that is from any angle.
- Visually identifying components of uncertainty

On that basis a 3-d ball or was created to enable better visualisation as below:

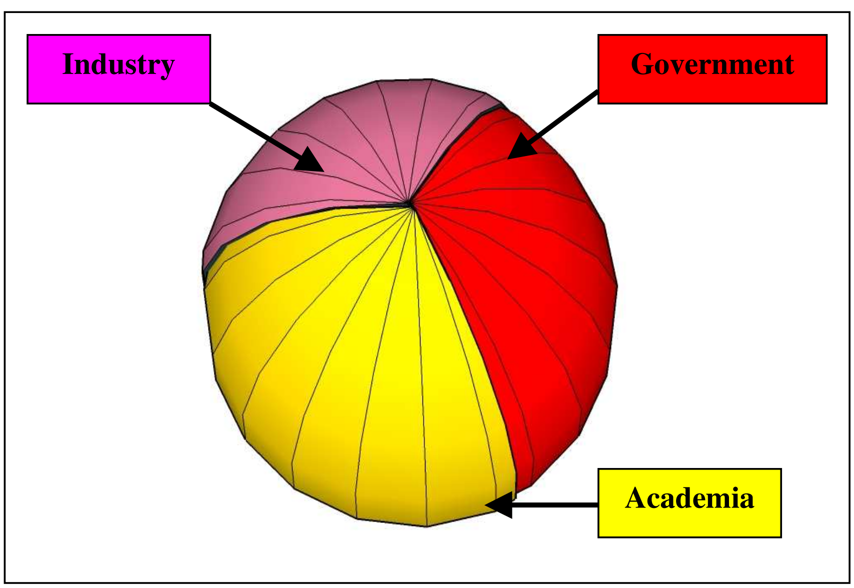


Figure 3: The 3 dimensions of Academia, Earthquake Engineering Industry and Government interactions used as a model in the earthquake engineering industry.

Each entity contributes towards the relationship in such a manner as to interact smoothly with the other components. The nature of the 3-d ball is however such that each entity can contribute a greater or lesser amount to the whole, taking up a function of one of the other entities, or giving up a function to another entity.

This can be clearly shown by increasing or decreasing the proportion of the ball representing each entity.

Further using readily available software (for example SketchUp) the 3-d ball can be rotated about any axis or any point on any axis. This is not possible using the more conventional triple helix visualisations.

Inherent in the relationship between the three UIG components is an element of relational uncertainty. This arises because:

- The structures, operations and expectations of each UIG component change dynamically and not always in synchronisation.

- Factors external to one or more of the components change creating uncertainty. For example a policy change in government may be signalled well before it occurs, but with outcomes that may not initially be clear in terms of strategic development and impact on some or all UIG components.

  This is shown in Figure 4 below.

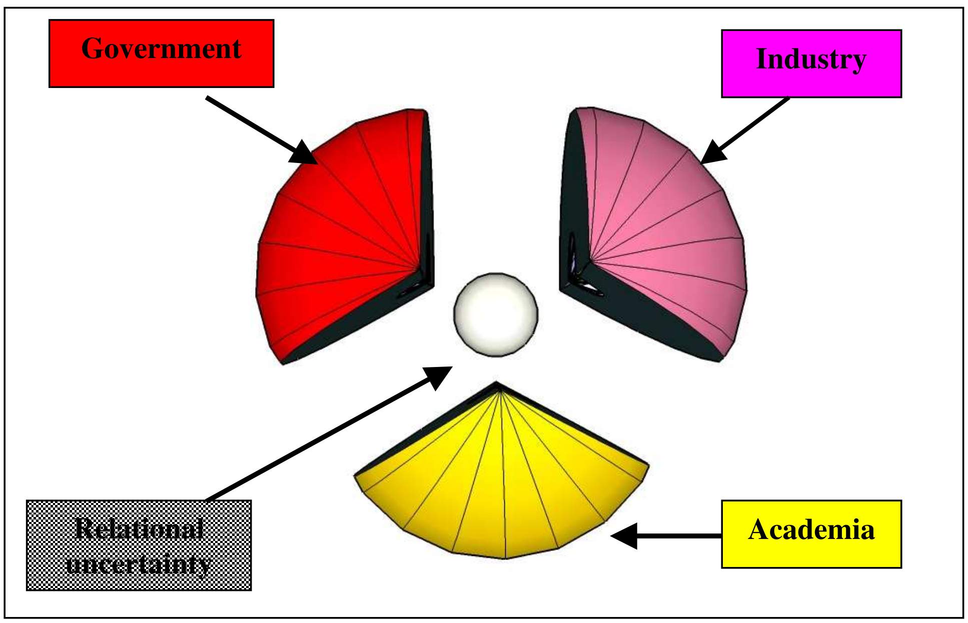


Figure 4: The 3 dimensions of University, Industry and government interactions, including relational uncertainty. An exploded view [(6)]

The conventional triple helix visualisation does to a limited extent identify the changing relationships between UIG components but does not easily visually allow for relational uncertainty.

The level of relational uncertainty can be easily varied visually to recognise significant changes as in Figure 5 below.

