The Unholy Alliance:

Collaboration and Innovation in Property and Construction

The Cooperative Research Centre for Construction Innovation (CRC CI) commenced operations in July 2001. Its vision is to lead the Australian property and construction industry in collaboration and innovation specifically in the areas of business and industry development, sustainable built assets, and delivery and management of built assets. Collaboration between industry, government and research partners encourages researchers and users to leverage their strengths and experience in driving applied research for real industry outcomes.

A key focus of the CRC CI is the asset management/facilities management sector. The Centre is undertaking a number of collaborative research projects that emphasise the value in adopting a whole-of-life approach to civil and building infrastructure.

In this paper KEITH HAMPSON describes the Cooperative Research Centre Program, and provides a background to the Australian property and construction sector, and describes the CRC CI as a lead agent for change for its 19 partners and the property and construction industry as a whole. The paper concludes with a summary of its current facility management-related research projects.

Dr Keith Hampson is CEO of the Cooperative Research Centre for Construction Innovation. This paper was presented at Ideaction 2003 in Sydney, Australia.

A most significant commitment to Construction Research in Australia has been made by the Australian Government to establish a new Cooperative Research Centre for Construction Innovation (CRC CI) with funding and in-kind commitments to the value of A$64 million over seven years. The CRC CI is a truly collaborative venture between 19 industry, government and research partners across Australia, with key links internationally.

The CRC CI is an example of the Australian Government's program to build stronger links between industry, universities and research agencies to achieve world class research and innovation. There are currently 65 CRCs in Australia receiving A$145 million of Government funding per year, a figure which will increase to A$201m per year in 2003/04.

Industry has committed more than A$1060 million to date, with additional pledges of A$276 million over the next seven years.

One important objective of the CRC Program is to leverage government Research and Development (R&D) funding into the business sector to enhance Australia's Business Expenditure on Research and Development (BERD). There is a relative shortfall of business investment in R&D in Australia economy-wide as compared to other OECD countries (illustrated in ***Figure 1***).

Since being launched in May 1990, CRC's play

an important role in the Australian Innovation System (AIS). CRC's bring together researchers and research users from universities, the public sector and business who undertake long term, collaborative research and development ventures of substantial quality and size that contribute to national objectives.

The objectives of the CRC program are to enhance:

- the contribution of long-term scientific and technological research and innovation to Australia's sustainable economic and social development;
- the transfer of research outputs into commercial or other outcomes of economic, environmental or social benefit to Australia;
- the value to Australia of graduate researchers; and
- collaboration among researchers, between researchers and industry or other users, and to improve efficiency in the use of intellectual and other research resources (DEST, CRC Compendium, 2002).

Australia's construction sector operates against a backdrop of industry fragmentation, intense competition, falling profits and new challenges including IT advancements, increasing public interest in environmental protection, increasing demand for packaged construction services, and moves toward private-sector funding of public infrastructure.

Innovation and innovative behaviour are seen as key opportunities to raise the sector's performance and meet new challenges. However, to date innovation in the Australian construction poor innovation levels, government, have marked sector programs of limited effectiveness and poor uptake of innovation programs already available (Hampson and Manley, 2001).

