

**Construction 2020: A Vision for Australia's Property and
Construction Industry**

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CONSTRUCTION 2020

A Vision for Australia's Property and Construction Industry



Keith Hampson

Peter Brandon

best dreams*

collaboration cohesion communication cooperation

"Dirt and danger replaced by decency and delight."

"Design: paperless, visual, automated and testable!"

"Long life, loose fit, low energy – our mantra!"

"Australia has the same attitude to construction performance as it does to sport performance."

"Integrate supply chains, engage their knowledge, capture output efficiency!"

"Information technology empowers individuals to improve their lot and the industry!"

"Integrated supply chain – using advanced information technology to seamlessly design, cost, manufacture and assemble buildings."

"Cost-effective, environmentally sustainable, aesthetically appealing, functional spaces for living and work that are accessible to all Australians."

"An industry that is well respected in the community as innovative, where young people are excited about employment opportunities."

"An industry that maximises reuse of materials for construction and reconstruction, minimises waste and creates buildings that can be easily modified using simple materials."

"An attractive, well-designed sustainable built environment improving lifestyles and Australia's economic prosperity, built by an industry strongly committed to sustainability with a community that values the contribution and professionalism of the industry."

"Seamless communication and data transfer between organisations during all phases of the design, construction and whole-of-life operation of a development."

*Construction 2020 asked workshop attendees around Australia to provide their best dreams and worst nightmares for our property and construction industry.

This is a selection of the Best Dreams.

CONSTRUCTION 2020

A Vision for Australia's Property and Construction Industry



Keith Hampson

Peter Brandon



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Foreword

The Australian Cooperative Research Centre (CRC) for *Construction Innovation* is committed to leading the Australian property and construction industry in collaboration and innovation.

Our industry is under pressure. Globalisation, advances in technology, environmental factors and changes in the structure of the Australian economy are presenting new challenges. To increase its contribution to Australia's wellbeing and to capture new opportunities, the industry must respond positively. New challenges require new approaches. A more collaborative approach to industry-focussed research and development and education is required.

Construction 2020 is an important *Construction Innovation* initiative to capture what the Australian industry believes are its future directions, to explore barriers to achieving this future and to identify the research required to realise the future of this industry.

I acknowledge the key support of industry leaders and members across the country in responding to questionnaires and attending workshops in the important industry consultation phase of *Construction 2020*. I am personally committed to the success of this initiative as an important step in strengthening the national relationship between our CRC and its industry and community stakeholders.

This *Construction 2020* initiative has benefited significantly from the input of Professor Peter Brandon, of The University of Salford, UK. Peter's breadth of international experience and his capacity to question each assumption has provided us with challenges that have substantially improved the quality of our approach. Complementing this, the energy and commitment from our CRC's Chief Executive Officer, Dr Keith Hampson, has ensured the success of this venture to this stage.

I look forward to sharing the results of this study with the industry throughout 2004 and leading the transformation of the Australian property and construction industry to a new era of applied research and innovation.

John McCarthy
 Chair
 CRC for *Construction Innovation*





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A Vision for Australia's Property and Construction Industry

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About the authors

Dr Keith Hampson is committed to building a more internationally competitive Australian property and construction industry by developing applied technology and management solutions, and delivering better education and technology transfer.

As Chief Executive Officer of the CRC for *Construction Innovation*, Keith has responsibility for crafting a blend of commercial and public good outcomes on behalf of the Centre's industry, government and research partners. Keith's career has spanned these three sectors, where he has developed a reputation as an energetic leader with a strong blend of technical and management skills and formal qualifications gained through international experience and scholarship.



Professor Peter Brandon recently completed his term as Pro-Vice-Chancellor for Research at The University of Salford, UK – the only UK University to be awarded a 6-star rating in the Built Environment in the independent UK Research Assessment Exercise. He is now the Director of Strategic Programmes.

Peter's research interests range from construction economics and management to information and knowledge-based systems for construction and more recently sustainable development. Several of the outputs of his research have resulted in commercial products. He has played a significant role in UK construction research policy. Peter founded *Construct IT*, the UK National Centre for Construction IT (which won the Queen's Anniversary Prize for Higher Education), and has established six other centres which work with industry on research and innovation.



Executive summary

Property and construction is unquestionably one of the most significant industry contributors to the Australian economy in terms of GDP and employment. Yet globalisation, advances in technology, environmental factors and changes in the structure of the Australian economy are presenting new and serious challenges. To increase its contribution to Australia's wellbeing and to capture new opportunities, the industry must respond positively. New challenges require new approaches.

Looking to the future is an important step in self improvement. This report presents the results of *Construction 2020* – an important national initiative, carried out by the Cooperative Research Centre for *Construction Innovation*, to identify where the Australian industry believes future directions lie, explore barriers to achieving these and to define the research required to realise the future of this industry. Quantitative and qualitative analysis completed in early 2004 highlighted the need for a more collaborative approach to industry research and development and education.



Nine key visions for the future emerged from the *Construction 2020* process:

1. Environmentally sustainable construction
2. Meeting client needs
3. Improved business environment
4. Welfare and improvement of the labour force
5. Information and communication technologies for construction
6. Virtual prototyping for design, manufacture and operation
7. Off-site manufacture
8. Improved process of manufacture of constructed products
9. Australian leadership in research and innovation.

Each vision is presented separately in this report. The visions provide a framework within which Australia can set its own research and industry development agenda to position itself to perform more competitively at an international level.

The overarching (or ninth) vision of achieving Australian leadership in research and innovation in delivering the 2020 vision is for the industry to embrace the concept of industry, government and research working together through applied research and innovation. A culture of self-improvement, mutual recognition, respect and support underpins this vision. By 2020, the vision is for the industry to be taking more responsibility for leading and investing in research and innovation. The tripartite collaboration between industry, government and research should have developed a robust and viable national research and innovation capability delivering real value to Australian property and construction business.

Australian industry has also clearly expressed the need in this change process for improved education and training. Accordingly, an important focus will be on education and training providers to deliver relevant education programs for both fresh industry entrants and experienced professionals to prepare them for tomorrow's challenges.

It will be the responsibility of the property and construction industry as a whole to ensure its ongoing future by exploiting research and innovation to continuously improve itself in line with international competition and to meet the increasing demands of clients and the community. Government at all levels has a responsibility as a major client and industry regulator and legislator to use its position of influence to drive industry improvements and promote research and research user linkages.



Conceiving the 2020 vision

The last time a report was produced on the state of the Australian property and construction industry was in the late 1990s – a government–industry initiative which brought together major players to identify issues to lift industry performance. The formation in 2001 of the Cooperative Research Centre (CRC) for *Construction Innovation* to service the applied research and development (R&D) needs of this important industry was one of the recommendations arising from the National Building and Construction Committee (NatBACC) and Australian Government Action Agenda process. The CRC for *Construction Innovation* is committed to leading the Australian property and construction industry in collaboration and innovation. *Construction Innovation* believes that applied research and development (R&D) will contribute to a more viable and sustainable Australian industry. Now that we have a CRC servicing the Australian property and construction industry, we look to the industry to help clarify the vision for the future.

Property and construction is a vital part of the Australian economy. As well as its own output, it has a significant impact on the efficiency and productivity of other industries. It promotes investment through its activities and generates further investment in the broader economy. According to Australian Bureau of Statistics figures, the industry accounted for 6.3 percent of Gross Domestic Product (GDP) at A\$46 billion and more than 7 percent of the labour force (730 000) in fiscal year 2002–3. However, this figure for GDP underestimates the full impact of the construction industry cluster. Analysis conducted as part of the Australian Government's Action Agenda for the industry estimated that the actual contribution of the construction cluster was roughly double the standard figure, accounting for 14.4 percent of GDP. Construction is unquestionably one of the most significant industry contributors to the Australian economy in terms of both GDP and employment.

"We need an industry that is recognised for delivering community assets and environmentally world-class assets as well as superb, economically performing assets. We need to be a sector that will attract the most talented people of each generation and provide appropriate rewards for risk taking." – Peter Verwer, Chief Executive, Property Council of Australia

The international context

For many countries, looking to the future is an important stage along the path to self-improvement. Over 30 countries have completed foresight exercises over the past three decades as part of national policy development or as part of an industry initiative.

In property and construction, some common themes have emerged that are shared across other industry sectors. Nearly all reports look at the *drivers* (the issues that will impact on the industry but are not under its control) broadly identified as:

- globalisation of the business environment
- demographic change
- urbanisation and the growth of city dwelling
- environmental sustainability and climate change
- aspirations for an improved quality of life
- new materials and technologies
- information, knowledge management and communication technologies
- governance and regulation
- vulnerability and security.

It is difficult to summarise how countries have responded to these drivers in examining their future aspirations for property and construction. However, the following are some of the key *aspirations* raised:

- environmentally sustainable development correctly benchmarked and evaluated
- full facility life cycle management and appraisal including cost and performance
- less adversarial procurement methods with fairer risk sharing
- improvement of the existing building/infrastructure stock for higher performance
- harnessing of information and communication technologies (ICTs) for more efficient working and better performance
- improved supply-chain management and rationalisation to improve efficiency of procurement and performance
- integration of processes *from cradle to grave*
- off-site manufacture of components to improve quality and reduce construction time
- improved site working conditions
- larger talent pool and improved skill levels
- improved financial and business environment for property investment and operation
- improved international competitiveness
- more systematic realisation of client needs and demands
- new materials and manufacturing technologies
- applied R&D with seamless collaborative industry and research involvement.

Like any other area of study, built environment research goes through phases, but the above aspirations have proved remarkably resilient over time and across national boundaries.

This broad review of drivers and aspirations seems to point to a general concern that:

- property and construction has not transformed itself sufficiently to meet today's demands, though it has the potential to do so if the will and business advantage can be identified
- the industry requires upskilling in a number of key areas of management and ICT
- the image of the industry and its treatment of the site workforce is poor
- the industry requires improved project delivery methods that meet client needs more effectively and equitably
- a more aware public will be more demanding of a sensitive interface between the natural and built environments
- R&D providers and industry have not collaborated well in the past.



"My vision is for us to be extremely smart, to be world leaders in innovation, and to be able to say, with justification, that we are leading-edge world's best practice." — John McCarthy, Chair, CRC for Construction Innovation



"Construction 2020 is about engaging with Australia's industry and ensuring a continuing focus of research delivering real business outcomes." — Dr Keith Hampson, Chief Executive Officer, CRC for Construction Innovation

Construction 2020 takes shape

The CRC for *Construction Innovation's Construction 2020* initiative is further engaging Australian industry in its activities, and focussing its ongoing research activities on real industry issues.

Construction 2020 began with a series of workshops held between November 2003 and February 2004 in every capital city of Australia. It sought the views of hundreds of industry leaders and members on the direction and challenges facing the Australian property and construction industry today and into the future. The questionnaire and workshop discussions asked respondents to consider a timeframe beyond the five to ten years covered in previous reports, and extend their vision to the year 2020. In doing this, the constraints of the present were expected to be less restricting and longer-term aspirations of the industry more evident.

The *Construction 2020* initiative:

- captures the visions towards which the Australian property and construction industry must head if it is to achieve sustainable world's best practice
- identifies the barriers to achieving those visions
- identifies how education and applied research can lead the industry to achieve this vision.

The respondents also described their best dreams and worst nightmares for the industry.

The visions evolve

Construction 2020 – A Vision for Australia's Property and Construction Industry has resulted from the collection and analysis of input from industry. A text analysis software package analysed the qualitative responses from the questionnaires and workshops and grouped them based on similarities. The results showed that responses reflect the major concerns of the industry and the expected improved future environment in which its stakeholders would like to work. The quantitative responses from the questionnaire were also analysed. Appendix III outlines the key results arising from this process. Based on these two data sets/response types, nine key themes for the future emerged. We have called these *visions*, and they are:

1. Environmentally sustainable construction
2. Meeting client needs
3. Improved business environment
4. Welfare and improvement of the labour force
5. Information and communication technologies for construction
6. Virtual prototyping for design, manufacture and operation
7. Off-site manufacture
8. Improved process of manufacture of constructed products
9. Australian leadership in research and innovation.

Each of the nine visions is presented separately, though in reality the visions are interdependent as the boundaries between them are blurred. The visions provide a framework within which Australia can set its own research and industry development agenda to position itself to perform more competitively at an international level.

The ninth vision – Australian leadership in research and innovation – is the overarching vision central to delivering the 2020 vision and is therefore considered first.

Figure 1 illustrates relationships between the nine visions that emerged from the industry consultation process. Listed vertically are the five visions that stakeholders want to see improvements in. Across the top are the technological and managerial breakthroughs which respondents believe can make a major impact on those five visions. These breakthroughs represent the remaining four visions. The shading indicates their level of potential impact (strong, medium or weak) on each of the visions.

“... the CRC for Construction Innovation is all about making the change from yesterday to tomorrow ...” – John McCarthy, Chair, CRC for Construction Innovation

Potential impacts	Design and communication		Process and manufacture	
	5. Information and communication technologies	6. Virtual prototyping	7. Off-site manufacture	8. Improved process of manufacturing
1. Environmentally sustainable construction	Strong	Medium	Strong	Strong
2. Meeting client needs	Strong	Strong	Weak	Medium
3. Improved business environment	Medium	Medium	Weak	Medium
4. Improvement of labour force	Strong	Medium	Strong	Strong
9. Research and innovation	Strong	Strong	Strong	Strong

Figure 1 Relationships between the Construction 2020 visions



Delivering the 2020 vision

"We need research to minimise the downside of the fragmented nature of the industry in terms of collaboration across company boundaries."

Construction 2020 is a most significant initiative for Australian property and construction. For the first time, direct engagement at a national level between researchers and industry is being conducted to ask industry what they need. Industry has clearly identified a closer relationship between researchers and research users as an aspiration for the future. Australian leadership in research and innovation is a key step to achieving a world's best practice industry.

The *Construction 2020* questionnaire and discussion outcomes have provided rich material for analysis in this industry report and for the future as we focus our efforts on targeted industry research, education and technology diffusion. Our task now is to act on this information in delivering better outcomes for Australia's property and construction industry and the community.