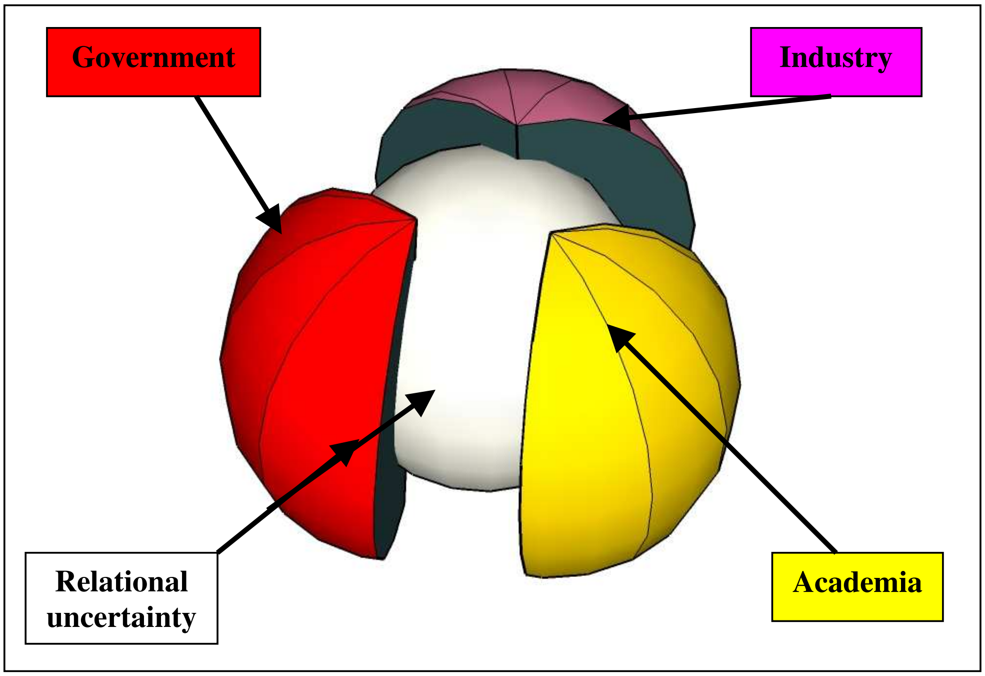


Figure 5: **The 3 dimensions of University, Industry and Government interactions, showing changes in relational uncertainty. An exploded view**

A metaphor for understanding the functionality of this visualisation may be to compare it with an elementary view of nuclear fission whereby explosives surrounding a central core of radioactive material are detonated such that the central core is crushed with equal forces at every point thereby creating a chain reaction resulting in a large generation of energy. A lack of balance between any of the components results in an uneven distribution of energy with consequent loss of efficiency of operation.

In a similar manner when all the components of a 3-d ball are balanced, it has the effect of minimising levels of uncertainty and maximising the strength of relationships between the UIG partners. In effect a balancing of UIG components generates an output potentially greater than the sum of the inputs.

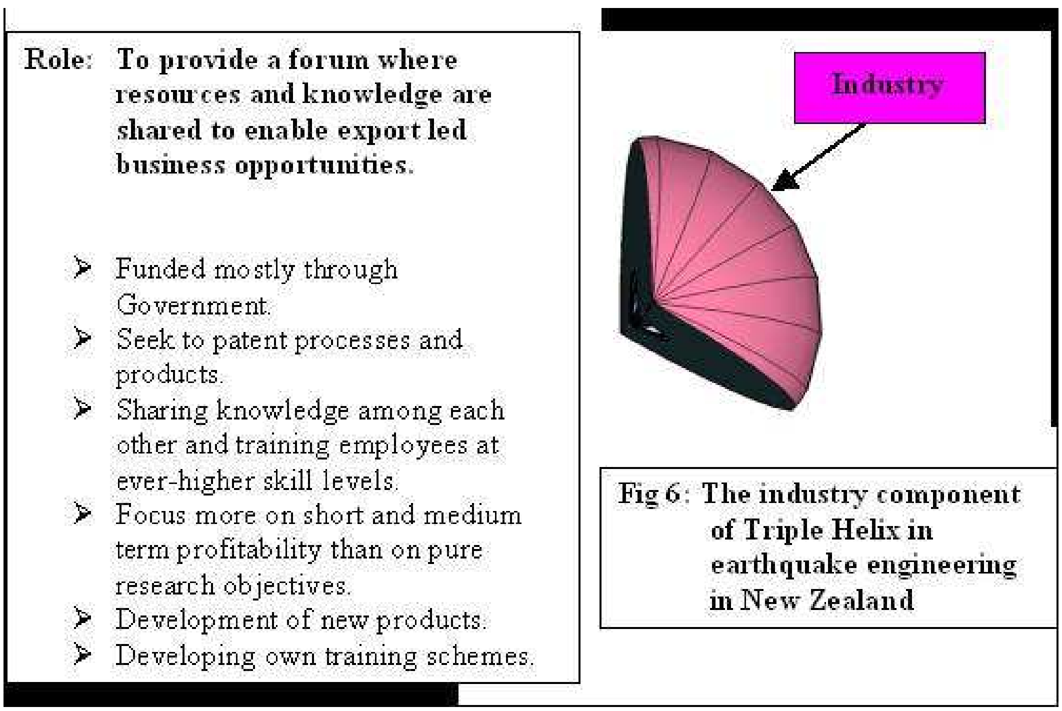
3.2 Nature of uncertainties

Uncertainties arise from mis-communication between each of the segments, anticipation of strategies and actions of the other segments and different agenda on the part of each segment. The end result is that uncertainty creates a negative influence on UIG relationships.

Key sources of uncertainty impacting on earthquake engineering NZ include:

- Technological change, which change the relationships between the UIG partners and introduces uncertainty, especially where the change is not clearly communicated.
- A change in institutional dynamics such as where a new strategic direction is set or people without a "triple helix memory" are appointed to key roles
- Governance structures, especially in the public sector, which may show inefficiency in aligning incentives and driving related institutional change
- Changing stakeholder expectations, such as criteria for allocating funding is changed arbitrarily as far as other parties are concerned.

Figure 6: Components of the Triple Helix in the New Zealand Earthquake Engineering Industry (simplified).