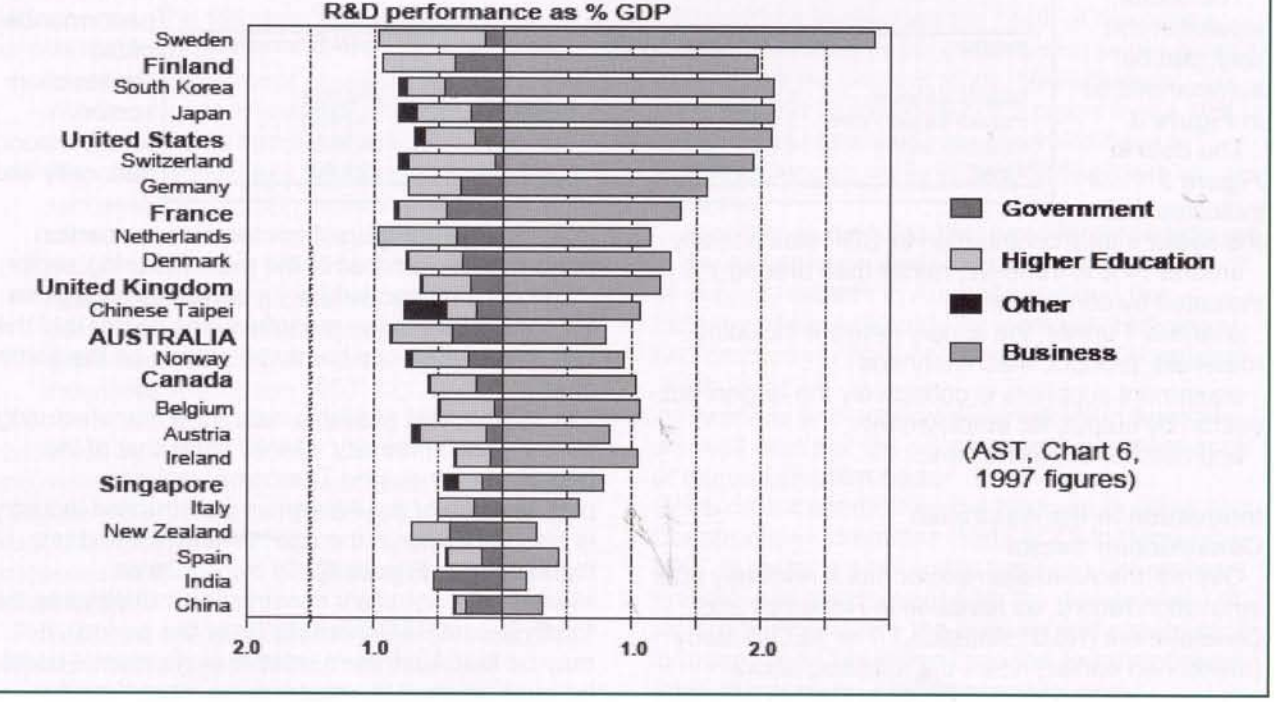
The Australian Property and Construction Sector

Both the private and public sectors in Australia undertake construction activity. The private sector is engaged in all three categories of construction (residential, non-residential building and engineering) and plays a major role in residential and other building activity. The public sector plays a key role in initiating and undertaking engineering construction activity and building activity relating to health and education (*Australia Now* 2002: http://www.dfat.gov.au/facts/).

The construction industry occupies a significant position in the Australian economy and plays a vital role in sponsoring economic growth. ***Figure 2*** illustrates the industry's long-term contribution to Australian national output.

Despite this, the Australian construction industry is highly fragmented with 94% of all businesses employing less than five people. Together they employ over two-thirds of all people working in the industry, but these small businesses earn slightly less than half of the total industry income (ABS 1996-97).

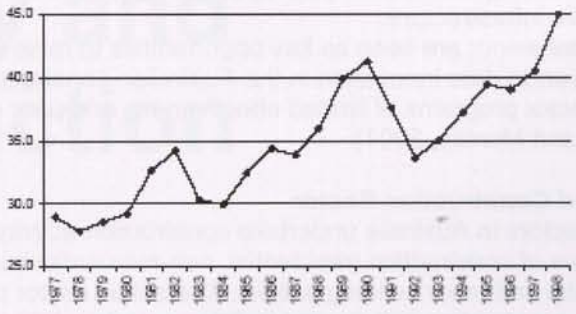
***Figure 1*: International R&D Performance** (Source: AST, 2000)



Over the past two decades, the Australian construction sector has grown at an average annual rate of approximately 2.6 percent in real terms. Over this period the industry, as conventionally defined, has mostly contributed a relatively stable proportion to GDP of between 6.5 and 7%. Such a contribution means the industry has a significant impact on national output. Even so, it is likely that this impact has been understated because it is based on a narrow definition of the industry (AEGIS 1999: 135).

There has been considerable focus in Australia over recent years on the performance of a *broadly defined* construction sector, which includes participants often overlooked in traditional analysis.

Figure 2: **Total Construction Industry Output (Value of Work Done), Australia, 1989-90 Prices, A$Billions, 1977-1998** [Source: AEGIS 1999: 136 (based on AUSTATS) and ABS advice[1]]



Whereas traditional analysis is based on the activities of project-based firms - firms that design, engineer and construct buildings and major projects, new analyses also take into account the activities of:

- the supply network - firms that manufacture and distribute materials, products, machinery and equipment; and
- the property sector - firms that invest in and manage property.

