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LEVERAGING R&D TO ADVANCE DIGITAL MODELLING PRACTICE IN AUSTRALIAN CONSTRUCTION

PROFESSOR KEITH D. HAMPSON[1] and DR JUDY A. KRAATZ[2]

[1]*Sustainable Built Environment National Research Centre, Level 13, 126 Margaret Street, Brisbane, Australia. E-mail: k.hampson@sbenrc.com.au*
[2] *Faculty of Built Environment and Engineering, Queensland University of Technology, 2 George Street, Brisbane, Australia. E-mail: j.kraatz@qut.edu.au*

This paper describes a lead project currently underway through Australia's *Sustainable Built Environment* National Research Centre, evaluating investment, diffusion mechanisms, uptake and impacts of R&D in the Australian building and construction industry. Building on a retrospective analysis of R&D trends and industry outcomes, an industry roadmap will be developed to inform R&D policies more attuned to future industry needs to improve investment effectiveness. In particular, this research will evaluate national R&D efforts to develop, test and implement advanced digital modelling technologies into the design/construction/asset management cycle.

This research will build new understandings and knowledge relevant to R&D funding strategies, research team formation and management (with involvement from public and private sectors, and research and knowledge institutions), dissemination of outcomes and uptake. This is critical due to the disaggregated nature of the industry, intense competition, limited R&D investment; and new challenges (e.g. digital modelling, integrated project delivery, and the demand for packaged services).

The evaluation of leading Australian and international efforts to integrate advanced digital modelling technologies into the design/construction/asset management cycle will be undertaken as one of three case studies. Employing the recently released Australian Guidelines for Digital Modelling developed with buildingSMART (International Alliance for Interoperability) and the Australian Institute of Architects, technical and business benefits across the supply chain will be highlighted as drivers for more integrated R&D efforts.

Keywords: Digital modelling; Building Information Modelling (BIM); design and construction practice, R&D policy; R&D diffusion; innovation systems; industry roadmapping.

1. Background

The Australian *Sustainable Built Environment* National Research Centre is currently evaluating diffusion mechanisms, uptake and impact of R&D in the Australian building and construction industry. A national research team is undertaking a retrospective analysis of R&D trends and industry outcomes; and developing an industry roadmap to inform R&D policies more attuned to future industry needs. As one of three case studies, this research will evaluate national R&D efforts to develop, test and implement advanced digital modelling technologies into the design/construction/asset management cycle.

The evaluation of past R&D investment (1990-2008) is being undertaken in the context of national KPIs developed to track industry productivity performance (Furneaux et al. 2010). These KPIs were developed in conjunction with the Australian Procurement and Construction Council (APCC) and the Australian Construction Industry Forum (ACIF) in response to the lagging productivity of the Australian building and construction industry (Property Council of Australia 2009). These KPIs are safety; productivity and competitiveness; economic security; workplace capability; and environmental sustainability/eco-efficiency. Examples of this poor performance include:

(i) Deaths in construction increased from 3.14 deaths per 100,000 workers in 2004 to 4.27 in 2008 (CFMEU 2010). This compares to an overall fatality rate of 2.7 deaths per 100,000 workers across all industries.

(ii) 'Productivity growth in the building and construction industry was less than the average for the market sector over the past five years. Were productivity growth to match that of the market sector, economic modelling shows that the accumulated gain in real gross domestic product between 2003 and 2010 would approximate $12 billion' (Royal Commission 2002:3).

(iii) Kajewski et al. (2001) identify a key driver for ICT uptake as improved productivity, however the level of uptake remains less than optimal (Gallaher et al. 2004).

(iv) Engineers Australia (2005) report that poor documentation is 'contributing an additional 10 to 15% or more to project costs in Australia' (EA 2005:3) with 'substandard project documentation' equating to an estimated financial loss of $12 billion nationwide annually (EA 2005:4).

Such conditions highlight the need for a focused approach to addressing these challenges in this complex industry. The intent is for outcomes of this research to deliver this focus, including: an industry R&D roadmap; policy guidelines for public and private firms; and an update and revitalisation of Construction 2020 (Hampson and Brandon 2004).