In a presentation in his role as Director of Research Training and Development for the (UK) Economic and Social Research Council, Alsop (2005) commented that:

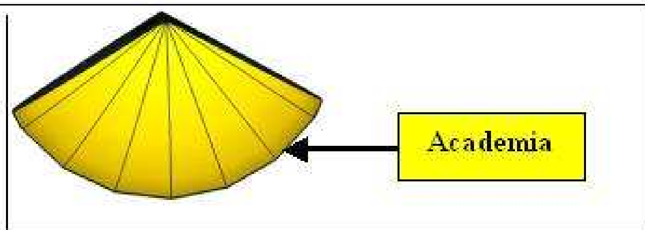
> *"(There is) undoubted merit in understanding the intertwining of businesses, governments and universities (but) in a global innovation system these will be of different thicknesses and interconnectedness in different places-and evolving at different speeds.*
>
> *But we may need to keep reminding ourselves that in capitalist societies the business strand is likely to be the dominant one-the three strands are not of the same importance"*

In the context of Earthquake Engineering New Zealand, industry is the dominant partner, if for no other reason that it undertakes a number of roles (research and funding for example), which in a more traditional model is the province of one or both of the other players.

Role: To provide academic input and research capability leading to knowledge and technology transfer for commercial advantage.

- Funded mostly by Government, student fees and research grants.
- Seeks commercial advantage in its own right and through strategic alliances.
- Seek to patent processes and products.
- Entrepreneurial tasks such as marketing knowledge and creating companies
- Relative lack of commercial experience.
- Training of future engineers, geologists, scientists and researchers.
- Develop business partnerships (such as incubators) with industry.

Fig 7: The academia component of Triple Helix in earthquake engineering in New Zealand



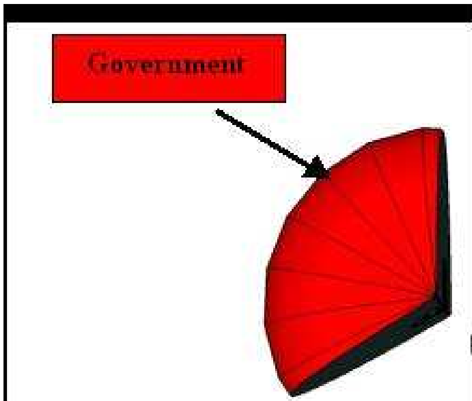


Fig 8: The government component of Triple Helix in earthquake engineering

Role: To provide legislative frameworks, policy and funding for tertiary institutions and research functions.

- Provides political direction.
- Funding of education and research.
- Funding for business opportunity development
- Encourages strategic alliances between industry, /government and academia.
- Addresses societal concerns relevant to Civil Defence, preparedness and mitigation.
- Provides feedback networks from trade representatives around the world.

Note that in the above model (a variant on Triple Helix III), the institutions of university, industry, and government, deliver not only their traditional roles and functions, but each assume some of the roles of the others. For example one university in New Zealand has assumed an industrial role more associated with the role of industry. Equally another body may assume a functional role as a manager of innovation more associated with that of government (e.g., Pires & Castro 1997; Gulbrandsen 1997).

3.3 Active relationships between UIG elements in a New Zealand earthquake- engineering context.

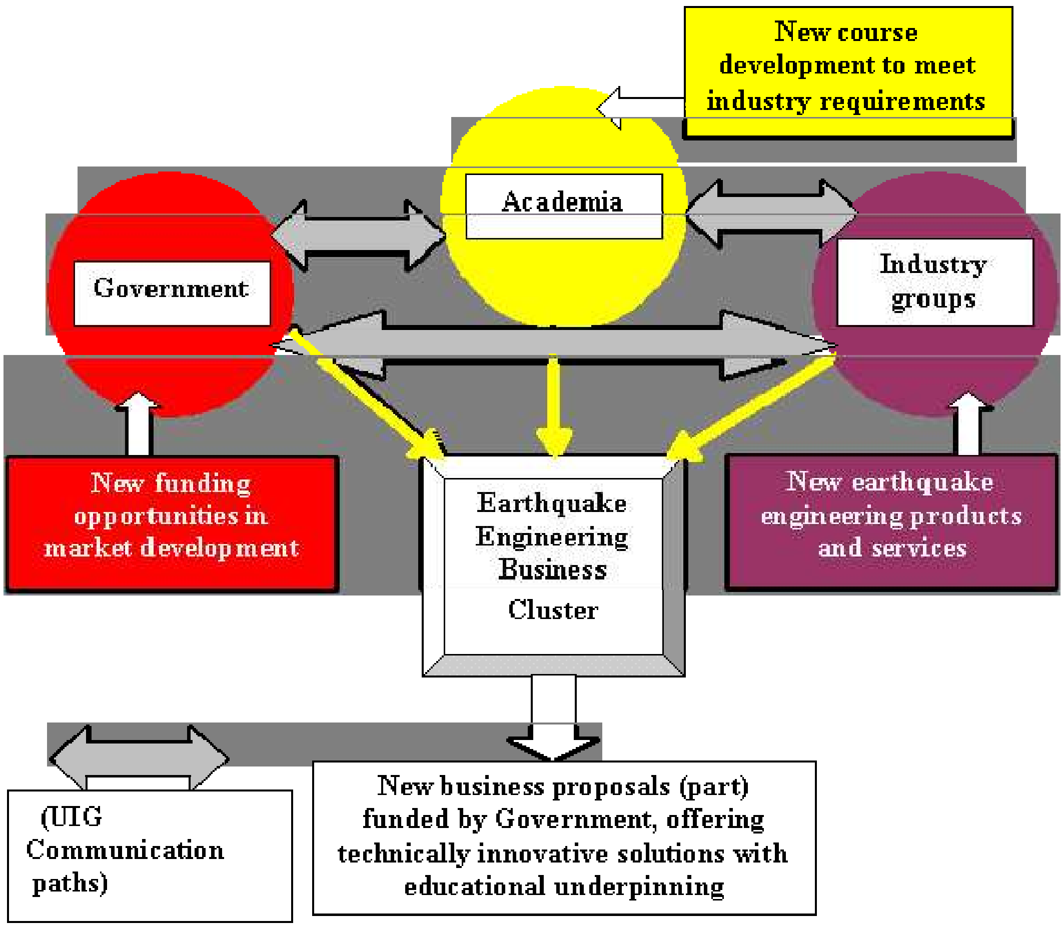


Fig 9: Relationship between UIG elements and Business Cluster (Simplified)