The sector, viewed in this way, can be summarised as in ***Figure 3***.

The data in ***Figure 3*** indicates that the sector's total contribution to GDP was actually around 14% in 1996-97, rather than around 7% as indicated by conventional analysis. Further, the supply network including materials, product, machinery and equipment suppliers is collectively the largest sub-sector, by output, for employment and number of businesses.

Figure 3: **The Australian Construction Sector, Key Statistics, 1996-1997** (Source: ISR 1999: 8)

Sector	Contribution to GDP	No of Firms	Total Employment
Supply Network	6.8%	165,300	452,900
Project-Based Firms	3.6%	46,600	182,400
Property Sector	4.0%	16,500	94,100
Total	*14.4%*	*228,400*	*729,400*

Innovation in the Australian Construction Sector

Overall, the Australian sector has a relatively poor innovation record, as revealed in Research and Development (R&D) statistics.2 The AEGIS study (mentioned earlier) notes the following about resources devoted to construction R&D in Australia:

Over the period from 1992-93 to 1996-97, R&D expenditure on construction averaged only 1.4% of total R&D expenditure in Australia. This is significantly less than the share of construction in total output, which averages around 6.5 to 7% of GDP [and up to 14.4% adopting a broad definition of the sector]. (AEGIS 1999: 60).

Further, in a ranking of Australian businesses by R&D expenditures, the Federal Government's *R&D Scoreboard .98* indicates that only one construction firm is among the top 20 private sector research performers (although another diversified company in the top 20 has some operations in the sector). Of the 325 companies listed by the *R&D Scoreboard* only 21 or 6.4% are in the construction sector (ISR 1999: 19).

Another key measure of the sector's R&D performance involves R&D intensity measures. The Australian sector's R&D intensity over a 13-year period during the 1980's and 90's is reflected in ***Figure 4***.

Despite significant growth in R&D intensity during the first half of the 1990s, the comparative performance of the construction sector remains poor, nationally and internationally. ***Figure 5*** compares construction performance with that of the manufacturing sector.

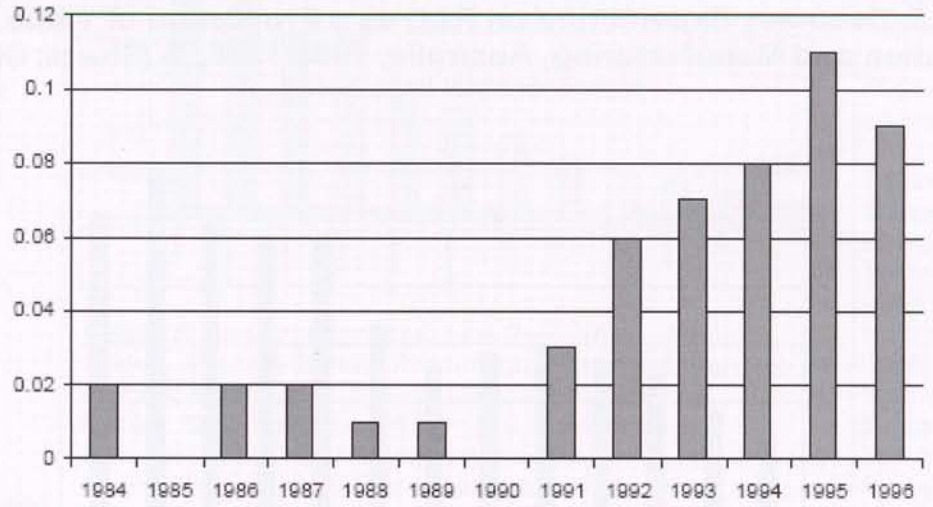
The construction industry's performance lags so far behind that of the manufacturing sector that the two sets of data can barely be plotted on the same chart.

In 1996 (latest available data), the manufacturing sector's R&D intensity was 40 times that of the construction industry. The comparative performance of the Australian construction industry is also very poor in the international context (as highlighted in ***Figure 6***). Of the countries measured, Australia's construction industry has the fourth lowest R&D intensity (over the period). It may be that Australia's relative performance could be even worse if the sector were more broadly

defined.