This section provides a response to delivering the 2020 vision. It is an integrating vision that overarches the eight more specific visions that follow in Section 3.

Each vision is discussed under the following headings:

The vision – a statement of the overall theme respondents are seeking in their quest for a better industry.

Why this vision? – the identified drivers for the vision, sourced from questionnaire and workshop responses and industry data.

The industry today – a snapshot of the current situation in the industry, gleaned from the questionnaire and workshop responses, and industry knowledge.

Achieving this vision – our analysis of the education and R&D pathways required for delivering the vision, informed by industry respondents.

Barriers – an analysis of the barriers-to-change responses collated through questionnaire and workshop discussions.

Assessing progress – a description of how progress may be assessed in achieving the industry vision.

Relevant quotes from the questionnaires and workshops have also been included to add a personal insight to each vision.



The overarching vision: Australian leadership in research and innovation

The vision

In this overarching vision, the property and construction industry strongly supports industry, government and research working together to advance the effectiveness and competitiveness of Australian industry through applied research and innovation. A culture of self-improvement, mutual recognition, respect and support underpins this vision.

By 2020, the vision is for the industry to be taking more responsibility for leading and investing in research and innovation. The tripartite collaboration between industry, government and research should have developed a robust and viable national research and innovation capability delivering real value to Australian property and construction business and the community.

Why this vision?

Construction is the backbone of the Australian economy. If the industry uses its resources more effectively and raises its efficiency by reducing construction cost and time, and increasing quality, Australian industry as a whole will be more competitive. Many studies have highlighted the positive relationship of investment in R&D and returns to firms, industries and national economies.

Construction 2020 respondents indicated refreshing support for more active applied R&D in this traditionally conservative industry. One important best dream was that *a new self-improvement culture emerges from engagement with R&D*. Since the 1980s, property and construction R&D in Australia has been carried out in a fragmented and competitive manner, with few enduring national linkages spanning industry or government research users. Respondents believe there is a better way. Synergies between research users can provide the opportunity for focussed and applied benefits. On the supply side, leveraging the research capabilities across universities and CSIRO can provide better staffing and equipment for leading-edge research. It can also develop an internationally significant critical mass to produce real outcomes and promote international legitimacy for Australian R&D.

The industry today

Property and construction training programs are being delivered through key industry associations (often in conjunction with private providers and universities) offer some professional development programs to complement their formal award programs. A number of Australian states are now requiring their trade and professional staff to undertake professional development programs to maintain their registration to practice, but there is a need for a more current and nationally uniform approach reflecting the input of leading-edge research.

Property and construction research is carried out in about half of Australia's 39 universities and in a number of other public-sector research institutions, including CSIRO in particular. Some research is also performed in the private sector. Previous studies indicate that many of these institutions undertake projects with the potential to have a positive impact on industry costs, productivity and international competitiveness. But few national linkages exist and the ability to collaborate nationally and capitalise on activities internationally has eluded the Australian property and construction industry until recently.

"Australia has the ability to set best practice standards for the rest of the world through credible and renowned R&D channels."

The Cooperative Research Centre for *Construction Innovation* was established in 2001 to lead the Australian property and construction industry in collaboration and innovation. *Construction Innovation's* research is making a difference to the business and cultural environment of its partners. Its broader industry development role is progressing as education and technology dissemination takes place – but additional commitment from the industry is required. The property and construction industry in Australia does not have a broadly accepted R&D culture, yet the national *Construction 2020* workshops confirm a growing acceptance of the need for applied R&D to improve effectiveness and efficiency across the industry. This trend has emerged from a base of some historical cynicism and lack of cultural understanding between researchers and research users in relation to their counterparts' drivers, behaviours and expectations.

To sustain this vision of Australian leadership in research and innovation, continued leadership will be required building on the fundamental belief that applied R&D and innovation will contribute to a more viable and sustainable Australian property and construction industry.

"We need more communication and collaboration between industry and researchers so we each know what is really going on in each other's patch."

Achieving this vision

Collaboration between industry, government and researchers is seen as the lynchpin to success in achieving this vision. Mutual recognition, respect and understanding in this relationship is crucial. Industry needs to achieve real business benefits while researchers need ongoing commitment and funding to achieve research outcomes. Early and clear successes in demonstrating the practical benefits of applied research will provide an entrée to longer-term success and mutual benefit.

In many cases the benefits are as likely to be implicit as well as explicit – with mutual learning arising from researchers and industry *rubbing shoulders* being as important as formal research outcomes. Heightened understanding of research processes for industry managers, and of industry drivers for researchers, is critical if the input of each partner is to be appropriately recognised and valued.

Further development of international alliances between researchers and research users is necessary to ensure Australia maximises the benefit of its modest investment in property and construction research. But Australia must *focus to make an impact* and take advantage of its research and industry strengths and international opportunities.

“My vision for the year 2020 is of an industry that invests more in R&D, is more innovative and has an international focus, particularly in relation to professional services.”

Education strategy

The positive relationship between applied research and industry benefits needs to be further developed at all levels of education – at trade, professional and managerial levels. Accordingly, links between applied R&D organisations and the vocational education and training (VET), Technical and Further Education (TAFE) and higher education sectors, is essential to provide the foundation for tomorrow’s industry leaders to value and promote the industry–research relationship.

Australian industry is recognising the need for change in the areas of business environment, environmental sustainability and information and communication technologies (refer to Section 3 for details). It also recognises the need in this change process for improved education and training in these areas. Accordingly, an important focus will be on delivering up-to-date, flexible and relevant education programs for the industry in preparation for tomorrow’s challenges.

Construction 2020 respondents highlight the value of:

- case studies or demonstration projects as valuable teaching tools through industry awareness programs (especially useful for small to medium enterprises (SMEs))
- national consistency of education to service a mobile and project-based workforce (complementing nationally consistent standards and legislation)
- integration of effort between TAFE, VET and higher education sectors together with professional and trade organisations.

Construction Innovation has as one of its core goals the development and delivery of industry-ready education and technology transfer programs. It will continue collaborating with CRC partners and education providers to enhance the value to Australia of graduate researchers, to deliver relevant professional development to industry and research personnel and to influence the curriculum of TAFE, VET and higher education providers.

R&D strategy

The research challenges and opportunities identified by industry through this *Construction 2020* process are significant and exciting. Integrating R&D strategies from the following eight specific visions includes the ability to impact industry performance by:

- developing tools for evaluating design standards and facility performance
- identifying more appropriate skill requirements for a changing business environment
- encouraging national uniformity of codes of practice and legislation
- comparisons with other national and international industries for adaptation of advanced approaches to Australian property and construction
- process analysis to better understand and identify interactions and opportunities for improved practice.

The integrated research agenda to achieve Australian leadership in research and innovation will leverage from existing achievements and the identified industry visions that follow in Section 3.

Construction Innovation's existing research structure is shown in Figure 2 and the program objectives follow. The three core programs of research are supported by an advanced ICT platform. This structure incorporates the research goals of its participants – shaped through a process of regular consultation at multiple levels.

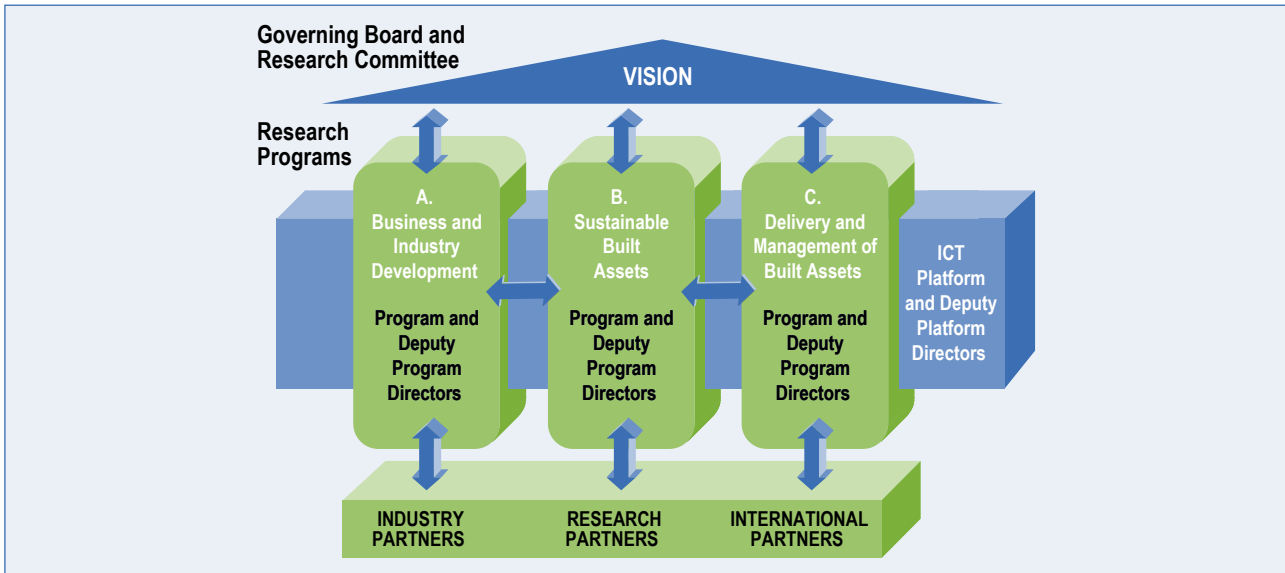


Figure 2 CRC for Construction Innovation: Research Program Structure

A Business and industry development

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

- greater innovation in business processes
- strengthened human relations and ethical practices
- more effective interactions between industry and its clients.

B Sustainable built assets

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

- a 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
- assessment of human health and productivity benefits of smart indoor environments.

C Delivery and management of built assets

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

- improved communication and use of knowledge
- increased productivity and value
- effective delivery and management of whole-of-life assets.

Building on Australia's strengths in R&D across five universities and CSIRO, *Construction Innovation* has formed international alliances ensuring Australian property and construction is linked with key international R&D providers. The International Construction Research Alliance (ICALL) between the CRC for *Construction Innovation* and leading international research organisations in North America and Europe will provide a vehicle for ensuring that Australian leadership in research and innovation is informed by global initiatives. Additionally *Construction Innovation* has now been appointed to the Governing Board of the International Council for Research and Innovation in Building and Construction (CIB).

"We can't afford to be complacent. It is time to do the research that is needed for the year 2020."

Barriers

Barriers to achieving this vision include:

- the cyclical nature of the industry with expectations for short-term deliverables
- shortage of client and industry leadership
- limited history of real and timely business deliverables from researchers
- self-interest of many of the participants
- the inability of the industry to foresee the tide of competition, in global or green terms
- lack of trust between industry and researchers in sharing vital information
- lack of long-term funding basis for national R&D centre.

Additionally, the failure of existing research organisations to consolidate the confidence of industry will threaten existing initiatives.

Assessing progress

To achieve a more effective and competitive property and construction industry, there must be a commitment to collaborative research and innovation. Genuine consultation with industry is essential for R&D to make a difference. The process should be mutual – with researchers and research users benefiting from productive interaction on personal and professional levels.

Major industry stakeholders together with government as a major client and regulator should collectively take the lead in pledging support for the continuation of a national applied R&D and technology transfer vehicle like the CRC for *Construction Innovation*. The performance of a national centre will be the subject of ongoing

evaluation by the participants and the Australian Government, together with the broader industry and the community. Clearly, ongoing support will be dependent on the performance of the centre in delivering real business benefits through research, education and technology diffusion.

Acceptance of the value of applied research driving improvements to industry practice will be the marker for success. Renewed support from existing partners and new partners joining R&D centres will also be important measures. But so too will be the development of a stronger research culture in Australian property and construction – a culture of self-improvement, mutual recognition, respect and support.

Conclusions

The ability of Australian property and construction to enhance its effectiveness and international competitiveness through technological advance and management expertise must be supported by well-resourced, creative and energetic research and innovation. An industry culture more embracing of research and innovation is developing, but there is some way to go.

It will be the responsibility of the Australian property and construction industry as a whole to ensure its ongoing future by exploiting research and innovation to continuously improve itself in line with international competition and to meet the increasing demands of clients and the community. Government at all levels has a responsibility as major client and industry regulator and legislator to use its position of influence to drive industry improvements and promote research and research user linkages.

Given that 94 percent of Australian construction businesses employ fewer than five people each, encouraging more involvement with SMEs is critical in ensuring the awareness and uptake of advanced technologies and management systems to upskill Australian industry.

Construction Innovation is well poised to deliver clear and relevant research outcomes and is moving to partner with other industry leaders in the important technology diffusion role to industry. But it will be impossible to achieve this alone, and *Construction Innovation* will need further support to continue the critical task it has begun. Other industry and government initiatives will be required to fully address the wide range of research and industry development challenges identified through this study. The focus of the *Construction 2020* study has been research initiatives to service the industry – and this has been carried out with a limited budget. The visions identified through the *Construction 2020* initiative have provided a base for developing future research and education – identified by industry. Existing Australian research does not fully address the issues identified. Achieving Australian research and innovation leadership will rely on a strategic focus of effort. Additionally, a more comprehensive national study of the broader issues impacting the industry needs to be carried out to provide an update on the Action Agenda process of the late 1990s.

“Currently R&D in construction industry is very low. This needs to improve and the construction industry should dramatically increase its R&D effort by 2020 compared to what is currently spent on R&D.”



The 2020 visions in focus

Vision One

Environmentally sustainable construction

"My vision is for an industry focussed on real value and sustainability, and able to deliver it economically, efficiently and safely."

This section details the eight specific visions identified from analysing the data collected through national industry consultation. The discussion is structured under six major headings – similar to the previous section. Again, actual quotes collected from industry respondents are reproduced to add depth and personal insight to each vision.

The vision

Vision One is for industry to design, construct and maintain its buildings and infrastructure to minimise negative impacts on the natural environment – minimise waste, maximise recycling and re-use, reduce the need for non-renewable resources (especially fossil fuels), and avoid pollution of land, water and air – preserving environmental choices for future generations.