The success of the triple helix relationship in this environment can be measured ultimately in overall economic performance of the industry, however a number of intermediate measures are also significant, such as improving communication channels and focussing on a common strategy also enhance the ability to achieve the ultimate goal.

Measuring the benefits that flow from the common operations of the UIG components in the earthquake engineering industry is difficult. The duration between any input factors and an output which leads to economic performance usually occurs over long periods of time, trickle into many parts of the economy and society and are, of course often part of a wider process of innovation and investment in which it is hard to pinpoint particular success factors.

There is therefore an acute need to build and refine channels of communication, collaboration and interaction between all the parties involved in the formation of this triple-helix model at all levels in the industry.

3.4 Performance of the New Zealand Earthquake Engineering industry

A diverse range of companies and other organisations involved in the earthquake industry have their own strategies for growth because many earthquake engineering and associated specialist services and products are but a small part of the full services and products provided by these firms.

The Earthquake Engineering NZ (EENZ) Business Cluster has become a forum for strategic planning including identifying specialist niche markets, analysis of value chain networks and the development of marketing plans and action initiatives such as collaborative bids for specific projects.

EENZ is a Wellington-based network of more than 30 members comprising consultants, device manufacturers, researchers, educators, insurers, seismologists, architects, structural engineers, building services engineers, urban planners, emergency management professionals, business continuance advisers, local government officials, loss assessment experts, safety advisors and cost engineers.

The role of EENZ is as a forum for members to share knowledge, develop new ideas and approaches for generating business, and to facilitate co-operation amongst members in pursuit of worthwhile prospects.

EENZ does not enter into contracts in its own right. Its function is to help identify and create opportunities and to bring members together to decide on viable prospects to pursue. Once a decision is made to pursue a particular prospect, one of the members will be appointed to lead the project with others joining in as they wish. From that point, members of the project team meet their own costs of mounting the bid.

Over the next five years the EENZ estimates that the cluster's collaborative initiatives will assist members generate at least an additional 15% in export income above what they might achieve by themselves. It is actively marketing in Turkey, India, China and the Pacific and to the Asian Development Bank and World Bank Development Funding agencies, as well as some early stage initiatives for Latin America.

EENZ offers the following products and services that represent new and/or sought-after technology:

- Seismic risk assessments for urban areas, including GIS applications
- Seismic isolation of existing and new buildings
- Development of EQC[7] -type insurance schemes for countries

- Seismological investigation and measurement
- Retrofit of existing buildings
- Development of codes of practice for structural and earthquake engineering

The cluster is assisted by a Cluster Facilitator who provides business development and marketing support to members, along with support from New Zealand Trade & Enterprise[(8)].

The strategic basis for developing the opportunities for the industry to move forward has been identified through the strategic planning process undertaken by the EENZ business cluster over the past 18 months. This process includes initial background analysis of value chain networks for specialist products and services for priority markets.

EENZ has developed a clear strategic agenda, business plan and marketing strategy with initiatives focused on a mix of priority markets that have the potential to generate an estimated export income of between $16–25 million in the next 3–5 years, subject to sufficient resources to become established in these markets. This represents a 15–25% growth over 3–5 years in export income from New Zealand engineering consultancy services.

EENZ members have to date invested more than $600,000 in time and resources (such as travel and other off-shore work as well as New Zealand-based marketing costs) into developing the priority markets.

The major issue facing the EENZ cluster is having sufficient resources to sustain the considerable level of marketing support needed in the initial years to identify and secure sustainable level of profitable offshore projects.

The market for EENZ services extends to all earthquake-prone countries, but including India, Turkey and China. Relationships with Taiwan, Philippines, Peru, Chile, Mexico and Iran are in the early stages of development.

4 The nature of Australian Cooperative Research Centres in a Triple Helix context

Australian Cooperative Research Centres (CRCs) have been developed "to enhance Australia' s industrial, commercial and economic growth through the development of sustained, user-driven, cooperative public-private research centres that achieve high levels of outcomes in adoption and commercialisation" This goal is achieved through linking researchers with industry to focus R&D efforts on progress towards utilisation and commercialisation, thus linking researchers and the users of research. They also aim, through their education programs, to produce industry-ready graduates (Department of Education, Science and Training 2007).

As at 2006, there were 71 CRCs, organised into the six groupings of manufacturing technology; information and communication technology; mining and energy; agriculture and rural based manufacturing; environment; and medical science and technology (Department of Education, Science and Training 2006, ii-iv)

CRCs are funded by the Australian government and their academic and industry partners (which can include government agencies), and can be quite large.

For example, the CRC in Construction Innovation, which began operations in July 2001, has been funded, over its seven year life, by a $AS14 million Australian Government grant through the CRC Programme and complemented by $AS50 million of cash and in-kind support from partners – a total of $AS64 million (CRC for Construction Innovation 2006,3).