A recent study reviewed R&D per head of population for the built environment sector. The study defined the built environment sector to include the construction sector (broadly defined), together with energy utilities, water supply, sewerage, drainage, transport, and public order and safety services. For this very broad sector, R&D per head in 1996 was equivalent to US$50 in the US compared to US$14 in Australia (Cebon et al 1999: 3).

***Figure 4*: R&D Expenditures by Construction Contracting Firms as a Proportion of Construction Value Added, Australia, 1984-1996** (Source: OECD 1999, Main Industrial Indicators[4])



A number of other factors underlie the Australian construction sector's poor innovation performance. The following key innovation constraints are noted:

- financial commitment . construction innovation involves high levels of risk, including whether an innovation is transferable across projects;
- time . key employees are needed for successful innovation, however with construction firms .running so lean. such people often have little free time; and
- intellectual property . the benefits of construction innovation tend to be highly dispersed, reducing firm-level innovation incentives (Hampson 1997: 9).

Cebon et al's work was extended by research conducted by AEGIS (1999: 196-197), which uncovered the following impediments to innovation:

Site-based production . the temporary nature of production processes disrupts innovation processes, in large part because of short-lived relationships;

Project size and complexity . large and complex projects involve significant communication challenges and invite .disparate and discordant effort.;

risk of failure . the sector exhibits a preference for established practices, based in part on bad experiences historically in relation to public safety issues;

competitive bidding contracts . result in an overdeveloped sense of cost and an underdeveloped sense of value and the importance of innovation; and

changing finance systems . the trend for industry contractors to provide finance can further squeeze resources, which might otherwise be devoted to innovation.

It is difficult to canvass the costs of Australia's lack of innovation in the construction sector given the limits of the present study. Nevertheless, Stoeckel and Quirke (1992, 37) report that a 10% reduction of costs in the sector would have a significant impact on long term GDP growth in Australia.

Another study notes that turnover per employee in the construction sector is amongst the lowest of all industry sectors in Australia and that this indicates clear prospects for increasing efficiency and productivity through innovations. (Cebon et al 1999: 3).

Analysts and public policy makers in Australia are well aware of the poor innovation performance of the construction sector. The Australian Government established the National Building and Construction Committee (NatBACC) in September 1997 to foster a partnership between Government and industry and to advise on the development of an Action Agenda for the building and construction industry. The Committee included representatives from all major industry, commercial and

professional groups in the building and construction sector. NatBACC presented a series of 35 recommendations for consideration to the Minister for Industry, Science and Resources in April 1999 centring on actions the Government should take to assist the property and construction industry and public research agencies.

Recommendation 11 encouraged the Government to assist in formulating a bid for the selection round of the Cooperative Research Centre's (CRC's) Program in 2000 (NatBACC Recommendations, 1999).

CRC for Construction Innovation

The CRC for Construction Innovation (CRC CI) is a new CRC established as an unincorporated joint venture in July 2001 following a successful application during 2000.

The Centre was offered Commonwealth funding over a period of seven years commencing 1 July 2001 and totalling A$14 million within the total Centre resources of A$64 million. CRC CI was established to strengthen industry collaboration and to develop key technologies, tools and management systems to improve the effectiveness of the Australian construction industry. The CRC CI is the only Cooperative Research Centre specifically servicing the needs of this important sector of the Australian economy.

CRC CI research incorporates a balance of short, medium and long-term activities and a portfolio of projects that reflect the diversity of the property and construction industry and the lifecycle of the constructed product.

Research projects require collaboration across at least two industry partners and two research partners. The integration of industry, government and researcher input provides for industry-focussed projects jointly managed over the project life, and a path for technology diffusion that capitalises on the complementary roles of each participant in the industry.

Research projects undergo a rigorous selection process based on their ability to make a real difference to industry; their research quality and compatibility with partner needs and capabilities; and their potential for industry Development or commercialisation.