By 2020, the vision is for the industry to have comprehensive eco-efficiency evaluation tools for all stages of the construction life cycle. Such tools would provide ready assessment of environmental performance against international best-practice standards and would be embodied in Australia's national building regulations.

Why this vision?

Respondents placed environmentally sustainable construction as a key research priority issue leading to 2020. Feedback indicated that sustainability issues will dominate our thinking and behaviour in the future, and that education in environmental issues will continue to increase sensitivity to the environment and increase demand from consumers for change in industry performance and standards.

Earth's non-renewable resources are being exhausted, and exploitation of some renewable resources is creating the potential for stocks to be reduced beyond acceptable limits. The built environment contributes significantly to resource consumption and environmental pollution, and, as such, represents a critical focus for sustainable urban development research and practice.

The industry today

The industry recognises that environmental and life cycle analyses are needed to inform decision makers in the design and construction of infrastructure and buildings and the manufacture of material components. Some firms and organisations are already including triple-bottom-line accounting (economic, social and environmental) into their balance sheets and the trend is increasing. Current redevelopment of the built environment is slow (being a long-term physical asset). Urgent attention needs to be given to the continuous improvement of built assets to enhance environmental outcomes.

Achieving this vision

Vision One requires the development of a collaborative national vision and action agenda for a sustainable built environment that includes development of the business case (and where necessary, incentives) for green construction in Australia, an agreed set of green rating tools for application to new and refurbished building throughout Australia, agreed sustainability performance standards and benchmarks, and education, training and accreditation programs. To do otherwise will see Australian industry jeopardise its ability to compete in the global design and construction marketplace.

"My dream is for sustainable design principles to be applied via appropriate tools by knowledgeable professionals throughout the whole of life of a building to provide quality environments for people to occupy."

To begin implementing this vision, a set of assessment and guidance tools is required that will allow all stakeholders to participate and contribute to improvement of the natural environment. The tools must also link to the design and manufacturing processes at all stages. They should be explicit and transparent and available to all who seek knowledge on environmental improvement. The application of these monitoring and evaluation tools must be tailored to the needs of the Australian climate and business environment, be easily accessible and agreed to be best practice. These applications should be linked seamlessly to programs for design representation, planning and manufacture for automatic assessment. Outputs can then be used to provide a feedback loop for organisational and industry learning.

The Building Code of Australia should also incorporate sustainability and minimum performance standards.

Education strategy

The government, educational institutions, and professional and trade bodies in the industry should develop courses and materials to encourage environmental assessment and implementation, as well as develop incentives for improvement in environmental performance. Case studies on innovative practice should be developed and widely communicated. Industry education and forums for technology transfer should become commonplace activities.

R&D strategy

The research agenda should develop tools for eco-efficient design and evaluation of infrastructure, buildings and components through their life cycle, including the monitoring of built assets through smart technologies. This will ensure that evaluation of design and construction performance, both before construction and in operation, becomes standard practice. Complementing this, industry performance should be openly reported in terms of key sustainable development indicators.

Barriers

Barriers to Vision One include short-term profit motives and quick-fix horizons caused by immediate self-interest and cost-based competition, together with a lack of understanding of what constitutes good environmental practice. Persistent barriers to green innovation also include:

- inertia – too expensive, too hard
- it being perceived as a capital cost rather than low-risk investment or benefit
- lack of information or agreement among decision makers on what works
- lack of capacity and incentives
- the slow incorporation of environmentally sustainable construction into university, TAFE and VET curriculums.

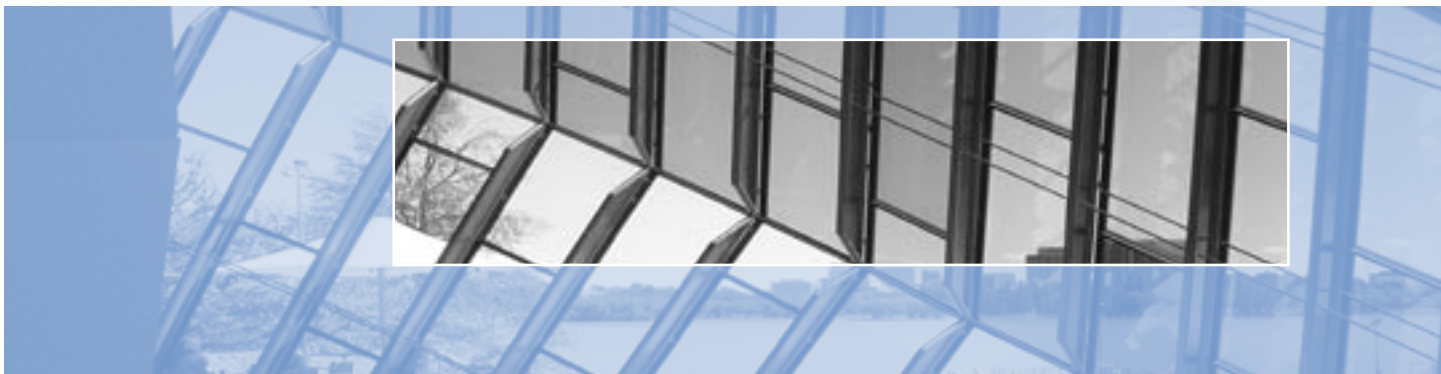
"My vision for the year 2020 is for the integration of sustainable design principles throughout the whole of life of a building delivered by knowledgeable professionals to informed building owners and community."

Assessing progress

We will know we have reached our goals for 2020 when:

- triple-bottom-line accounting practices are adopted by most property and construction firms
- environmental assessment exists alongside other assessments in design and manufacture of built assets and is considered of equal importance
- smart technologies are used to monitor and control environments in all new buildings and the majority of existing structures to improve all aspects of environmental performance
- state-of-the-environment reporting on Australia's human settlements and other regular benchmarking exercises indicate consistent trends towards a more sustainable built environment across key dimensions of performance.

"My dream is for an integrated industry delivering sustainable development within an environment of certainty, valued by community."



Vision Two

"My vision for 2020 is of informed clients understanding quality in life cycle terms, and focussing on best product result rather than least initial cost."

Meeting client needs

The vision

Vision Two is for the design, construction and operation of facilities to truly reflect the present and future needs of the project initiator, future owners and tenants, and aspirations of stakeholders. This should take into account the need for improved quality, and economic viability, and have the flexibility to adapt to future circumstances, technologies and needs of society. The aim is to maximise the value added at each stage of the development cycle.

The industry will aim for a 10 percent reduction in defects per year. It will develop better systems for capturing client requirements throughout the asset life so that clients can benefit from an improved knowledge of their needs. The future users and beneficiaries of the asset will also be considered and *long life, loose fit, low energy* will be encouraged in all design solutions. The industry needs to match the consistently high-quality standards that have been achieved by other industries in recent years.

Why this vision?

Underlying many of the responses were statements suggesting that the property and construction industry needs to be more responsive to its clients and its beneficiaries throughout the asset life cycle. Responses in the questionnaire showed strong general support, particularly from the property and design professions.

The responses suggest that insufficient attention is given to client requirements – intentionally or unintentionally. This results in poor performance compared with the quality and standards now demanded in other industries.

The industry today

The view is held that many sectors of the industry, despite significant improvements in design and manufacture, still exemplify the craft industry.

The respondents particularly challenged clients to take a more proactive and educated leadership role and to enforce a total life cycle cost approach. The concept of a *more informed client* appeared often in discussions and questionnaire responses – focussing on a need for improved project solutions, a higher quality of the project delivery team and flexibility of the facilities.

Achieving this vision

Processes for benchmarking defects and dealing with the ability to monitor progress should be developed. Systems for improving the capture of client needs should be created, and these can become standard practice, even for *one-off* clients. Life cycle analysis should begin at inception and be available throughout the life cycle for all decision makers.

All participants in the development process should determine their needs and develop approaches in response to these needs. The systems used in other industries should be examined for their applicability to construction.

Industry-wide groups should establish benchmarks for client satisfaction and set milestone targets. Each group should also develop appropriate systems to reflect current and future needs and create industry tools and guides for addressing performance related to client needs.

"I dream that the construction industry works in a collaborative arrangement with its clients to deliver sustainable solutions tailored to client and community needs, and as a result, enhances its profitability."



Education strategy

Alongside the development of best-practice guides should be continuing education programs in which concept design development and user-satisfaction measures are explained and their use encouraged. Additionally, a mechanism for sharing such information to the industry at large should be developed.

R&D strategy

An R&D strategy should enable the industry to learn from best practice in other industries and other countries, to distill this knowledge, and to adapt it to suit the particular needs of Australian property and construction. The new knowledge will be encapsulated in the guides and in the systems developed. Studies will be needed to demonstrate the best mechanisms for making these available to the industry.

Barriers

Ad-hoc arrangements for capturing client needs or design evaluation do not allow the evolution of methods for improving consistency and performance. The industry needs to work together with its clients to achieve major improvements. Narrow sector interests and short-term thinking have the potential to jeopardise emerging methods.

Assessing progress

Progress will be assessed through performance indicators and benchmarks to identify major improvements according to agreed targets. Broader industry adoption of the tools will facilitate comparison of performance across organisations. The reduction in defects per year and improved client satisfaction will be measured and reported.

"I wish for educated clients who understand and appreciate good design and give it priority."

"My vision is of an industry with informed clients who focus on the big picture and are happy to make an up-front investment for long-term benefit with service providers who sell on quality, not lowest initial cost."

"I dream of an industry working together to meet the needs of users with strong user feedback driving innovation and improvement."

Vision Three Improved business environment

"My vision is of an innovative, forward-looking partnership between regulators, researchers and industry practitioners supported by uniform defensible building standards."

The vision

The business environment in which property development and construction is initiated and executed will reflect a need for all stakeholders to work more productively for mutual benefit serving the needs of society over the long-term life of the asset. This will be supported by a regulatory, financial and procurement framework which encourages longer-term thinking and returns, a sharing of ideas and innovation between stakeholders, and a fair distribution of risk and returns.

By 2020, the vision is for the industry to have a business environment achieving four types of dividends:

1. economic – with a fairer balance of risk and return to stakeholders
2. social – providing equitable returns across the community
3. environmental – striking a more sustainable balance between the built and natural environments
4. governance – providing clarity of business responsibilities, leading to a more informed, transparent and honest marketplace.

Why this vision?

This vision was considered the highest priority for an improved future for the Australian property and construction industry. The business environment was also identified as the most important future research topic.¹

Constructed assets are created to produce a dividend for stakeholders – either privately or publicly. Invariably, the business environment impacts on the industry's ability to effectively provide these dividends. An advanced and healthy property and construction industry operating in a supportive business environment is vital to national interests and the ability of Australia to compete in global markets.

The industry today

The very nature of the Australian industry, characterised by fragmented and adversarial industry structure, low profit margins, low-bid tendering, inequitable risk sharing, small firm size and poor investment in technology, provides a context of concern for this vital industry.

Construction 2020 respondents communicated concern on a number of levels in a:

- day-to-day sense with convoluted tendering and project administration practices
- mid-term sense through an inconsistent drive to life cycle analysis contrasting with the predominance of low-bid tendering
- strategic sense through frustration with a poor industry image and profile, and the resultant inability to adequately secure and retain high-quality, skilled staff.

Each of these concerns was consistently expressed across respondents' visions, barriers and future research needs. Respondents highlighted the need for fundamental reform of the entrenched design–bid–build procurement model in Australia to help drive more advanced practices through business and technical innovation. As a major client, government is seen to instinctively rely on the traditional lowest initial cost of construction criterion. The challenges of achieving *collaboration, cohesion, communication and cooperation* frustrate the industry as it seeks to achieve world-class outcomes.

¹ The business environment theme includes life cycle analysis and management processes, demographic, cultural, social and political issues, industry profile and image, allocation of risk, quality and efficiency issues, competitiveness, and the procurement process.

Achieving this vision

To achieve a healthy and more productive industry, there must be a commitment to collaborative action between industry and government, between clients and project delivery teams, and between researchers and research users. The goal should be achieving *best possible project* solutions over the life cycle of the facility.

In this vision, considerable importance was placed on information sharing and collaborative design, as well as on construction and maintenance responsibilities. This reflects a business improvement focus where ICT solutions can enable improved business communications and knowledge transfer. Such systems need to be approached in conjunction with process re-engineering.

Educational strategy

For the industry to be transformed to support this vision, its key managers and leaders require broader skills. Programs developing tomorrow's leaders (and the professional development of today's managers) need to emphasise these broader skills and responsibilities to balance across economic, social, environmental and governance outcomes.

R&D strategy

The research agenda should explore the link between economic, social, environmental and governance performance and long-term stakeholder value. Learning from the experience of other industries and countries will be valuable. In particular, the relationship between long-term life cycle costs and initial facility costs should be better understood and communicated. Research should also evaluate the role of government as a major client and as a regulator/legislator, and further encourage the public sector to establish best practice models for improving industry behaviours.

Barriers

Barriers to Vision Three include the fragmented and adversarial industry structure and short-term approach to finance and planning, the industry's aversion to risk, and unsustainable profit margins.

Respondents from around Australia consistently highlighted their worst nightmare as being *nothing's changed*. Lack of client leadership will exacerbate this inertia and frustrate efforts to improve Australia's business environment.

Slow adoption of ICT tools and collaboration strategies to improve the business environment will also impede progress.

Assessing progress

We will know we have reached our goals in improving the business environment for 2020 when:

- property and construction businesses extend their performance assessment to include governance as a key benchmark complementing economic, social and environmental measures
- the image and overall stakeholder satisfaction with the industry has improved
- clients and constructors agree that a life cycle analysis of facilities takes precedence over the low-bid tender mindset
- property and construction is accepted as having a positive influence on government policy
- the Australian property and construction industry is recognised as being at the forefront of international practice.

"I dream of a collaborative, sustainable industry, focussed on producing a quality product. This is facilitated by a procurement system that encourages efficient innovative behaviour by adequate reward and equitable risk allocation."