2. Significance of this research

The building and construction industry in Australia accounts for between 14%-20% of GDP (Furneaux et al. 2010). In 2008, the cumulative value of site-based residential, non-residential and engineering construction was A$160 billion (Newton et al. 2009). The industry employs around 950,000 people through 250,000 firms, the vast majority of which are small to medium-sized enterprises. The Australian Bureau of Statistics estimates that from an initial $1 million of extra output in construction, $2.9 million in additional output could be generated in the economy as a whole. This would create nine jobs in the construction industry and 37 jobs in the rest of the economy (ACIF 2002).

The Australian Department of Innovation, Industry, Science and Research (DIISR 2010) identifies an on-going decline in spend on science and innovation in Australia since 1993-94 of 22% (DIISR 2010:2). By way of comparison, from 1996 til the time of this report, R&D spending in Australia increased by 8% whilst that in China across the same time frame has increased by 22%. More specifically, Hampson and Manley (2001) report on the relatively poor innovation record of this industry in Australia with an R&D expenditure of 1.4% compared to the share of site-based construction activity in total output of around 7% of GDP.

3. Aim of this research

The key aim of this project is to build new understanding and knowledge of R&D dissemination and uptake in the Australian building and construction industry, and thereby develop pathways to increase the

safety, productivity, competitiveness and environmental sustainability of the industry. Effectively leveraging R&D is a major challenge for the industry due to its disaggregated nature, intense competition (Hampson and Kwok 1997), and limited investment in R&D, and new technologies.

New and emerging technologies (e.g. digital modelling and green technologies) especially require the development and adoption of new practices to facilitate uptake and productivity improvements across the industry's supply chain. These areas will be specifically investigated in case studies designed to evaluate recent R&D investment outcomes. One such case study will advance recent research by the CRC for *Construction Innovation* tracking Australian and international efforts to integrate advanced digital modelling technologies into the design/construction/asset management cycle. This research will investigate several projects employing the recently developed Australian Guidelines for Digital Modelling developed with buildingSMART (International Alliance for Interoperability) and the Australian Institute of Architects. Technical and business benefits across the supply chain will be highlighted as drivers for more integrated R&D efforts in this area.

4. Research intent

The intent of this research to develop new models of interaction and investment that maximise the value of R&D investment. These models will be based on improved understandings of the nature of future industry research needs, and lessons learned in diffusing research outcomes into public and private industry practice. Case studies are planned on building information modelling (BIM) and integrated project delivery (IPD). Characteristics of building information models include 3D representations based on objects which include embedded information or properties beyond the graphical representation (CRC CI 2009a:1). IPD is characterised by a shift towards greater team collaboration (e.g. design consultants, the contractor, specialist trade contractors), ideally beginning early in the design process so that contributions maximise benefit and minimise cost (CRC CI 2009a:1). This case study will draw upon eight years of R&D investment and collaboration in this field, via the CRC for *Construction Innovation* with key partner, the Queensland Department of Public Works (QDPW). QDPW manages the Queensland's capital works program, building and maintaining public facilities (i.e. schools, public housing, hospitals, police stations and courthouses). In addition, this is the State's lead agency in the application of whole-of-Government information and communication technology, procurement, and the provision of support services (e.g. fleet management and disaster management and recovery).

Research outcomes will provide benefit to both public and private organisations in enhancing their uptake of R&D outcomes. This will be achieved through the active involvement of public sector infrastructure and building agencies along with industry leaders in innovation such as the Australian Government's Built Environment Industry Innovation Council (BEIIC), established by the Department of Innovation, Industry, Science and Research.

5. Structure of the research project

Four project phases have been designed to achieve project outcomes (Figure 1).