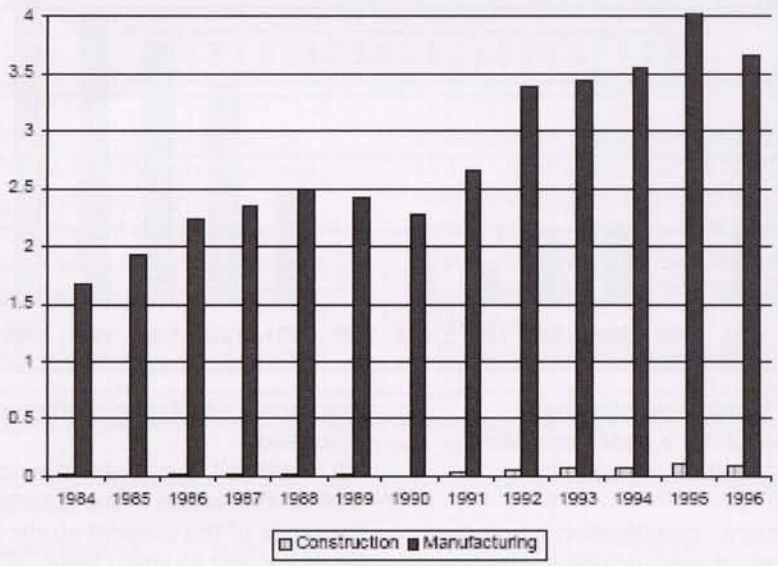
The CRC CI's collaborative research activities combine basic and strategic research and development in three integrated programs:

1. business and industry development,
2. sustainable built assets, and
3. delivery and management of built assets.

The use of advanced information and communication technology underpins each of these three programs. ***Figure 7*** illustrates the three-program structure.

Directors and Deputy Directors lead research Programs and the ICT Platform. The Director derives from one of our research partner organisations while the Deputy Director derives from our industry partner organisations. Each Program and the ICT Platform are described in more

***Figure 5*: Business Expenditure on R&D as a Proportion of Value Added, Construction and Manufacturing, Australia, 1984-1996, %** (Source: OECD 1999, Main Industrial Indicators[5])



detail below ***(Figure 8)***.

Education and industry dissemination also forms a vital component of the CRC CI. The CRC is investigating opportunities for skill development to enhance the competitiveness of the Australian construction industry.

The 19 partners represent leading industry, government and research organisations throughout Australia, and include:

- Arup Australasia
- Queensland Department of State Development
- Australian Building Codes Board
- Queensland University of Technology
- Bovis Lend Lease
- Rider Hunt
- Building Commission, Victoria
- Royal Melbourne Institute of Technology
- CSIRO
- Springfield Land Corporation
- DEM Architects
- University of Newcastle
- John Holland
- University of Sydney
- Kennards Hire
- University of Western Sydney
- Queensland Department of Main Roads
- Woods Bagot
- Queensland Department of Public Works

CRC CI is headquartered at Queensland University of Technology (QUT) in Brisbane, with research nodes in Brisbane, Sydney, Newcastle, Canberra and Melbourne. It has also recently entered into an international strategic alliance with CRC CI Research Programs

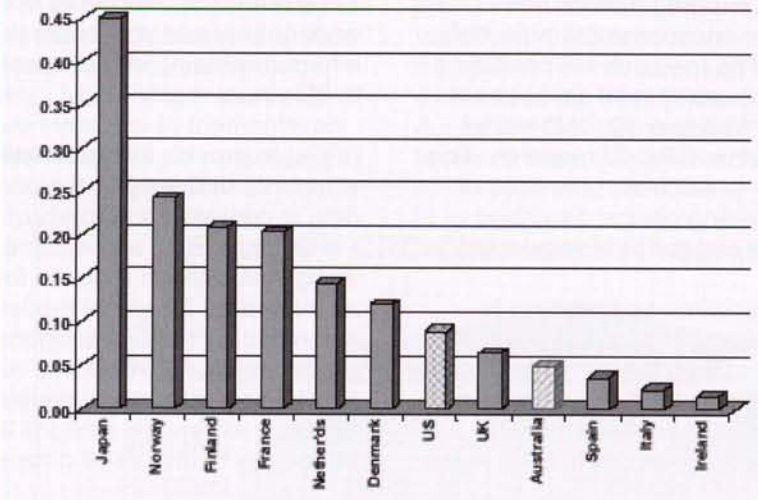


***Figure 6*: Construction R&D as a Proportion of Value Added, Average Annual Proportion, 1986-1996, Various OECD Countries, %** (Source: Compiled by Dr Karen Manley, QUT, based on OECD 1999, Main Industrial Indicators; OECD STAN; US National Science Foundation. US figure 1996 only. Countries shown are those for which comparable data is available.)