Vision Four

"My vision for 2020 is of a highly technically skilled workforce, with greater reliance on technological solutions, significant off-site work and low/zero tolerance of unsafe work practices."

Welfare and improvement of the labour force

The vision

Vision Four is for the industry workforce to be computer literate and highly skilled showing mutual respect for each other through management and workers acting collaboratively with health and safety conditions on-site.

As construction is highly labour intensive, one goal for 2020 is for there to be an ongoing supply of skilled workers to service this vital Australian industry.

The diverse and fragmented set of occupational health and safety (OH&S) laws supports a call for a national code of construction safety management.

The industry must also aim for a more internationally productive and effective labour force operating in a less adversarial industrial relations context.

Why this vision?

Almost 100 percent of site respondents confirmed that workforce- and workplace-related issues should form a part of the future research agenda for this industry. Forty-two percent identified these issues as being important for future research. This vision incorporates skills and education, productivity, health and safety, industrial relations, labour costs and welfare.

Most questionnaire responses in this vision related to skills and education requirements, revealing a concern that the industry was not adequately developing skills for the industry's future, with health and safety being the second-most important cluster of concern.

Industrial relations is viewed as the third most important element of this cluster. Respondents viewed industrial relations as a critical barrier to change and are particularly concerned about the ability to drive innovation in an industry where unionised labour is seen to limit the uptake of more advanced methods. This issue is seen as somewhat specific to the Australian industry.

The industry today

Skill development in Australia has moved from a qualification base where completion of formally accredited programs formed the basis of a trade career, to one that is competency based. This has altered the role that VET and TAFE institutions provide in the industry to one of reviewing competence rather than delivering accredited programs. With more high school students continuing to senior school years (for ages 16 and 17) and more high school leavers continuing to university studies, fewer quality candidates are entering construction trade training. Respondents believe that this is a major concern for the future of this industry.

Building and construction workers are more than twice as likely to be killed at work as the *All Industries Australian Average*, and the incidence rate of serious injury in the property and construction industry is about 50 percent higher than the *All Industries Australian Average*. Compounding this, the industry must consult disparate codes of practice, advisory standards and guidelines.

Since 1991, enterprise bargaining has been in force across the property and construction industry, with intense three-yearly negotiations between employer and employee groups.

"My 2020 vision is for an appealing industry that attracts the best people. Australia is known for world's best practice in construction process and safety."



Achieving this vision

The community image of the construction industry as a dirty, dangerous and poorly paid profession must change. The industry must become a more attractive place of employment for trades and professionals alike.

A collaborative response across the industry to standardise safety procedures and competencies for workers from project to project and employer to employer would improve the construction safety record. A national strategy for unifying safety legislation/codes should be developed along with industry support. The developing *National Code of Construction Safety Management* based on standardised competencies is one early example of the initiative required.

Respondents suggested the need for an improved process providing more ready access to a mediating third party between employer and employee groups to facilitate more moderate and equitable outcomes. A workforce attuned to embracing changes that improve industry effectiveness needs to be developed.

Education strategy

Improved vocational training and career progression through further education coupled with a broadening of professional skills is required. National consistency is also important for a mobile and project-based workforce with ongoing skills-development programs for trades and professions.

Improvement of attitudes to drive a zero-accident culture is required to improve Australia's OH&S record. A culture of responsibility at all levels for personal and colleague safety should be engendered.

R&D strategy

Traditional skills developed under adversarial project delivery mechanisms are increasingly inappropriate. Research highlighting the skills required for tomorrow's business environment will improve this.

Research highlighting the need and benefits of cultural reform including national uniform codes of safety practice, is necessary to drive the OH&S reform process.

Barriers

Barriers to Vision Four include short-term economic rationalism limiting the ability of this industry to secure a continuous supply of quality labour. Compounding this, respondents highlighted:

- poor industry image
- low levels of education in information and communication technologies and management
- poor employer–employee relations
- procurement structures that promote adversarial site relationships
- the disparate OH&S legislation and guidelines across states.

Assessing progress

We will know we have reached our goals for 2020 when:

- top-quality school leavers choose property and construction as their career of first choice – at both a trade and professional level
- OH&S statistics for the construction industry are on par with manufacturing
- time lost through industrial disputes is on par with other industry sectors.

"I envisage that by the year 2020, the construction industry will be seen as a high-tech industry that will attract young people into both the trades and professions and will be seen as an industry of choice. The skills and knowledge gained will be consistent in standards and therefore readily transportable across states and industry sectors."

Vision Five

Information and communication technologies for construction

"In 2020, there will be greater use of intelligent technologies in all building types to manage heating, ventilation and air conditioning, lifts, ICTs and electrical systems. Computers, systems and information technology will become integrated building components, and there will be greater flexibility of electrical and electronic systems."

The vision

Vision Five is for communication and data transfer of the industry to be seamless, enabling transfer without interruption and delay, and include mobile devices providing a commercially secure environment. These technologies will be embedded within both construction products and processes to improve efficiency and effectiveness.

The goal is to develop a seamless web of communication available to all participants in the development, construction and operational cycle of the project and the firm. This will allow management information to be readily available to all relevant personnel, to monitor performance (remotely if needed), to speed up decision making using shared data models (see Vision Six) and employ handheld devices to empower individuals to achieve corporate objectives.

Why this vision?

Information and communication technologies (ICTs) permeate all scenarios for the future and are seen as the drivers that will enable major improvements in performance of both product and process as well as significantly reducing transaction costs.

The information revolution and the knowledge economy will require that the property and construction industry becomes more engaged in developments in the broader society. Developments in ICT have the potential to radically change certain sectors of the property and construction industry. An increase in performance through higher levels of ICT uptake will be demanded by clients nationally and internationally.

The industry today

The industry has embraced some technologies such as the mobile phone and various aspects of computation but has not broadly integrated them or harnessed the power of new communication media and computing power to the same extent as other major industries.

Achieving this vision

This vision relies on the industry clearly defining requirements allied to its processes and objectives, and providing major support to the drive for interoperability² and adaptation of new technologies to construction. Also essential to this vision, is determining how these technologies should be embedded in both process and product to ensure usability and to encourage the sharing of information through knowledge networks³ and knowledge grids⁴.

Vision Five requires industry to endorse standard approaches to interoperability, seek generic approaches to process, engage in continuous education for all personnel alongside advanced technologies, and build on current ICT successes such as mobile phones.

Implementation requires people to achieve agreement on the adoption of interoperability, selecting key early winners for demonstration purposes, encouraging major firms and clients to demand such technologies, providing awareness courses on ICT potential, and developing a non-adversarial environment where knowledge sharing can build trust and allow benefits of advanced ICT to add project value.

² the ability to exchange information between different software programs without loss of information

³ A knowledge network refers to the sharing of appropriate information among a collaborating group of people with appropriate links. Within the context of a building project, this would include all of the information incorporated in the current *standard* documentation plus links to all the public supporting information used in making decisions about the project by the various participants.

⁴ A knowledge grid is the use of groups of computers to share information over a network among a group of people and their software applications. It will also protect related private information from inappropriate access.

Education strategy

Advanced approaches to concept development, design, construction and facilities management using state-of-the-art ICT tools should be standard fare in all industry education and training programs.

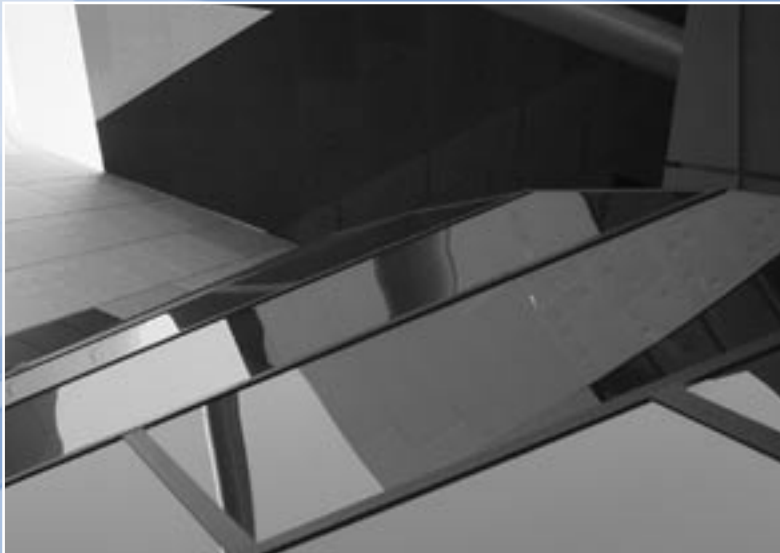
An education strategy should identify exemplar projects which can demonstrate commercial benefit and provide these for limited trial. The strategy would provide an action learning environment where personnel can share experiences and learn from one another, and enhance the supply chain to encourage uptake and improved satisfaction of client needs (see Visions Two and Eight).

Part of the strategy would involve diffusing the results of the trials to industry through workshops, and distribution to the media.

R&D strategy

The aim of an R&D strategy would be to bridge the gap between general technology *push* and construction industry *pull* to promote the development and uptake of ICTs for construction. The strategy would also provide forward thinking for the industry so that investment can be made in an intelligent and united way, ensuring maximum benefit accrues to the industry as a whole.

Some applications of ICT in allied areas, such as manufacturing, could be adapted to suit the property and construction industry. Because of the unique characteristics of the industry, other applications will need to be identified and developed from *scratch*.



Barriers

Barriers to achieving of this vision include:

- a reluctance to invest in ICT technology as a market differentiator
- ignorance of the potential of ICT
- a lack of coherence in the supply chain and the industry as a whole, resulting in fragmented approaches to adoption
- limited interest from ICT companies to deal with property and construction.

A major restriction on ICT companies is their lack of confidence that their investment in targeted development will yield the necessary returns.

Assessing progress

Vision Five will be realised when:

- advanced ICT technologies have widespread use throughout the industry
- software vendors adopt interoperability principles for the industry
- site personnel use handheld devices to access site information in a similar way to how they use the mobile phone
- clients expect, demand and receive a level of service which can only be developed through ICTs
- robust systems are developed for the industry to enable real added value to be achieved and measured.

"I dream of seamless computer communication and data transfer between all organisations during all phases of the design, construction and whole-of-life operation of a development."

Vision Six

“Visualisation software applicable to the life cycle of assets from development assessment through construction to demolition would be my wish for the future.”

Virtual prototyping for design, manufacture and operation

The vision

Vision Six is for a virtual prototype of the facility to be available, which will provide the opportunity to *try before you buy* at all stages of the development cycle – from inception to design, construction, demolition and rebuild. The prototype will be an electronic representation of the facility, from which all relevant decisions can be made and from which the procurement processes can develop.

The goal is to simulate the physical product and the processes by which the product can be created and to develop information-rich CAD models for managing the asset throughout its life cycle. The CAD model will form the common basis for all stakeholders to exercise their design, management and operational expertise for the constructed asset.

Why this vision?

This advance is needed to avoid abortive work, to demonstrate to clients the performance of their product before they decide to construct, to test alternative courses of action in advance, to provide a common reference point for all design and planning throughout the product life cycle and to speed up the introduction of e-business processes based around a CAD model.

Respondents considered that virtual prototyping would have the highest likelihood of becoming the basis for design, procurement and asset management in the next 5 to 10 years. Likewise, modelling the design of buildings and infrastructure in a CAD system was considered to have the highest likelihood of occurrence in the next five years.

The industry today

Virtual prototyping technology is currently available but is not sufficiently integrated. The simulation packages have yet to be developed to commercial standards, automated business models have yet to be developed that relate to the common model, and the workforce is not sufficiently versed in the technology.



Achieving the vision

Achieving Vision Six requires the development of:

- communication media to aid collaboration
- standards for interoperability
- ambient computing⁵ and powerful low-cost handheld devices to allow individuals to have access to the electronic model for their own use
- simulation packages to *test before invest*
- a culture of virtual environments for leisure and learning, and increasing sophistication and level of comfort of clients in all aspects of ICT.

Achieving widespread success will require restructuring the supply chain to accommodate new ways of working as the virtual prototyping technology provides opportunities for new collaborations that supersede others. Long-term arrangements can be established between partners so that the sharing of knowledge and expertise through the model becomes seamless and supportive. It will also require capital investment in information technology and support throughout the industry, upgraded compatibility within both software and hardware and improved security of information exchange across electronic networks.

Industry has identified the potential benefits of advanced ICT. It remains for industry to work with software vendors to define needs and find the best ways of having them met to provide an appropriate return to both industry and software developers.

Education strategy

An education strategy should focus on new processes and industry structures to achieve an integrated information system, increase the skill base in ICT operation of operatives and professionals and create learning systems able to assimilate and apply new technologies as they emerge.

R&D strategy

The R&D strategy for the industry would involve:

- adapting methods from other industries to property and construction
- identifying areas where property and construction requirements exceed those of other industries and develop new methods of handling these
- agreeing on standards for interoperability
- obtaining major client support, to encourage application
- developing a standard platform for property and construction allowing flexibility by all stakeholders to suit their needs.

"I hope for a future with greater attention to the logistics of construction via computer-aided design at the shop drawing level and computer modelling construction elements for simulated construction of a project with resource modelling, construction sequencing and costing."

"In 2020 I envisage the complete automation of data harvesting from concept design to construction documentation and the use of design tools early in the design process, providing clearer understanding of the practicalities of the design and more predictable outcomes."

Barriers

Barriers identified for Vision Six are resistance of users to explore electronic modelling as a viable option, legislation and regulation regarding information exchange, data protection and intellectual property, resistance from suppliers and subcontractors, inertia and resistance from the workforce, insufficient investment from the software/hardware suppliers and a lack of clear evaluation and communication of benefits.

Assessing progress

We will know we are succeeding in this vision when the entire project can be visualised electronically, with the visual model providing ready access to the underlying knowledge related to the facility's design, construction and operation.

"I dream of the seamless integration of CAD design information with quantity and price information."