Another engineering based CRC, the CRC for Integrated Asset Management (CIEAM), similarly has a government grant of $AS17.5 million and $AS68.3 million in other support, giving it total resources of $AS84.8 million over its seven year life, or $AS12.3 million per year. This amount translates to 48 postgraduates and 65 fulltime equivalent research staff (Department of Education, Science and Training 2006, 22).

CRCs funded from 2002 onwards are required to develop and implement a commercialisation plan that maximises the benefits to Australia of publicly funded cooperative research, measured in terms of economic, social, and environmental outcomes. Examples of the way in which national benefits may be demonstrated include financial gains, productivity gains, export development, development of strategic industry clusters, enhancement of Australia's skill base, consumer and user benefits, and a range of other measures (Department of Education Science and Training 2004, 2-3).

As collaborative organisations with significant government funding, CRCs need to measure and communicate the benefits from their research. Garrett-Jones and Turpin (2002), in reviewing the framework for measuring the outcomes of the CRC program, noted that the most universal measure used by CRCs for the strategy for utilisation and application of research outputs was the extent to which users are prepared to engage and pay for expertise within the CRC (this was often a good source of income).

Other measures included the number of spin off companies (often small) and licensing of intellectual property (such as patenting and the licensing of patents). The report observed that particular indicators carry different importance for different Centres.

One of the challenges for CRCs is to transfer the technologies they develop to the particular industry that they serve. Major contributors to a CRC have the resources and knowledge to quickly utilise CRC research. Similarly, large organisations have the resources to evaluate these technologies. However, smaller organisations, which in many cases underpin major industry, may struggle to utilise the advances developed by a CRC without assistance. This can present a challenge to CRCs when operating in a true triple helix environment. It is discussed in more depth later in this paper.

4.1 Performance of CRCs

CRCs work closely with industry to provide outcomes beneficial to both industry and the national economy in general. For example, the CRC for Construction Innovation undertakes research in the three areas of business and industry development, sustainable built assets, and delivery and management of built assets, all underpinned by an ICT platform. It does so in collaboration with industry, research, government and international partners.

In 2005-06, this particular CRC reported on approximately 25 separate projects. In addition, it undertook education and training in initiatives in areas like scholars' workshops and industry forums (CRC for Construction Innovation, 2006, 15-40). One of the major initiatives of this particular CRC in 2006 was the conduct of an international Clients Driving Innovation conference (CRC for Construction Innovation, 2006, 53)

The CIEAM CRC has also reported close industry collaboration, noting that in 2004-05, 85% of its projects comprised at least one industry participant (CIEAM, 2005, 54). This CRC also hosted a significant international conference, involving a large number of industry participants, in 2006 (CIEAM 2006).

In addition to technology transfer, research collaborations should also result in knowledge transfer. This was investigated for CRCs by Sheen (2005), who studied the management of intellectual property and licensing in CRCs. His study rested "on the proposition that research and development (R&D) has a critical role to play in making important contributions in the new economy where high prices for knowledge can be realized" (Sheen, 2005, 3).

His study, which surveyed sixty-two CRCs, found that CRCs need to understand the nature and process of managing intellectual property in a collaborative context. In doing so, Sheen added to an intellectual asset management model developed by Sullivan (2000), and noted the importance of relationship, project management, agreements and licensing (Sheen 2005, pp 260-274).

In the case of the CRC for Construction Innovation, for example, intellectual property is managed according to the terms and of a centre agreement and in the specific project level agreements. Through this process, this CRC has signed a licence with a major international consulting engineering firm with respect to a particular innovation, which allows this organisation to continue the development of the intellectual property and for commercial sale of the consultancy service it supports. A number of software evaluation licence agreements have also been put in place to allow the trial of software by organisations external to the partner group, with the aim of protecting the intellectual property while at the same time sourcing valuable user feedback on its suitability

To meet its challenges in transferring technology to smaller firms, the CRC for Construction Innovation has worked with industry and professional associations to deliver information sessions through breakfast sessions or half-day industry forums (CRC for Construction Innovation, 2006, 14).

Similarly, CIEAM (which did not commence until 2003), recorded that during 2004-05, four seminars devoted to CIEAM activities had been delivered, and that 12 publications of CIEAM research had been published in refereed journals, books, or book chapters (CIEAM, 2005, 54).

The example CRC activities quoted above show that CRCs not only impact on the economy by employing large numbers of researchers, but also have considerable potential to positively impact on the nation's economy through the results of their research. However, there are clearly challenges to be overcome if this impact is to be maximised.

4.2 Addressing conflicts relevant to CRC Environment

The objectives of the partners in CRCs are likely to differ. Private industry partners are likely to be seeking a return on their investment in particular research projects and researchers fair recompense for their efforts. Both groups are likely to be interested in commercialisation and intellectual property protection where possible. While encouraging commercialisation and its positive impacts on the national economy, government partners in a CRC are also likely to be seeking the public good.

This difference between the objectives of the CRC partners is likely to change over time. In their early stages, CRCs are in a formative process, in which research outputs tend to be low and the partners are establishing the projects of interest to them. At this stage, objectives of all partners are likely to be in reasonably close alignment. The differences are likely to become manifest as the CRC matures and more significant research outcomes are produced. A challenge, therefore, for CRCs is to manage this tension while producing positive research outcomes.

As indicated earlier in this paper, one of the potential conflict areas that might be expected to arise from this tension between goals of the partners in a CRC is the transfer of technology (including knowledge), which if the maximum national benefit is to be obtained, requires to be ultimately transferred to the small and medium enterprise (SME) sector, which underpins many industrial activities.

This transfer of technology is a complex process, requiring transfer of both knowledge and the technology itself, and interaction between researchers, sponsors of research, clients, consultants, contractors, trade and industry associations, and other parties. It is also subject to the readiness and ability of industry organisations to adopt innovations that have a potentially unknown impact on their operations and profitability. The degree to which such this transfer occurs is likely to be subject to the ability and willingness of the partners in the CRC to provide it.