Business and Industry Development

To improve the long-term effectiveness, competitiveness and dynamics of a viable construction industry in the Australian and international contexts through:

Greater innovation in business processes,

Strengthened human relations and ethical practices, and

More effective interactions between industry and its clients.

Sustainable Built Assets

To drive healthy and sustainable constructed assets and optimise the environmental impact of built facilities through:

Sound conceptual basis for economic, social and environmental accounting of the built environment,

Virtual building technology to examine design performance prior to documentation, construction and use, and

Assessing human health and productivity benefits of smart indoor environments.

Delivery and Management of Built Assets

To deliver project value for stakeholders for the whole-of-life, from business need, design and construction through to ownership, asset management and reuse through:

Improved communication and use of information,

Increased productivity and value, and

Effective delivery and management of whole-of-life assets.

ICT Platform

ICT is the fundamental enabler of process re-engineering in the property and construction industry. The ICT Platform integrates the ICT input and acts as a leading research and development organisations in Europe and North America including: The University of Salford (UK), VTT (Finland), CSTB (France) and Stanford University (USA). This global alliance . ICALL (International Construction Research Alliance) aims to drive excellence in built environment research to benefit industry and society. The Australian CRC CI is a core partner to this key group, which will collaborate on applied research projects, conferences and workshops, student and researcher exchanges and joint international promotion.

Current Research Projects

The CRC CI currently has 20 research projects

underway across Australia. A significant focus relates to the FM sector. A summary of the key projects are:

Environmental Assessment Systems for Commercial Buildings

(2001-006-B Project Leader . Selwyn Tucker, CSIRO)

This project will provide a practical tool, known as LCADesign, for designers, material producers, government regulators, building owners and managers to assess the environmental impact of commercial buildings. The research will produce a tested prototype of the nvironmental assessment tool capable of being linked to a 3D CAD model being developed in another CRC CI research. This model has the capacity to calculate quantities of each element in any building design described in the 3D computer model and the ecological footprint of those elements.

The benefit of this research to designers is access to the environmental impact and costs of commercial buildings enabling the consideration of these two aspects in tandem as design decisions are being made. This link is clearly essential in a market where construction decisions have to make commercial sense.

Managing Information Flows with Models and Virtual Environments

(2001-007-C Project Leader . Robin Drogemuller, CSIRO)

CRC CI researchers have recognised two important developments that provide the basis for a dramatically better approach to use advanced ICT in construction.

The first is the use of advanced ICT which already enables designers in other industries to work quickly and accurately with complex sets of information using object-oriented databases linked to 3D virtual reality

development of Industry Foundation Classes (IFCs) to provide internationally accepted standards that support the communication of digital data in construction projects.

IFCs provide an architecture allowing all the design information required for a building to form an integrated 3D virtual model, which can be linked automatically to the management systems, used in controlling quality, time and cost.

The new technology developed through this research will enable designs to be analysed more thoroughly to ensure all details are constructed

efficiently, within budget and on time. Better quality buildings will be able to be produced faster and at lower costs.

Smart Building for Healthy & Sustainable Workplaces

(2002-043-B Project Leader . Greg Foliente, CSIRO)

This project promotes social, economic and environmental sustainability in the built environment by research in an area of potentially significant impact being the development of 'smart building. technologies that support healthy indoor environments and energy efficient operation and maintenance of workplaces.

While the CRC CI team is working on a scoping study in the first instance, the long-term goal for this project is to develop and implement technologies to support healthy, eco-friendly and commercially viable buildings and facilities, and facilitate triple-bottom-line assessment and reporting. The study aims to review and assess technologies that could measure and control factors important for healthy and sustainable workplaces.

Benefits include development of smart building technologies, improved worker productivity, reduced building operation and maintenance costs. In addition to these immediate financial benefits, there are also long-term environmental benefits to the wider community through reduced energy usage.