⁵ the ability to access and interact with ICT wherever you are – also called pervasive computing

Vision Seven Off-site manufacture

"My vision for 2020 is one where construction methods will minimise on-site labour – more prefabrication. Buildings may be more transportable, moving and growing as required. Sustainability and re-use of building materials will drive materials and construction methods."

The vision

In Vision Seven, a majority of construction products will be manufactured in factories off-site and brought to the site for assembly. This will enable better quality control, improved and more efficient site processes, better health and safety control, more environmentally friendly manufacture and possible reductions in cost.

The goal is to establish the economic viability of off-site manufacture to ensure a major improvement in the quality of components. In addition, jointing mechanisms for modular components that retain flexibility of design and lead to higher performance of the final facility is required.

Why this vision?

The degree to which quality control, greater efficiency and improved working conditions can be achieved is limited by the conditions and methods used on-site. Off-site manufacture gives the opportunity for volume manufacture under factory-controlled conditions. It also provides opportunities to embrace *lean production*⁶ methods and re-engineer the construction process.

Respondents considered off-site manufacture to have a very high likelihood of occurrence in the next 5 to 15 years. This confirms a trend away from conventional site manufacture to assembly from components manufactured off-site.

The industry today

In certain sectors, an estimated 50 percent of the value of components may be manufactured off-site and brought to site for assembly, but current practices still tend to favour on-site fabrication. The pressures of time and site access are regarded as more significant than other potential benefits. Increased off-site manufacture is seen to be limited by economic structures of the industry in which large constructors can purchase materials with volume discounts, construct under integrated site management, often using subcontract labour with mechanised on-site assembly equipment, and produce customised constructed products.

Achieving this vision

To achieve Vision Seven, the industry needs to both review the potential for further off-site manufacture and determine the economic, social and environmental criteria that will make the investment in industrialised processes worthwhile. Industry also needs to examine the impact of off-site manufacture on the construction process to demonstrate the benefits of making the manufacture of buildings and infrastructure more efficient.

To begin implementation, designers and contractors need to agree on the benefits and demonstrate the economic, social and environmental advantage of manufacturing under controlled conditions off-site.

Once the current position of off-site manufacture is established, modelling the changes required in the processes of construction should follow. This will allow for advances in quality control and building performance through assembly on-site.

"I envisage that many building processes will have undergone a transformation in technique and material use by the year 2020. Elements requiring a relatively high labour content on-site will have been analysed and modified to be constructed off-site in factory-type operations. This will have led to reduced accidents on-site and fewer occupational health and safety issues generally. It will also mean that there will be an improvement to product quality and duration of site construction."

⁶ Lean production seeks to better manage the production process by managing the conversion of input to output, and maximising the value of the output, in the most efficient way.

"My vision for the Australian property and construction industry will be one where building sites will be fully mechanised. Most construction components will be made off-site in units and only connections will be made on-site. Designers will become more ingenious in the way they design the interlocking components. The difference is that off-site construction will allow more consistency of product and will reduce the number of site personnel who will now be more highly skilled in placing and connecting the components."

Education strategy

An education strategy would develop case studies that demonstrate the advantages of off-site manufacture from business, environmental and human perspectives. It would also integrate manufacturing technology into traditional design and construction training for trades and professions.

R&D strategy

This strategy requires the development of models to aid decision making in:

- investment in plant and equipment
- design and manufacture of facilities encompassing modular approaches where appropriate
- efficiency and effectiveness gains achievable from lean production methods.

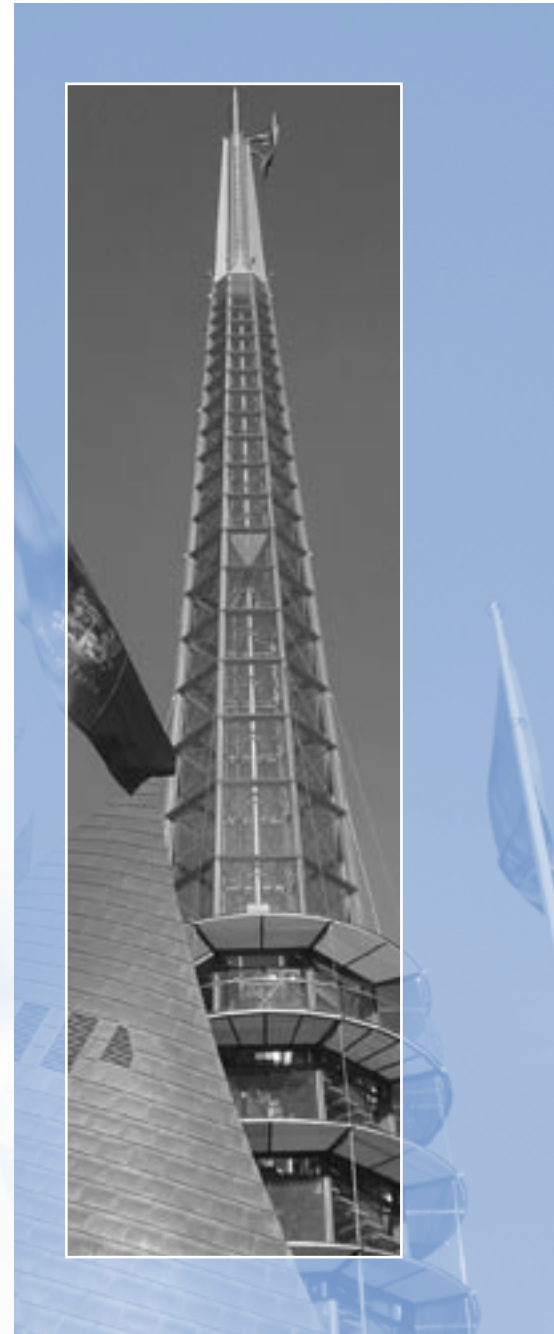
Research on modularisation and jointing techniques between modules will also be beneficial. The overall economics of off-site versus on-site processes should be considered, together with market attitudes to increased use of off-site manufacture.

Barriers

Barriers for this vision include natural conservatism in the market influenced by limited successes in the past, lack of investment in major plant, lack of flexible open systems with designed-in flexibility to create exciting design as well as improved efficiency, and an Australian preference for individualised solutions.

Assessing progress

Vision Seven will be reached when majority off-site manufacture is seen as the norm, and building processes, supply chain management and site conditions reflect this shift in production methods.



"By the year 2020, there will be more and more off-site automated production, less skilled site trades, more prefabrication, pre-finished elements and products."

"I dream of more off-site pre-construction for enhanced quality, safety, timeliness and consistency."

Vision Eight

Improved process of manufacture of constructed products

"I imagine a future with seamless integration of all involved in the construction process, enabling knowledge and innovation to drive best practice."

The vision

In Vision Eight the industry will develop new production processes, allowing it to work more efficiently using improvements in ICTs. This will enable a lean production environment in which the supply chain is restructured and integrated, and where the environment is collaborative rather than adversarial so that time and cost overruns are considerably reduced.

The goal for 2020 is to re-engineer the supply chain to ensure that the property and construction process of construction is as *lean* as possible. The industry will use ICT to enhance the value of the product to the client and stakeholders through better quality control, organisation and management of site activities.

Why this vision?

A substantial proportion of respondents referred to improving *processes* of manufactured and constructed products. The industry worldwide is seeking new ways of organising itself to improve efficiency and effectiveness in delivering buildings and infrastructure. The primary focus is on the *process* of construction to achieve these improvements rather than on the final constructed *product*.

The international property and construction industry has been slow to adopt new process analysis and improvement methods and this is considered to be a major factor in its limited effectiveness and efficiency compared with other industries. There is considerable wastage of human and material resources and time lines are often exceeded. In addition, the *craft image* of construction mitigates against attracting the best personnel to the industry.

The industry today

Some sectors of property and construction are seeking ways to restructure themselves and their supply chains to introduce new methods of production which more closely reflect improvements seen in other industries. Many firms are working in the traditional mode developed before new methods and technologies were established.

"I dream of an industry that sells its buildings, like cars, but with a 30-year warranty and maintenance contract. Key performance indicators in safety, environment and productivity are defined in the user brief."

Achieving this vision

The industry can achieve this by developing a process protocol⁷. This identifies the content of the process and the timing, and can be adapted to meet local requirements. A process protocol forms the basis of the software platform for reorganising and optimising its activities. Process protocol is critical to the implementation of ICT support because, unless we understand process, then we are unable to properly support it.

A generic understanding of construction processes that has the agreement and support of major organisations willing to drive it to implementation needs to be developed. Suppliers and subcontractors will need to adapt to the new systems.

This vision involves encouraging a group of interested stakeholders to steer research that will provide information about how benefits might accrue. Industry needs to commit to the adoption of such systems in their own firms which can then be monitored to provide benchmarks for industry improvement.

⁷ A process protocol is a common process framework for managing and controlling a project enabling participants to work together knowing the actions and decisions that need to be taken, resulting in fewer problems, mistakes and duplication of effort.



Education strategy

An education strategy would make the industry aware of the advantages of lean production techniques and the necessary restructuring of the industry required to make it work in practice. It would also provide instruction on process remodelling and systems thinking related to lean production in all courses related to construction and to the industry as a whole. It would develop demonstrator projects to show how project parties will benefit.

R&D strategy

The R&D strategy should develop a system for understanding all processes throughout the project life cycle. It would come from existing protocols and systems in other industries and countries, and be appropriate to the needs of Australia. It would form the basis of any ICT platform which could be developed to implement re-engineering improvements. The strategy would also develop new processes to take construction process management to a level comparable with those operating in the best of related industries.

Barriers

To achieve major advancement, the industry needs to agree on process improvement and adopt the potential advances available through ICT. Continued industry fragmentation will make it difficult to implement re-engineering processes through lack of a critical mass using the process protocol. Inertia and reluctance to use advanced ICT will also hamper progress.

Assessing progress

Vision Eight will be realised when the adopting firms can demonstrate that significant improvements have been made against key benchmarks and that an industry-wide model and platform is available for all to use.

"My vision is for the cost effective, collaborative delivery of client-focussed outcomes that incorporate integrated design solutions, and state-of-the-art technology with minimal environmental and social impact and maximum environmental, social and economic outcomes."

"By 2020 I'd hope for the construction industry to be as efficient at process and production technology as the international car industry."

This report is based on the views of several hundred people from the Australian property and construction industry who participated in activities including workshops held across the country from November 2003 to February 2004, and the completion of a questionnaire related to their vision for the industry to the year 2020.

The method adopted was as follows:

- A literature survey of recent visioning and foresight exercises held in a number of countries throughout the world established common trends and issues.
- A survey of recent Australian studies looking at innovation and advancement of the industry was examined to establish current thinking in Australia and in particular to identify any long-term trends.
- A questionnaire was developed from the above background research (see Appendix II). The questionnaire built on existing views of the future and encouraged those responding to also provide their view of what was different about Australia and describe their aspirations and concerns for the Australian property and construction industry. Some timescaling of expectations was encouraged.
- Interactive workshops were held in eight locations throughout Australia. Key discussion outcomes and *best dreams* and *worst nightmares* were recorded from each of these workshops.
- A balanced distribution of property and construction industry trades and professions were represented by the people who attended the workshops and responded to the questionnaire. They included architecture, engineering, construction, property services and development, asset/facility management, professional business services and building materials. There was also a sound distribution across the public and private sectors.
- Qualitative¹ and quantitative² analysis of the results of the questionnaire and the workshop discussions established the key themes for visions. These form the main thrust and content of this report.
- The key issues raised at the workshops and through the analysis of questionnaire responses were then discussed at 'toolbox' sessions with additional site personnel to gain a richer perspective on what was being suggested. The visions were then refined accordingly.
- Respondents identified possible visions that could be the target for the industry to achieve by 2020.
- The workshops identified the educational and research support required to achieve the visions and potential barriers to the visions³.

¹ NUD*IST software (N6) was used to perform the coding, analysis and reporting of textual questionnaire responses. Qualitative responses were coded against seven key themes and 28 sub-themes from which quantitative data were developed to report response patterns.

² SPSS analysis was used for all numerical responses.

³ This report will be discussed at venues around the country to gain further clarification and support from industry and agree on a joint path forward.

Appendix // Vision questionnaire



Your vision for Australia's property and construction industry to the Year 2020

This questionnaire is part of an important national effort to engage the industry in self-reflection and improvement.

Please think ahead to the Year 2020, and picture what you would like Australia's property and construction industry to look like. We call it creating a vision.

1. Profile

- a. State/Territory where you live:** NSW QLD WA TAS VIC SA NT ACT
- b. Type of organisation where you are employed:** Public Private Selfemployed Other
- c. Number of years your organisation has been active in the industry:** years
- d. Number of employees in your organisation:** 1–4 5–49 50–100 100+
- e. Trade or profession of your organisation:**
- | | | | |
|---|--|--------------------------------------|--------------------------------------|
| Design (<i>tick speciality</i>) | <input type="checkbox"/> Architecture | <input type="checkbox"/> Engineering | <input type="checkbox"/> Other |
| Construction (<i>tick speciality</i>) | <input type="checkbox"/> Residential | <input type="checkbox"/> Commercial | <input type="checkbox"/> Engineering |
| <input type="checkbox"/> Property Services/Development | <input type="checkbox"/> Asset/Facility Management | | |
| <input type="checkbox"/> Professional Business Services | <input type="checkbox"/> Building Materials | | |
- f. Your organisation's market reach:** Regional Regional/State National International
- g. Your name (*optional*):**
- h. Name of organisation (*optional*):**
- i. Address of organisation (*optional*):**
- j. Telephone (*optional*):** **k. Email (*optional*):**

2. Picture your vision for the Australian property and construction industry to the year 2020.

Please write down what is different about your vision of the Australian property and construction industry in the Year 2020, compared with the industry today.

.....

.....

.....

.....

3. Trends – what is influencing your vision?

(a) Global trends – affecting the property and construction industry

Based on your vision of the property and construction industry to the Year 2020, please CHOOSE 5 GLOBAL TRENDS and RANK THEM FROM 1–5 in terms of how they may impact on your industry vision for the future to the Year 2020. Do not rank the trends that you add to the list.