This balance between the transfer of technology and positive gains for the CRC partners involved in a particular research activity can be achieved through the development of a strategy that utilises factors such as those identified by Sheen (2005, pp 260-274) in his study of the management of intellectual property and licensing discussed earlier in this paper. The development of good written contractual relationships between the partners, sound project management and the use of appropriate agreements and licensing, in conjunction with an awareness of the need to develop a sound technology transfer process of essential research outcomes to the SME sector and others, is likely to mitigate the tensions involved and lead to a true cooperative relationship.

The two CRCs used as examples in this paper have shown how such a process is possible through strategies like industry presentations, conferences, and involvement of industry groups in the research and technology transfer process. It is apparent, however, if maximum benefit is to be achieved, there needs to be further research into technology transfer processes within CRCs, and in particular with the links between them and their partners, their industry and the national interest.

5 Parallels between New Zealand earthquake industry and CRC as far as UIG relationships

	Earthquake Engineering New Zealand	Australian Cooperative Research Centres
Underpinning strategy supporting Triple helix	Contribution to creation of wealth. Creating an environment for sustainable economic performance. Promoting enterprise, innovative practise, increased productivity and consequently growth.	Enhance Australia' s industrial, commercial and economic growth through the development of sustained, user-driven, cooperative public-private research centres that achieve high levels of outcomes in adoption and commercialisation
Components of success	Inspired leadership, majoring on opportunities and strategies, not difficulties and excuses	Strategic leadership focussing on technology transfer and commercialisation
Approaches to funding	Funding comes from corporate members who pay a modest fee each year **and** from Government channelled through New Zealand Trade and Industries in terms of time in identifying business opportunities and providing grants for exploratory visits to relevant international destinations and mostly through *Positively Wellington Business, which is fully owned and funded,* by the Wellington and Regional Councils.	Funded by the Australian government and their academic and industry partners Funding from 2002 onwards requires that national benefits be demonstrated, such as financial and productivity gains, export development, development of strategic industry clusters, enhancement of Australia's skill base, consumer and user benefits, and a range of other measures
Setting up a Triple Helix Relationship	The Forum comprises members from each of industry, academia and government The current directors include those from industry and academia with a key adviser from government Current reporting is to each of the UIG entities. Finding is from each UIG sector with most through City and Regional Councils.	CRCs are predominately research organisations which transfer their technology and intellectual property for purposes of commercialisation. Directors have a largely research and commercial focus Funding is from industry and government with most from government

New product development within a Triple Helix context	Most innovative practical research and resulting products are developed through industry[9], most theoretical research is undertaken by academia that also provide training and qualifications for industry needs.	Most research is undertaken within CRC itself with some applied research also undertaken in cooperation with industry
Marketing through the Triple Helix relationship	Each element recognises the mutual benefits of cooperation. Marketing seeks to provide a comprehensive package of others products and services so that all benefit. Competitors at a national level become collaborators in an international forum.	(Some CRCs) undertake education and training in initiatives in areas like scholars' workshops and industry forums. Works with industry associations to deliver information sessions through breakfast sessions or half-day industry forums
Boundaries between UIG elements	To some extent the boundaries been government, academia and industry is in transition, with industry undertaking more practical research and academia undertaking more theoretical research, industry training many of its own staff while academia produces graduates in established engineering science who are then trained in specifics by industry and funding coming from members and government through various agencies.	Private industry partners are likely to be seeking a return on their investment in particular research projects and researchers fair recompense for their efforts. Both groups are likely to be interested in commercialisation and intellectual property protection Government partners in a CRC are also likely to be seeking the public good.
Benefits to industry	Each business within the industry group, benefits from the technology produced by one member as it enables a collaborative wide coverage offering to made available to a client. Academic and industry research is available to all industry members Government information on market opportunities is available to all industry members. Students undertaking specific earthquake engineering research in academia are potential recruits for industry. Opportunities to incubate new products.	CRCs work closely with industry to provide outcomes beneficial to both industry and the national economy in general. For example, the CRC for Construction Innovation undertakes research in the three areas of business and industry development, sustainable built assets, and deliver and management of built assets, all underpinned by an ICT platform. It does so in collaboration with industry, research, government and international partners. In 2005-06, this particular CRC reported on approximately 25 separate projects.

Benefits to academia	Liaison with industry enabling understanding of industry skills requirements Funding provided for research through Government statutory bodies such as EQC[(3)] and through industry grants or sponsorship Research based on strategic needs of community which therefore provides long term benefits Access to decision makers in government and industry. Enables Masters and Doctoral students to work outside academia. Opportunities to incubate new products. Opportunities for Continuing Professional Development (CPD), in-house training and Consulting Opportunities for Contract Research Co-operation with existing companies Shared governance of research.	Australian Cooperative Research Centres and Centres for Excellence that span a number of diverse locations have been very difficult to manage due to the divided commitments of researchers to their host faculties and research programs and the mission of the CRC (Howard 2003). However, they have also provided a vehicle for channelling another source of research funding into ongoing faculty research interests and programs. In some cases, junior and senior researchers resign from academia to work on these projects full time. Jointly funded with key universities for specific research

Benefits to Government	Supporting government strategic needs in terms of addressing societal requirements. Development of new business opportunities and new products leads to increased gross domestic product, export revenue and ultimately taxation. Encourages employment in value added industries. Create a higher level of economic certainty. Identifying and promoting links, research and other projects between academia and industry leads to collaboration and economic performance.	Government achieves through its National Collaborative Research Infrastructure Strategy (NCRIS), a series of National Research Priorities which enhance the quality and impact of research effort by building critical mass in these areas and by promoting collaboration between research organisations and with industry. The Australian Government is providing $542 million over 2005-2011 to provide researchers with major research facilities, supporting infrastructure and networks necessary for world-class research.
Benefits to Triple Helix	Development and implementation of new products and (consultancy) services arising from academic and industry research Increased revenues through licensing for both industry and academia Employment creation for civil and structural engineers, geologist, geophysicists and other earthquake technology specialists Potential improvements in living standards not only through revenues generated but also through local use of earthquake damage mitigating products. Recognition that building collective capacity to respond to surprises and new challenges lies in strong relationships between research and practice.	Provides a working model in a high- level triple helix context, with balance between each of the UIG entities constantly changing. Generates commercial gain, increased research profile and clear economic benefits.