There is also potential for improving design concepts in both architectural and engineering aspects, and in developing new materials, sensors and technologies for future smart-building systems, and in monitoring their effectiveness in reducing lost productivity costs associated with deficient working environments.

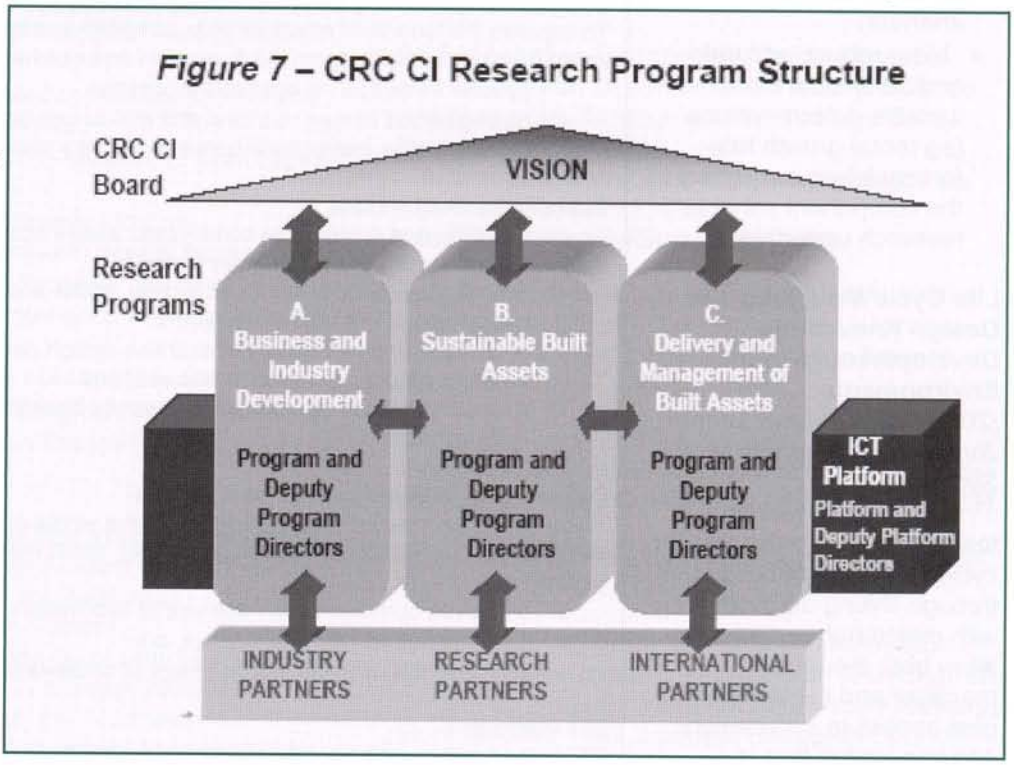
Investment Decision Framework for Civil Infrastructure Asset Management

(2001-010-C Project Leader . Arun Kumar, RMIT)

In the short term CRC CI researchers on this project are developing an investment decision framework for asset management in the roads sector incorporating economic, environmental and social factors using multi-criteria analysis. In the long term the framework will be developed into a software tool for road data and monitoring techniques. The model may then be modified for application to other infrastructures such as railways, buildings, and bridges.

The benefit of this research for the construction industry is the ability to better advise clients on effective investment choices and to the ability to identify and implement an investment decision framework for infrastructure asset management. An example of the usefulness of this model is that during the first 12 months of the project, the research team has been able to identify significant potential savings for private and public civil asset owners.

Figure 7 – CRC CI Research Program Structure



Evaluation of Functional Performance in Commercial Buildings

(2001-011-C Project Leader. Terry Boyd, QUT)

This CRC CI team of researchers and industry experts is seeking to enhance commercial real estate performance within both operational and investment contexts through the evelopment of a model designed to support improved decision making over the life cycle of the facility.

Benefits from this project will include an enhanced appreciation and understanding of property market trends, forecasts and facility management. These trends and forecasts will provide access to a practical market-based cash flow model. The tool will guide the buy/sell/hold/

redevelop decision process and will be a standardised model capable of assessing:

- The most probable current value for a given property and potential value range
- Historical value change
- Value sensitivity to social, environmental and governance variables
- Value/return outcomes under alternative scenarios (eg different holding periods, various capital expenditure positions)
- Enhanced knowledge and understanding flowing from component variable research (eg property market cycles, tenant demand, and risk analysis)
- More robust, accurate and defensible input variable determinations (eg rental growth rate forecasts) as a corollary to the component variable research undertaken.