Global trends	Choose 5 trends	Rank from 1–5*
a. Integration of computer and communication technologies		
b. Increased power of computers (e.g. to undertake visualisation)		
c. Reduced size of computers (e.g. handheld devices)		
d. Shift away from manual trades to service industries		
e. Changing demographic patterns influencing demand and work		
f. Knowledge sharing across national and organisational boundaries		
g. Drive to greater levels of national security due to terrorism etc.		
h. Increased work skills and industry capacity		
i. Increased globalisation of the property, design and contracting market		
j. Sensitivity to sustainable development		
k. New materials		
l. Other (please state):		
m. Other (please state):		
*Ranking 1 most important or significant 5 least important or significant		

(b) Comparing global trends to those in the Australian property and construction industry

LIST what you think is distinctive about the Australian property and construction industry compared to the global property and construction industry.

Tick here if you feel you do not know enough about the global environment in order to make a comparison.

1	
2	
3	

(c) Issues and technologies – specific to Australia's property and construction industry

CHOOSE FIVE TRENDS and RANK FROM 1–5, THEN PLACE UNDER THE APPROPRIATE TIME PERIOD according to which trends you think will have the greatest impact on the industry. Consider when the trend would have the **maximum impact** between now and 2020. Do not rank the trends that you add to the list.

Trends	Choose 5 trends	Rank from 1–5*	Select time period			Tick here if you are not familiar with this trend
			Short (<5 yrs)	Medium (5–15 yrs)	Long (>15 yrs)	
a. Improved process and management						
b. Information technology support, improving design collaboration, supply chain management, etc						
c. Focus on environmental sustainability and sustainable communities						
d. Whole-of-life management and analysis (offsetting long term ownership costs against upfront capital costs)						
e. Smart or intelligent buildings and infrastructure						
f. Less adversarial business relationships						
g. Increased private/public partnerships						
h. Improved health and safety on-site						
i. Better evaluation of clients' needs						
j. Other (please state):						
k. Other (please state):						
*Ranking 1 most important or significant 5 least important or significant						

4. Picture your vision for the industry. What do you wish for?

What do you want the industry to look like in the Year 2020? From the wish list below, CHOOSE 5 ITEMS which you think are essential to an improved industry in the long term, which meet the needs of society, and which would help to make your vision for the industry a reality.

Wish List	Choose 5 Items	Tick here if you are not familiar with this trend
a. Restructuring of the supply chain for greater efficiency		
b. Improved management of design and construction		
c. Improved asset management		
d. Improved building performance meeting or exceeding client demand		
e. Computer-based 'Business to Business' transactions including bringing the supply chain on-line		
f. Virtual (computer) simulation of the design and construction process to 'test before you commit'		
g. Automated sensing of built environments		
h. Avoidance of adversarial relationships within the team		
i. Fairer distribution of project risks in the procurement process		
j. Design/contractor involvement for period beyond project completion		
k. Environmental assessment and management throughout the development and operation cycle		
l. Improved working conditions for site personnel		
m. Greater off-site manufacturing		
n. Other (please state):		
o. Other (please state):		

5. You've got a wish list, but do you agree with others about technological and other breakthroughs? What timescales are we talking about?

TICK ONE BOX FOR EACH EVENT to indicate when you really think that event is likely to happen in a significant proportion of the Australian property and construction industry.

Events	Select Time Period					Tick here if you are not familiar with this trend
	<5 yrs	5–10 yrs	10–15 yrs	>15 yrs	Never/unlikely	
a. Collaborative design through the Internet or other computer-based networks						
b. Three dimensional modelling of design of buildings and infrastructure in a CAD system						
c. Virtual prototyping becomes the basis for design, procurement and asset management						
d. Hand held devices become the norm for management and communication of design on-site						
e. Knowledge grids where many computers act in unison to share knowledge and aid collaborative working						
f. Remote sensing of buildings and processes to aid management						
g. Triple bottom line (economic, social and environmental) reporting on balance sheets and project planning becomes the norm						
h. Whole life analysis becomes the norm						
i. Supply chain is rationalised, integrated and supported by information and communication technologies						
j. 80% of construction components are manufactured off-site						
k. Skilled labour shortages change the design of construction assets						
l. Energy becomes scarce and drives new forms of manufacture and design						
m. Health, safety and welfare on-site is on a par with other industries						
n. Climate change demands new types of construction						
o. Pollution levels demand extensive regulation of the industry						
p. Terrorism acts are factored into the design and construction of buildings						
q. Other (<i>please state</i>):						
r. Other (<i>please state</i>):						

6. Barriers to change

CHOOSE FIVE BARRIERS TO CHANGE in Australia's property and construction industry and RANK FROM 1–5. Do not rank the trends that you add to the list.

Barriers to Change	Choose 5 Barriers	Rank From 1–5*	Tick here if you not familiar with this barrier
a. Level of education of site personnel in computer applications			
b. Level of education of management personnel			
c. Awareness of technological development in the industry			
d. Outdated regulatory controls			
e. Too many levels of regulatory control			
f. Employer and employee relations			
g. Fragmented and adversarial industry structure			
h. Risk aversion of the industry and its clients			
i. Low technological investment			
j. Professional designations and demarcation of trades			
k. Lack of informed client leadership			
l. Short term approach to finance and planning			
m. Lack of modularity in components			
n. Lack of interoperability between software making data exchange more difficult			
o. Craft culture of the industry			
p. Profit margins in the industry			
q. Sector diversity			
r. Structure of the industry			
s. Cyclic nature of the industry			
t. Other (please state):			
u. Other (please state):			
*Ranking 1 most important or significant 5 least important or significant			

7. Research agenda to achieve your vision

Please LIST what you think needs to be researched to help improve the performance and international competitiveness of the Australian property and construction industry to the Year 2020.

1 Most important	
2	
3	
4	
5 Least important	

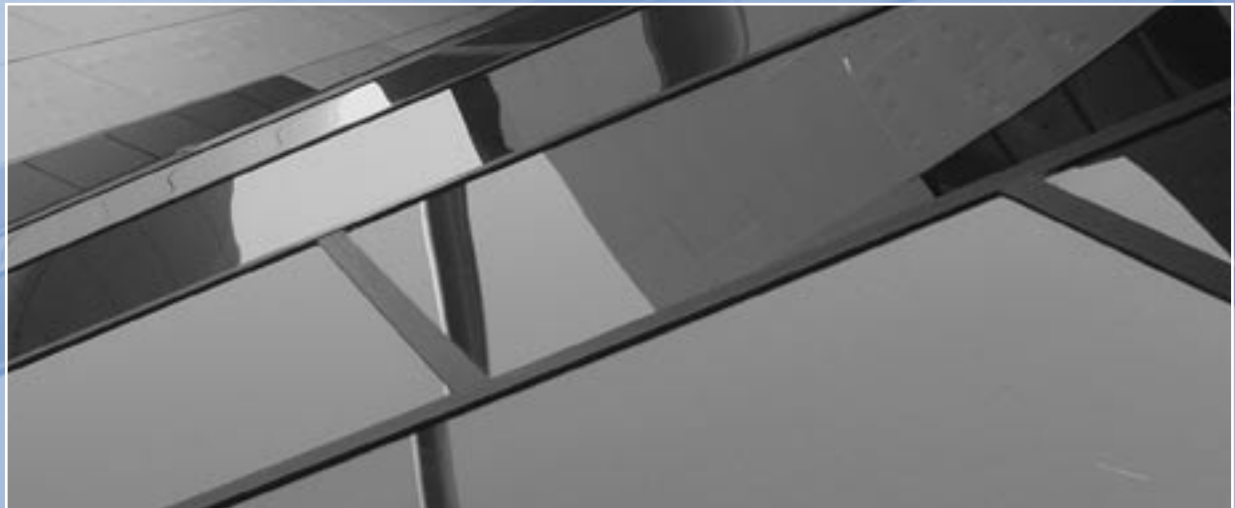
Thank you for your cooperation.

Your efforts will provide valuable input to the development of a more collaborative and innovative Australian property and construction industry.

John McCarthy
Chair
CRC for *Construction Innovation*
Board

Dr Keith Hampson
Chief Executive Officer
CRC for *Construction Innovation*

Peter Brandon
Professor
University of Salford, UK



In preparing *Construction 2020 – A Vision for Australia's Property and Construction Industry*, the authors have analysed the results of the questionnaires, workshops and other discussions that took place under the *Construction 2020* initiative. This brief description draws out the key issues arising from these activities and provides the basis for the identified visions.

What are the major global trends affecting the industry?

Studies of this nature in many different countries (with sets of respondents from different backgrounds), have suggested that issues related to **sustainable development** are likely to have the greatest impact on the way we will behave in the future. This includes the impact of global warming, reduction in non-renewable resources, pollution, and, to some extent, conservation. In recent years this concept has been extended to include sustainable communities, particularly after the Rio de Janeiro Conference on Sustainable Development in 1992. The *Construction 2020* study is no exception, and **sensitivity to sustainable development** was seen as the major driver with over two thirds of respondents placing this in their top five priority list and 34 percent making it their top priority.

Following from this in importance, respondents felt that the **integration of computer and communication technologies** would have a major impact on the activity of the property and construction industry, with many also mentioning the increased power and miniaturisation of computers as important. This was followed by the changing **demographic patterns** in the world, **knowledge sharing** across national boundaries and **increased globalisation**. Figure A1 shows the relative importance of these based on the proportion of total respondents selecting the trend in their top five.

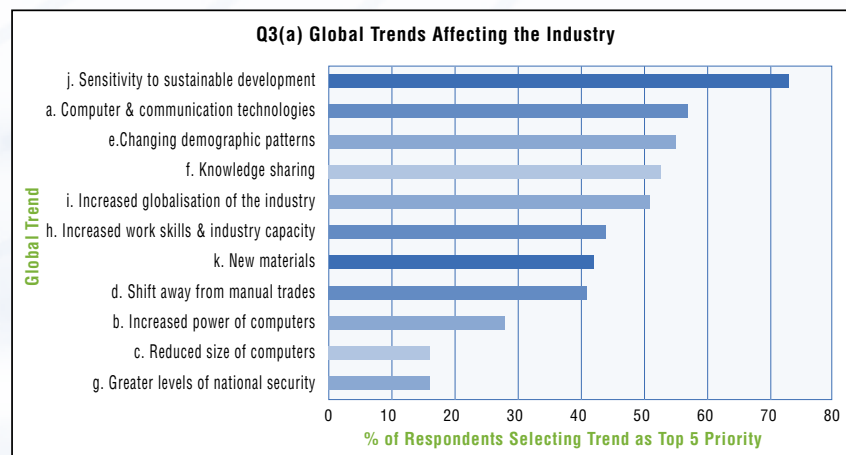


Figure A1 Global trends affecting the property and construction industry

Of those who wished to identify other issues than those presented, the majority identified the changing **business environment** in one form or other.

What issues and technologies will have the most impact on Australia?

Once again, **sustainable development and environment** was the top priority identified through the completed questionnaires, followed by **whole-of-life management, information technology** and **smart or intelligent buildings**.¹ However, these were closely followed by **less adversarial business relationships** and this was also strongly borne out in workshop discussions. Reinforcing this, when respondents were asked to express their own ideas for improving the industry in addition to the suggested list, they identified issues relating to **business environment** as the most important issue.

¹ It may have been possible to infer that respondents felt that there will be a drive to take the longer view in investment and planning and that technology would inevitably begin to make inroads into industry behaviour.

Respondents were given a free hand to identify what was distinctive about the Australian property and construction industry compared with the global industry. Textual analysis of responses highlighted seven major themes as shown in Figure A2.²

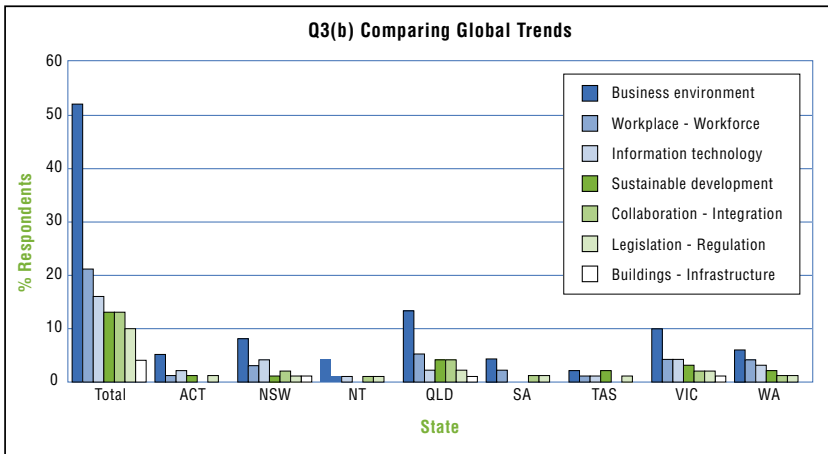


Figure A2 Comparing the Australian property and construction industry with the global property and construction industry

Aspirations of the industry?

Figure A3 shows the relative importance of themes raised when respondents were asked to picture their own vision for the industry in 2020.

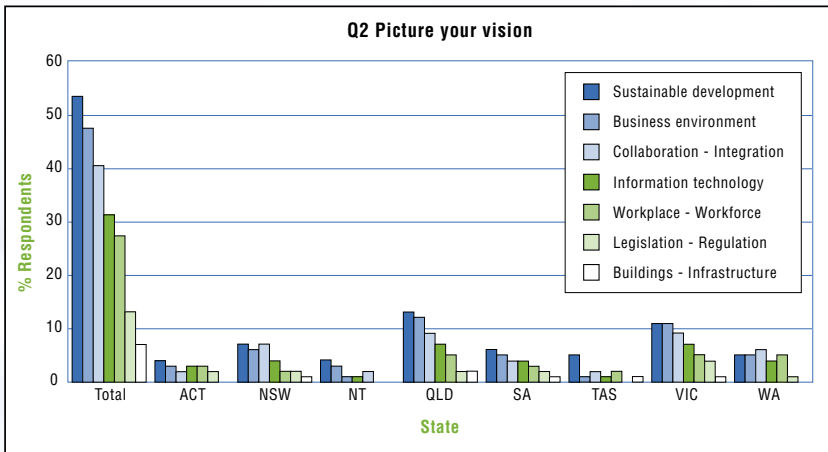


Figure A3 Vision for the year 2020

This request for their own vision gave respondents the opportunity to express the main themes which needed to be addressed in the new vision for the industry. Again, the top set of issues related to creating a **sustainable development** environment, closely followed by improvements to the **business environment**. **Collaboration/integration** and the means to facilitate this through **information technology** were third and fourth respectively. Although the authors have classified the textual

information in this way, it should be stated that improvement of the business environment might also include the means of improvement as suggested under the collaboration and information technology headings. What is clear is that the respondents were not content with the current environment in which they had to work and a major focus for improvement should be business issues. In particular, the drive to obtain lowest short-term cost was seen to be counterproductive to the long-term wellbeing of the industry and the society it serves.