Limitations of Triple Helix	Successful research can be limited through a slow and cumbersome technology transfer function, especially where limited funding is available outside the area where the product was developed. Industry may be limited in its ability to commercialise a product, not only financially, but also in terms of resources such as skilled staffing. Management of Intellectual Property can seriously limit effective commercialisation. The cost of patent protection worldwide and the time taken may limit commercialisation.	The objectives of the partners in CRCs are likely to differ. Private industry partners are likely to be seeking a return on their investment in particular research projects and researchers fair recompense for their efforts. Both groups are likely to be interested in commercialisation and intellectual property protection where possible. While encouraging commercialisation and its positive impacts on the national economy, government partners in a CRC are also likely to be seeking the public good and since they provide most funding, the balance of UIG entities appears to lean more towards the government requirement..
Challenges of Triple Helix	Managing ethical issues such as conflict of interest, confidentiality and protection of intellectual property. Maintaining integrity of research while recognising consequences and expectations of those providing the funding. Managing patent and licensing activities while maintaining profitability. Ensuring reasonable funding while maintaining productivity, recognising that a number of competing international centres may be better funded. Encouraging creativity in research and entrepreneurship while funding is limited and focussed more on short-term commercial gain. The roles, positions and nature of interaction changes frequently; requiring flexibility in resourcing, information flow, decision making and modes of engagement.	

	Changes in factors beyond the control of industry and academia, such as the international value of the New Zeal;and dollar can make good proposals unprofitable on an international stage. Short term versus long term knowledge creation and use and a balance between being independant and responsive. Blurring of the boundaries between the roles of industry and academia in terms of research and all elements in terms of funding. Build more national and international networks and partnerships. Recognition that industry and academia have different missions, needs and timetables such as a different view of short-term applied knowledge needs of industry and research as discovery Recognition that proximate industry-academic collaboration is likely to be more successful than when there is a wide geographical gap. The need to incubate new research ideas and innovations, otherwise a high failure rate is likely. Confusion between research being problem focussed or discipline based. Academia still has a strong problem based approach. Actors in the Triple Helix environment have too many demands on their time and energy. Hard work tends to be forgotten and experience tends to go unused.	This balance between the transfer of technology and positive gains for the CRC partners involved in a particular research activity are not always achieved in a manner that meets the needs of the participants. The development of good written contractual relationships between the partners, sound project management and the use of appropriate agreements and licensing, in conjunction with an awareness of the need to develop a sound technology transfer process of essential research outcomes to the SME sector and others, is likely to mitigate the tensions involved and lead to a true cooperative relationship. The two CRCs used as examples in this paper have shown how such a process is possible through strategies like industry presentations, conferences, and involvement of industry groups in the research and technology transfer process. If maximum benefit is to be achieved, there needs to be further research into technology transfer processes within CRCs, and in particular with the links between them and their partners, their industry and the national interest.

Strategic components in moving forward	A transparent process of priority setting and implementation A fast response to new opportunities and Challenges Promote and ensure engagement with all stakeholders in strategic process Identify and build on strengths Identify and overcome weaknesses Do not get into ”victim mode” and blame others for current circumstances Generate our own future, don’t be passive followers, be active future creators Invest in people, new ideas, knowledge and training Become a knowledge-based industry Create an entrepreneurial business culture	Maintaining funding quantities Promoting increased participation between all UIG entities and their staffs. Strengthening Australia’s ability to generate ideas and undertake research Accelerating the commercialisation of ideas Developing and retaining skills: Strategic investment in information and communications technology (ICT) to ensure that as the pace of innovation and ICT development increases, Australia does not fall behind other countries. Strengthening collaboration and linkages across the science and innovation system to create the necessary critical mass of expertise, infrastructure and resources and provides more pathways to the marketplace. Australia must continue to strengthen relationships between research and business communities if both are to contribute effectively to innovation outcomes.

Key conclusions arising from the research underpinning this paper include:

6 Conclusions

- Cognitive limitations of individual are the major determinants of the organizational structure.
- The success of the partnership between industry, academia and government is to a large extent a reflection on a trusting and cooperative environment created by the individual actors and transcends formal business relationships.
- The necessary institutional arrangements are required to be provided in order to build the increased level of communication and interaction between actors involved in the innovation process
- The patterns of coordination and interaction should be flexible in order to continuously re-adjust and reconfigure the roles and positions of respective actors to build the level of social capital required to compete in an increasingly competitive industry
- Outward-looking, leadership style – leaders with wide experience, who express clear goals and grant autonomy promote more creativity
- Harmonious social atmosphere not necessarily better – different cognitive styles causing some 'irritation' may generate beneficial 'creative tensions' (Wilke & Kaplan, 2001)
- There is a need to increase the role of universities into more than research resulting in papers being produced so that new technology (such as base isolation systems) are developed in a joint university-academic relationship, not just industry as at present. Certainly joint industry/university/government research is an increasingly common form of conducting both basic and applied research.
- The challenge is to make good deals which address the classic issues of intellectual property rights, publication, secrecy, academic nepotism, etc., right up front and not always live the old model of doing everything ourselves because we can' t deal with these concerns.
- The need to strengthen University-Industry Linkages to ensure international competitiveness especially as most work done by the Business Cluster is overseas.
- No single approach has the versatility to address all issues in a continuously changing innovative environment.
- The triple helix model has to be flexible enough to reconfigure and refocus continuously within their operating environments and evolve as challenges emerge.
- There needs to be numerous channels of communication, collaboration and interaction (both formal and informal) between participants in the UIG triple helix environment.
- Include in its management an active person of vision, with power of decision and with high and visible profile, who is perceived by relevant actors in society as embodying the interface between academia and industry, long-term plans and good management