Life Cycle Modelling and Design Knowledge Development in Virtual Environments

(2001-002-C Project Leader . John Gero, University of Sydney)

This CRC CI research team aims to improve the life cycle modelling of buildings through linking 3D models with maintenance data to allow both the facility manager and the designer to gain access to information and knowledge that is currently inaccessible. The research also integrates data mining agents into the maintenance process to produce timely data for the facility manager on the effects of different maintenance regimes.

Benefits of the research outcomes include the provision of better connections between maintenance and design knowledge on projects. This will be achieved by having access to a demonstration modelling tool in a 3D environment that can be attached directly to an Asset Management Systems.

Decision Support Tool for the Use of Fibre Reinforced Polymer (FRP) Composites in Rehabilitation of Concrete Structures.

(2002-005-C Project Leader . Sujeeva Setunge, RMIT)

CRC CI researchers are developing a decision support tool for identifying the most efficient methods of using Fibre Reinforced Polymer composites for strength and durability enhancement in ageing concrete structures. This integrated approach will facilitate the transfer of knowledge gained from current fragmented technical research and available case-studies and will add a whole of life value concept providing a unique tool suitable for asset managers. The general framework developed will be suitable for decision making in rehabilitation of structures under different scenarios.

Benefit includes access to a decision support tool to enable asset owners and managers to select the most suitable technique using FRP composites for rehabilitation of aging concrete structures. The decision support tool will include:

Assessment of extension of economic life in compliance with the current design philosophy of concrete structures codes,

Cost/benefit analysis of construction procedures, and

Assessment of intervention of deterioration at different stages of the lifecycle.

Figure 8 - **CRC CI Research Programs**

CRC CI Research Programs

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- Improved communication and use of information,
- Increased productivity and value, and
- Effective delivery and management of whole-of-life assets.

ICT Platform
ICT is the fundamental enabler of process re-engineering in the property and construction industry.

Life Prediction of Building Material Components

(2002-010-B Project Leader . Ivan Cole, CSIRO)

This CRC CI team recognises there is a crucial need for a comprehensive and reliable database of building sub-systems and component service life as a function of environment and use. The Durability of Materials Fraternity in Australia and internationally is making progress in predicting the life of individual components for specific materials but it will be many years before comprehensive databases are constructed from such studies. The CRC CI is developing a pilot Delphi study bringing together an expert panel of architects, scientists, statisticians, IT professionals, asset and facility managers, and construction contractors. This multi-sectoral team will ensure robustness as well as the ability to gauge variability in opinion, with a focus on metallic components.

Benefits from this research include access to a database that can be used for:

- Life cycle costing (LCC) - as distinct from capital costing of buildings
- Eco-efficiency assessments (cost vs environmental assessment) design tools
- Decision support tool for asset planning, estimating future maintenance and replacement outlays on assets
- Building maintenance optimisation
- Design tools for optimising component selection
- Acquisitions strategies/feasibility.

Conclusions

Cooperative research centres integrate the efforts of researchers and research users under one roof, and are a major plank of the Australian Government's Innovation System.

Property and construction represent 14.4% of the Australian economy and is a major stimulus to economic growth. Overall, the Australian construction sector has a relatively poor record of Research and Development (R&D) compared to other Australian industries and international comparisons of investment in construction.

The Australian CRC for Construction Innovation (CRC CI) represents a major opportunity for strengthening the research base of the Australian property and construction industry, as well as driving collaboration and innovation. CRC CI research incorporates a balance of short, medium and long-term activities and a portfolio of projects that reflect the diversity of the property and construction industry and the lifecycle of the constructed product.

A significant focus of CRC CI research relates to the facilities management sector, with projects across the sustainability, investment decision analysis, and civil and building focus, from a building material, project and industry perspective.

Each project is underpinned by an advanced information and communication technology platform ensuring consistency and interoperability across the research project portfolio. The CRC CI is well poised for making major inroads into improving the international effectiveness of the Australian property and construction industry this next decade.

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