What items do you think the industry needs to address to achieve an improved industry in the longer term?

From the list provided in the questionnaire, it is clear that the priority ratings still pertain when respondents are asked to select their top five changes that would lead to an improved industry. Broadly speaking, the top three related to **environmental assessment and management** followed by issues related to management within the **business environment** (see Figure A4).

Following from this, the next group of issues concern technical matters followed by a variety of issues, some of which related to these other two big themes, but at a more detailed level. These results are interesting since they suggest that, when thinking about the future, the industry is most concerned with broad strategic directions and values within which the industry has to work.

² Business environment issues were considered to be by far the main differentiator and this was reinforced in later responses (see Figure A3). These views were consistent across all states.

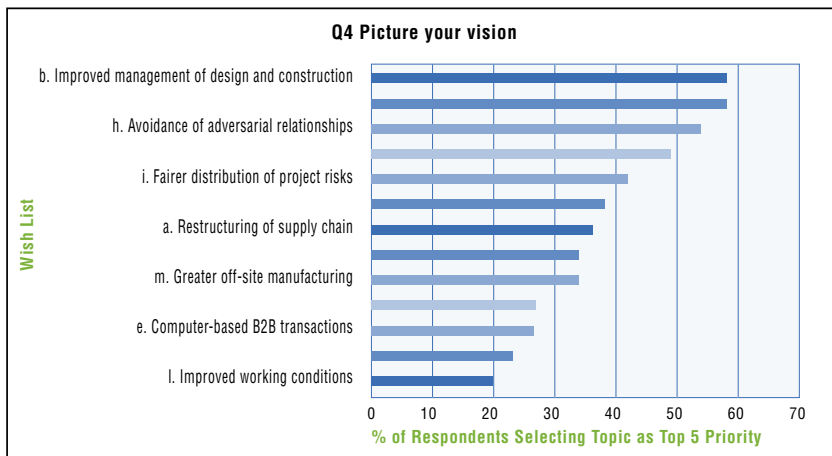


Figure A4 Picture your industry vision – What do you wish for?

One caveat should be given. The site workers, when asked their views, were more concerned with people issues such as the shortage of skilled workers and the welfare of the workforce than were the respondents to the questionnaire and the largely professional audiences of the workshops. This suggests a divide in terms of the perceived needs of the industry, and this needs examining. Neither side will achieve their wishes for the future unless some harmony in aspiration is found.

Do you agree that what the rest of the world is saying will happen?

A number of studies have suggested specific change in the industry for the future. Respondents were asked to consider a selection of technological and other breakthroughs and place each event within an expected timescale of it happening, from less than 5 years to greater than 15 years, in five-yearly intervals. There was also the opportunity to suggest that the event might never happen.

In general, the results show that the expectation from the majority of respondents is that most of the advances were expected in the next 10 years, and in many cases in the next five years. The reason for this may be that the events listed were largely technological (for the most part ICTs), and there is now an expectation that these advances will happen more quickly than they have in the past, and many are already to be seen in demonstrator form. The major exceptions to this, where a longer timescale was expected, were perhaps surprisingly:

- the expectation that 80 percent of construction components would be built off-site
- energy becomes scarce, driving new forms of manufacture and design
- climate change will demand new types of construction
- pollution levels demand extensive regulation of the industry.

However, for every listed breakthrough possibility, some respondents thought the event would never happen!

Where are the barriers to change?

Here the respondents were asked to identify their five major barriers to change and rank them. The selection process clearly identified the **fragmented structure of the industry** as a major problem, followed by a **short-term approach to financing and planning**, with **risk aversion** and the **profit margins** of the industry falling within the top group. The next group contained a variety of issues mainly concerned with management and also relationships between employees and employers, with outdated regulations, education and the cyclic nature of the industry being included. Finally there were technological issues and problems associated with the structure of the industry.

What research is needed?

Respondents were given a free hand to identify their priorities in terms of future research investment to achieve the improvements they seek. Using textual analysis of responses to identify major themes (see Figure A5), the **business environment** easily came first followed by **sustainable development** and then **information technology**. Interestingly, the next highest were **workforce- and workplace-related issues**, and then **collaboration/integration** between members of the design and manufacturing team. Under each of these major themes were a series of interesting and more detailed suggestions which have been collected and will form the basis of further examination by the CRC for *Construction Innovation* in the future.

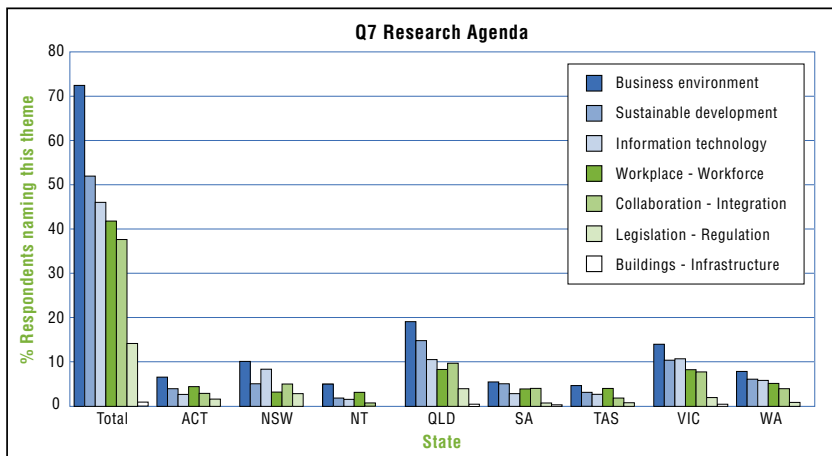


Figure A5 Research agenda to achieve your vision

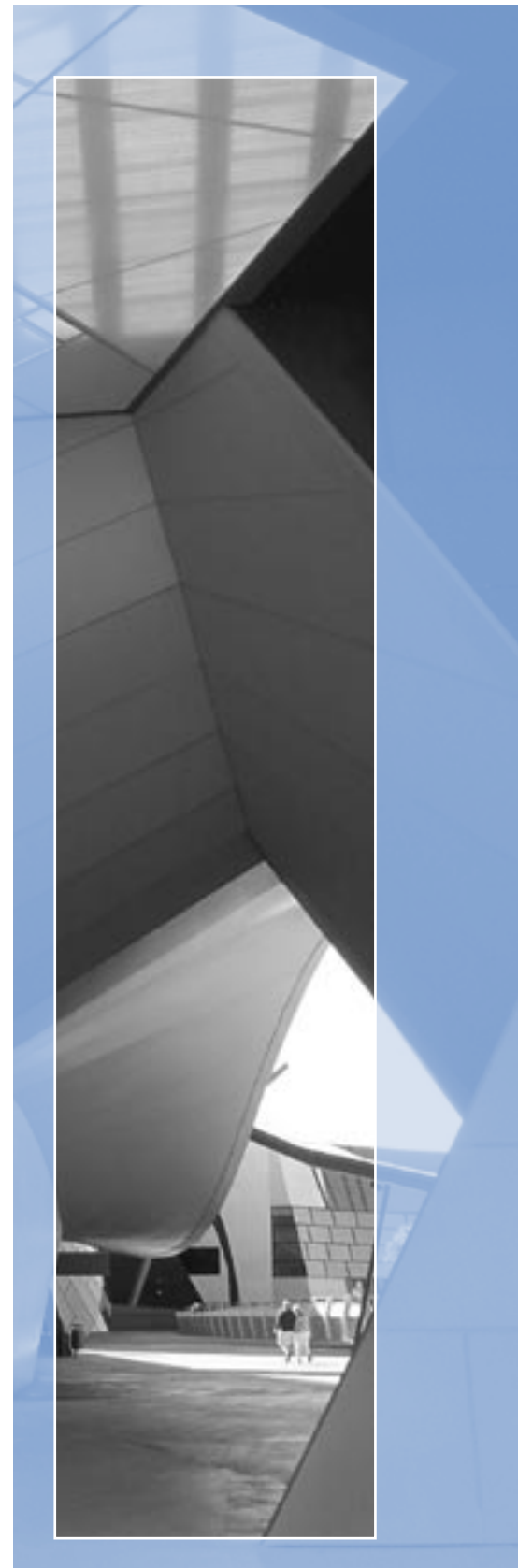
General observations

This report highlights some key issues but does not do justice to the wide variety of ideas and views expressed. These will be explored further as the CRC for *Construction Innovation* continues to develop its national research and technology transfer agenda.

It is clear, however, that three principle themes are the ways in which the Australian property and construction industry can improve its competitiveness, performance and image. These are:

- **Improving the business environment** – this requires a corporate effort between all stakeholders, leadership by government and better understanding of the problems faced at the present time.
- **Addressing sustainable development and the full life cycle of assets** to ensure that present and future generations do not have to pay the price for our unwillingness to consider their future requirements. This requires better evaluation and monitoring as well as better design and maintenance solutions to our built environment.
- **Harnessing the power of new ICTs** to ensure that the industry is effective and efficient in using communications and data transfer technologies and can be compared favourably with other advanced major industries.

Other issues run through these major themes. They include the image of the industry, the way the industry is structured, the lack of education in some sectors, the diminishing skill base, and the financial environment in which organisations are expected to work. These are not trivial matters and will require further examination to establish a robust and effective research and innovation agenda for the future.



A 2020 vision scenario: Construction innovation design studio¹

Improved business processes, embedded information and communications technologies and greater sensitivity to environmental issues will inevitably shape the future of the property and construction industry. The following scenario provides a future view of a possible scenario. It is intended to be thought-provoking and imagination-stretching. It is based upon likely advances in business practices enabled by advanced information and communication technologies.

Peter Newton Chief Research Scientist, CSIRO Manufacturing and Infrastructure Technology, and CRC Program Director – Sustainable Built Assets.

Robin Drogemuller Project Leader, CSIRO MIT and CRC for Construction Innovation Platform Director – Information and Communication Technologies.

Achim Weippert Senior Researcher, School of Construction Management and Property, QUT, and Senior Researcher, CRC for Construction Innovation Internet-based Construction Project Management.

It was 0815 Monday when I brought the Sydney design studio's live i-Wall on-line as I entered the *I-Room*. Now recognised² with a *G'day Pete* it presented me with several windows of information assembled overnight by my VPA³ for me to scan as I drank my coffee. The windows within the live wall contained a filtered set of business items of interest, weekend sport highlights, my calendar for the day, and a prioritised set of B-mails⁴ received over the past 12 hours.

One of the high priority B-mails was confirmation by the Queensland Super Fund Ltd that *Construction Innovation Design* had been contracted to supply concept plans, cost estimates and building performance signatures⁵ for initial client discussion on Wednesday in Auckland. A win for design firms operating the D5 paradigm⁶ – a new standard for competition.

By 0900 Monday, I had all the key contributors for this project linked into a videoconference: Mike, from our Los Angeles office, via his PDA from a Sunday evening Santa Monica dinner party – he would develop several 3D concept models; Selina from Melbourne who would undertake the preliminary performance assessments; Anil, also from the Melbourne office, would perform the visualisations; and Bill from his Sydney office would do the preliminary estimates. Using our Virtual Project Manager expert system, we identified the relevant list of *to-do* items, by whom and when. These basics hadn't changed from my first year in practice, although by now this process was quick, documented, automated and distributed in real time – providing a template for what would quickly become a seamless flow of large volumes of information over the next 48 hours.

¹ *Construction Innovation Design* was established as a spin-off company in 2011, created around new design technologies that emerged from the CRC for *Construction Innovation* between 2005 and 2010.

² The significant investment in security and authentication technology that occurred under Homeland Security activities since 9/11 has subsequently found its way into a range of commercial applications.

³ Virtual Personal Assistants (VPAs) are a class of net-bot (internet robots) that trawl the Internet and other digital media for information on topics of relevance to their bosses.

⁴ Broadband emails (B-mails) comprise mixed voice, text, image and video messages.

⁵ The shift to performance-based design and construction which began in the 1990s has developed to the point where there are a core set of 43 building performance measures that need to be satisfied for approval purposes. Performance benchmarks have been established in the National Building Code (NBC) (minimum acceptable performance) as well as in *Construction Innovation's* Australian and Global Best Practice Design Guide.

⁶ D5 competition is now accepted best practice among the design professions, and spans *creativity*, cost (now life cycle cost – a marked contrast to capital cost which dominated until a decade ago), *quality*, (a continuation of the 1970s ISO-initiated innovation), *time-based competition* (thanks to advances in broadband, automation and visualisation), and *performance* (sustainability had finally been added in 2015 – to safety, health and access – as a major new theme in the Building Code of Australia, together with performance targets and assessment tools).

Key drivers for the *performance* dimension of D5 competition were two transformative and convergent technologies. One was the revolution in ICT that gave birth to the 'city of bits' – an ability to represent every element of the built environment (bricks, tiles, pipes, lights, trees etc.) as a digital *object* capable of multiple representation, manipulation, analysis and display (the principal platform for automation *complex integrated modelling* and visualisation in design). The second was the emergence of *sustainability* as a conceptual force in research, government, industry and community thinking. The power of convergence derives from an ability to attach triple-bottom-line attributes (economic, social, environmental) and behaviour (e.g. service life performance under a variety of operating conditions) to built environment objects providing the first opportunity of realising sustainable buildings through virtual building.