7 Closing comment:

> *"…the persistence of many of the problems facing humankind today is to a large extent due to the excessive compartmentalisation, fragmentation and specialization which are so characteristic of education, research and government today." (Boyden et al 1981)*.

8 Endnotes

8.1 SME

8.2 The author is an Executive Member of the New Zealand Earthquake Engineering Business Forum.

8.3 The Earthquake Commission (EQC), a statutory body responsible for addressing insurance and mitigation impacts relevant to earthquake and natural hazards for residential homeowners.

8.4 Wellington is the capital city of New Zealand and sits astride a major earthquake fault zone.

8.5 The Institute of Geological and Nuclear Sciences, a Government funded national research body.

8.6 For convenience in this visualisation each component (segment of the ball) is shown as the same size. This is simply for convenience of visualisation. The relative volume of the 3-d ball occupied by each segment will change constantly.

8.7 EQC is the Earthquake Commission of New Zealand, insurer of all residential property.

8.8 Trade and Enterprise NZ is that Government Department responsible for promoting New Zealand businesses in an export environment.

8.9 For example, Base isolation Devices which minimise the impact of an earthquake on a structure, by absorbing the energy release, rather than the energy being absorbed directly by the building structure

9 References

Ackoff, R. (1981). *Creating the Corporate Future*. New York: John Wiley & Sons.

Alsop, A (2005). *Presentation on "The Future of Research"", Economic and Social Research Council.*

Boyden, S. Millar et al. 1981. *The ecology of a city and its people: the case of Hong Kong*. ANU Press, Canberra

CIEAM, (2005). *Cooperative Research Centre for Integrated Asset Management 2004-2005 Annual Report*, Cooperative Research Centre for Integrated Asset Management, Brisbane, Australia.

CIEAM (2006), *Proceedings of the First World Congress on Engineering Asset Management (WCEAM), 2006, Gold Coast, Queensland, Australia, 11-14 July 2006*, Springer, London.

Corbitt, B. and Al-Qirim, N. (2004). *e-Business, e-Government & Small and Medium-Sized Enterprises: Opportunities and Challenges*. Australia: Yurchark Printing Inc.

CRC for Construction Innovation (2006). *Annual Report 2005-06, Cooperative Research Centre for Construction Innovation*, Cooperative Research Centre for Construction Innovation Brisbane, Australia.

Department of Education Science and Training (2004), *Cooperative Research Centres programme: commercialisation and utilisation plan guidelines*, Australian Government Canberra.

Department of Education Science and Training (2006). *CRC Directory 2006*, Australian Government Canberra.

Department of Employment Science and Training (2007). *Cooperative Research Centres – About the Programme*, Australian Government Canberra. Retrieved 4 April 2007, from https://www.crc.gov.au/Information/ShowInformation.aspx?Doc=about_programme&key=information-about-programme&Heading=About%20the%20Programme#Overview.

Etzkowitz, H. (1999). *Science-based regional economic development: A Triple Helix of university-industry-government relations,* a Paper Presented at Triple Helix Øresund Conference: Innovation by dynamic university-industry-government interaction in an emerging cross-border science region.

Etzkowitz, Henry, Andrew Webster, and Peter Healy eds. (1998). *Capitalizing Knowledge: New Intersections Between Industry and Academia*. New York: State University of New York Press.

Garrett-Jones S and Turpin T (2002), *Measuring the outcomes of the CRC program: a framework*, University of Wollongong, Australia.

Gulbrandsen, Magnus (1997). *Universities and Industrial Competitive Advantage*, pp. 121-31 in: Etzkowitz and Leydesdorff (1997).

Hemlin. S, Allwood. C.M, Martin. B.R. (2006). *Creative Knowledge Environments*, Submitted to *Research Polic,* March 2006

Howard, John H. (2003). *Evaluation of the Cooperative Research Centres Programme: A Report to the Department of Education, Science and Training* Howard Partners: Canberra.

Mitroff, I. and Linstone, H. (1993). The Unbounded Mind: Breaking the Chains of Traditional Business Thinking. New York: Oxford University Press.

Pires, Artur da Rosa and Eduardo Anselmo de Castro (1997). *Can a strategic project for a university be strategic to regional development? Science and Public Policy* 24 (1) 15-20

Sheen, P. B (2005), *Managing Intellectual Property and Licensing: A Study on Cooperative Research Centres*, unpublished PhD thesis, Queensland University of Technology.

Sullivan PH, (2000), *Value-driven intellectual capital: how to convert intangible corporate assets into market value*, Wiley, New York.

Van De Ven, A., Angle, H. and Poole, S. (2000). *Research on the Management of Innovation*, Oxford: Oxford University Press.

Wilke, H. and M. Kaplan, (2001). *Task creativity and social creativity in decision-making groups*, in C.M Allwood and M. Selart (eds), Decision Making: Social and Creative Dimensions, Kluwer Academic Publishers, Dordrecht, pp.35-51.