Urban design has entered the realm of computer gaming. Under the *design as gaming* paradigm, a range of Internet sites emerged to provide individual consumers with the tools to *build* and *play* with different house layouts, materials etc.

The key tasks were identified as follows:

Task one

Task 1, the 3D modelling, was required in our Australian east coast offices by 0800 Tuesday⁷. Generating an entire building model in one day used to be a *big ask*. Now each designer has a range of default parameters that can be called up at the start of a new project. These define preferred material selections, design templates etc.

Task two

Task 2, the preliminary performance assessments, were needed by noon Tuesday.

The first cluster, relating to safety, health and access, were undertaken via the National Building Code website on a pay-per-use basis — ensuring that *Construction Innovation Design* used best available analytical tools⁸.

The second cluster related to environmental assessment — *ecological footprint* had assumed equivalent prominence with *building footprint* from the perspective of the planning approval process. Selina was able to compile a series of different environmental views within two hours using *LCA Sketch Design*⁹ — two alternative facades (glass curtain wall versus concrete panel), two alternative structures (steel versus concrete), three prospective building shapes and three alternative indoor environment control systems were all tested. The analyses ensured there would be a number of issues for discussion with the client on Wednesday.

Task three

Task 3 involved automated quantities take-off and costing, performed using ESTIMATOR software¹⁰. Bill had trained as a quantity surveyor and previously would have spent several days costing several sketch designs. Now he oversees an automated process taking minutes. No problem meeting the Tuesday noon deadline.

Task four

Task 4 involved Bill analysing the prospective impacts of a spectrum of extreme events. The large insurance claims due to natural disasters like bushfires, earthquakes, cyclones, floods, hail and storm surges¹¹ over the past 20 years, together with acts of human destruction by terrorism have led to reassignment of risks across a wider range of stakeholders: designers, property developers, and regulatory approvals agencies. This engenders a more resilient class of building.

⁷ The 3D models were developed in our LA immersive design office — a self-contained room with a mix of physical user-input devices. One wall shows the 2D projections (plans, sections, elevations etc.) while the holographic display allows the designer to interact in three dimensions as an external observer. Another option for interaction is to switch the entire room to immersive mode. The special glasses allow the users to perceive the proposed project as it will be, just as though they were there. We gave up using the old WIMP (Windows, Icons, Mouse, Point) interface years ago. We now used pen-based interfaces when working in two dimensions, just like my grandfather did (except he used paper). We use gestures and voice to communicate with the 3D interfaces.

⁸ Since ISO protocols were endorsed for interoperability of building object data, there had been a major shake-out of design software, ensuring only the best global performers survived — another impact of convergence, this time of interoperability and Internet access. Automated checking for compliance against national standards is *de rigueur* now. The early versions were not of much use until the design was fully specified. Now these tools can work at the conceptual stages of design, checking as you work and projecting forward to identify possible problems.

⁹ *LCA Sketch Design* is the world's leading eco-efficiency assessment tool. It has become to the architect what Spellchecker became to the text writer. With automated materials take-off from 3D CAD, it accesses plug-and-play environmental life cycle analysis (LCA) databases for all building components, providing assessment of their impact on the natural resource base and the environment via the manufacturing process. What was commonplace with manufactured food products in supermarkets a decade ago (i.e. labelling shelf life, cost, ingredients, health implications) is now available via the eco-labelling, to ISO standards, of manufactured building products (i.e. service life, cost, resource input, environmental impacts).

¹⁰ The integration of cost planning tools with environmental assessment meant that the environmental designer was able to work closely with the cost planner to ensure that all of the constraints imposed by the client and legal requirements were met first-off. A number of conflicts and potential problems were immediately identified. Some have already been resolved. Others will have to wait until our meeting with the client.

¹¹ Many of these extreme events have now been conclusively linked to global climate change and climate variability.

Task five

Task 5 involved a series of visualisations prepared by Anil that gave us all a sense of *being there*. The external views of the proposed project were superimposed over digital video taken at the site. When we visit the site our new 3D-augmented reality glasses will give the appearance of the building actually being there. The integration of *immersive 3D* – 3D-interaction through our hologram table and the traditional 2D-images on our wall displays – means that we can move to anywhere on the proposed project, move in, around and through spaces and check for clashes between the initial designs of the various systems.

By mid-afternoon on Tuesday, I had assembled inputs from all of the task leaders. Scanning the inputs revealed a number of areas where additional analysis was required. This no longer caused stress the way it once did, thanks to collaborative design tools and virtual enterprise processes that are now well established in the firm.¹²

By close of business Tuesday, I had all the material I needed assembled on our external server for presentation in Auckland the next day. All I will have to do is log on remotely to access all of the prepared material. I will be taking some light 3D-projection equipment with me since we cannot expect our clients to have all the sophisticated tools we use every day.

Taking the last flight out of Sydney for Auckland, I settled back in seat 3A to my pre-ordered supper knowing that all bases had been covered for tomorrow's meeting.

Six months later, the benefits of a closely integrated design and construction team with widespread access to collaborative technologies was demonstrated:

Hey Pete, it's Tony here. I am on-site and we have just found an old rubbish tip while excavating for the structural core. We are going to need a redesign of the foundations over this area. Tony was at the Mobile Project Simulation Centre (MPSC)¹³ located on-site and he had just pulled up the 2D- and 3D-representations of the project once this new problem had emerged. Tony had a similar i-Wall to ours and I was able to set my displays to mirror his.

Tony, have you got locations on this tip? Tony patched in the new GPRS data over the initial site layout generated from satellite imagery. We then patched in Jane, the structural engineer, to discuss the problem. She ran several quick simulations testing alternative ideas while we discussed the issues. *I will have a revised design for you by the time you get back from lunch,* she offered.

True to her word, we linked up straight after lunch and looked at the revised structural proposal. *Looks good,* said Tony, *but this will impact on our schedule.*

Tony ran several possible revisions to the construction schedule using the new IntegraPlan software. Sue, the site foreperson, viewing the data through the Digital Hardhat display near the excavation, said *This will put us three days behind, but by bringing in an extra crew for a week we can catch up within two weeks. The increased cost will still be within the budget for excavation so we won't need to go back to the client.*

All of these communications were automatically logged in the MPSC project database.

¹² I remember sitting in the lecture theatre at Telstra Research Laboratories in June 1992 for a demonstration of the world's first application of real-time collaborative work between designers located in different urban centres (I recall it was called *CAD Conferencing*). It was almost another 20 years before this process had become commonplace in the property and construction sector.

¹³ Mobile Project Simulation Centre: MPSC 2020 is the most technologically advanced mobile project communications/information/simulation centre with an assembly of components that ensure improved efficiency of all project-related documentation and communication, including Internet-based Construction Project Management (ICPM); virtual reality (VR) communication solutions (WAP, satellite, GPS, wearable technology) allowing virtual workstations e.g. linking on-site personnel with off-site design consultants; real-time audio and visual linkage to site personnel and on-site activities e.g. hologram/virtual *walk through station* – where, for example, the site manager stands on a virtual pad, slips on a pair of infra-red sensor gloves, puts on a virtual audio and visual headset and walks through the project viewing on-site progress through on-site cameras and/or on-site personnel cameras (fixed on their hard hats), or deals with issues by real-time linking to relevant decision makers (consultants/client etc.) and bringing them into this virtual environment to help solve the issue from anywhere in the world (without actually being on-site).

Appendix V Acknowledgements

This *Construction 2020* initiative arose from the desire by the Governing Board of the CRC for *Construction Innovation* to make a real difference to the Australian property and construction industry. They were determined that outcomes of this research be transferred to industry practice – for the benefit of direct shareholders in the CRC, the industry and the community at large. Broader industry engagement beyond *Construction Innovation* participants was always seen as being a mandate for this CRC.

In delivering *Construction 2020 – A Vision for Australia's Property and Construction Industry*, we have relied substantially on the goodwill and commitment of our CRC participants, the industry associations represented particularly by the Australian Construction Industry Forum, together with the Australian Procurement and Construction Council, Civil Contractors Federation, Housing Industry Association, and the Australian Department of Industry, Tourism and Resources. We are grateful for the sponsorship and organisational support provided by these organisations, for without their commitment to this process, we would have fallen short of securing the views of those in our industry who matter.

In the planning and implementation of this project Louise Adams and Carolyn Hall have provided exceptional administrative and analytical support – Louise from August 2003 to May 2004 when she left us to have her second child. Thank you, Louise, for your contribution throughout.

Professor Martin Skitmore from the Queensland University of Technology worked through the quantitative analysis with his usual diligence and professionalism. His analysis provided the baseline for our interpretation and documentation.

Paul den Ronden applied his industry experience and ever-present good humour in leading the important site workshops in February 2004.

Special thanks to Kate Finlayson and Colleen Foelz for their combination of creativity and insightful editing in the development of this publication.

The Australian CRC Programme builds stronger links between industry, communities and research agencies to achieve world-class research and innovation. The CRC Programme also funds the creation of effective and innovative education and training programs, targeted at technology diffusion and the specific needs of industry. We acknowledge the support from the Australian Government through the CRC Programme for this centre serving the property and construction industry.

This report is the culmination of the efforts of many people across our industry to better prepare for the future of this vital Australian industry. To the hundreds who have contributed to our data collection and interpretation through the national workshops, the interviews and personal discussions – thank you. We trust we have leveraged your investment by providing this report to benefit the Australian community. We share your best dreams for a better Australian property and construction industry.



Australia's CRC for *Construction Innovation*

The Cooperative Research Centre (CRC) for *Construction Innovation* is a national research, development and implementation centre focussed on the needs of the property, design, construction and facility management sectors (broadly referred to as the property and construction industry).

Established in 2001 under the Australian Government's Cooperative Research Centres Programme¹ with headquarters at Queensland University of Technology in Brisbane, the CRC for *Construction Innovation* is developing key technologies, tools and management systems to improve the effectiveness of the property and construction industry.

The CRC for *Construction Innovation* is committed to:

- enhancing the contribution of scientific and technological research and innovation to Australia's sustainable economic and social development
- enhancing the collaboration between researchers, industry and government, and to improving efficiency in the use of intellectual and research resources
- creating and commercially exploiting tools, technologies and management systems to deliver innovative and sustainable constructed assets to further the financial, environmental and social benefit to the industry and the community.

Construction Innovation takes ideas, and turns them into collaborative research to produce industry-relevant results for our partners and the whole industry. We encourage innovation in our research and collaboration in our projects.

The CRC for *Construction Innovation* carries out applied research projects across three major programs:

- Business and Industry Development
- Sustainable Built Assets
- Delivery and Management of Built Assets.
















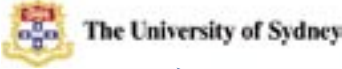

An advanced Information and Communication Technology platform underpins and integrates each of the three programs.

For each program, a director and deputy director, drawn from our research participants and from our industry or government participants respectively, oversee the development, management and completion of the projects. This management structure provides a sharp focus on developing applied research and delivering industry-ready outcomes.

Construction Innovation's core partner group comprises seven private partners, six government sector partners and six research partners – five universities and CSIRO. A fundamental criterion for the selection of these partners was that they complement each other from different positions on the supply chain. Another rationale for this partner network was that each *Construction Innovation* partner would bring a unique set of skills and experiences and be willing to share intellectual property and business experiences.

¹ CRCs bring together researchers from universities, Commonwealth Scientific and Industrial Research Organisation (CSIRO), private industry and public sector agencies, in long-term collaborative arrangements which support research and development and education activities that achieve outcomes of national economic and social significance. The CRC for *Construction Innovation* has been made possible through a \$14 million Federal Government grant through the CRC Programme and complemented by A\$50 million in cash and in-kind support from industry, research and government partners.

Each of the partners has demonstrated willingness to lead by example through investing in innovation research and the future of the Australian property and construction industry.

Industry	Government	Research
      	     	     

From our partner network, *Construction Innovation* has secured commitment from 280 individuals across five major Australian cities equating to more than 60 full-time staff. This extensive network has provided this CRC with the impetus for a strong research program and for developing growth in the important technology diffusion function.

The Governing Board of *Construction Innovation* comprises directors from across the industry, government and research participants with a majority of research users. It is chaired by an eminent, independent industry leader. The Research Committee, responsible for selecting and overseeing the 30 research projects, provides guidance to the Board and is also chaired by an industry representative. The CRC's Education and Technology Transfer Committee determines policy and practice in ensuring that the results of the applied research make a difference to industry practice. This committee is chaired by a senior education representative.

Construction Innovation collaborates with world leaders in research and innovation with the aim of creating world's best practice in property and construction management. It is a corporate member of the International Council for Research and Innovation in Building and Construction (CIB) and sits on the governing board of this global research network. *Construction Innovation* has also led the formation of the International Construction Research Alliance (ICALL) linking together a select number of leading research providers in Europe and North America.



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worst nightmares*

division deception degradation domination

"Do nothing!"

"Stay where we are."

*"Boom, bust and
breakdown!"*

*"Adversarial climate
deepens the bunkers
we live in!"*

*"Short term-ism creates
long-term losers."*

*"Fragmented industry
with no clear vision."*

*"Failure to attract the
best and brightest of
future generations into
the industry."*

*"An industry confused
about standards and
sustainability and can't
use tools to help improve.
Australian industry falls
behind world's best practice."*

*"Regulations and
procurement practices
stifling innovation,
business systems and
industry advancement."*

*"An industry dominated by
lowest up-front cost with
little regard for whole-of-life
ecological impact, innovation
or quality."*


*"Insufficient education
to address future industry
demands at all levels and
a continuing shortage of
tradespeople."*

*"A conservative industry
disconnected from
community aspirations
with little changed from
today's practices."*

*Construction 2020 asked workshop attendees around Australia to provide their best dreams and worst nightmares for our property and construction industry.

This is a selection of the Worst Nightmares.

C O N S T R U C T I O N
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v i s i o n r e p o r t



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