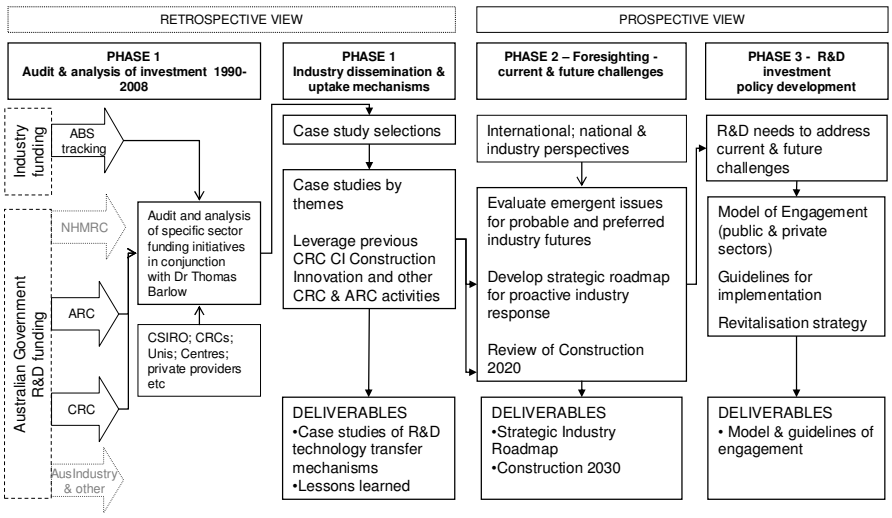

Figure 1– Project Overview

Phase 1 – Investment Audit and Analysis

This phase involves an audit and analysis of R&D investment in this industry, in order to better understand the key criteria influencing successful R&D uptake and dissemination. This phase will identify trends in investment and its distribution by funding source. Outcomes will include (i) recommendations as to how R&D investment in this industry might be strengthened; and (ii) benchmarking between this and other comparable sectors (e.g. automotive manufacturing and chemical).

Phase 2 – Industry dissemination and uptake mechanisms

Building on the Phase 1 information base, this phase will provide deeper insights into R&D dissemination and uptake through three national exemplar case studies. These will further develop the knowledge base previously established by researchers at the Queensland University of Technology (Brisbane, Australia) relating to the impact, diffusion and uptake mechanisms of research and innovation in Australian organisations. These case studies will be used to determine the critical characteristics of the processes of realising research support; direction-setting; project engagement; identifying and communicating research outcomes; and pathways to adoption and impact.

In-depth understandings of the translation of R&D investment into tangible outcomes will be sought, including (i) explicit and implicit problems being addressed by the research; (ii) criteria for success; (iii) benefit/cost ratio and return on investment; and (iv) what would be the benefit if extended across whole industry?

The digital modelling case study will extend previous research in this field which sought to integrate advanced digital modelling technologies into the design/construct/asset management cycle in Australia. Building information modelling (BIM) and integrated project delivery (IPD) are not yet mature practices in Australia, and thus codified industry standards do not yet exist in this country for these practices (unlike the USA, Norway, Denmark and Finland) (CRC CI 2009a:5). Australian guidelines have however been recently published (CRC CI 2009a&b) based upon a series of case studies, research, and industry workshops conducted in 2008. This research will further investigate current practice in terms of *technology*, *process* and *policy* implications, to better informing Phase 3 of this project.

Phase 3 – Foresighting – current and future challenges.

This phase will build on and extend a solid base of technology and industry foresighting carried out by VTT Technology Foresight and Technology Assessment research unit (Finland) (Roos and Pike 2009) and Swinburne University of Technology (Australia) (Voros 2003). Foresighting is the application of systematic, participatory, intelligence gathering and medium-to-long-term vision building processes to inform present-day decisions and mobilise collaborative actions. This brings together foresighting experts and knowledge experts to develop strategic visions and anticipatory intelligence. Using an envisioned futuristic state as the goal, short, medium, and long-term strategies will be defined in the context of a roadmap and supporting strategic implementation actions.

Phase 4 – R&D investment policy development.

The intent of this phase is to maximise the value of R&D investments to public and private organisations. This will be done through (i) identifying priority opportunity areas and applications for R&D investment; and (ii) actions for implementation. The key outcome of this phase will be a model for engagement providing a set of strategies to allow organisations to more profitably engage with research institutions. These policy guidelines will inform and direct public and private R&D investment in this industry in Australia, for the coming decade.

6. Digital modelling

Considerable variation exists the current industry understanding of what constitutes BIM. Such models can represent the work of a single discipline, containing minimal information, or more challenging scenarios where the work of multiple disciplines provide a rich source of information for contractors, sub contractors and others. In this latter form, the model may be considered as a 'virtual building' where issues can be explored and resolved digitally prior to construction.

IPD provides the further challenge of how to develop ways to form and manage the project delivery team in this digital environment, while still maintaining competitiveness. The development and adoption of IPD will be required to maximise the effectiveness of using virtual building technologies and processes, including off-site manufacturing (CRC CI 2007).

The intent of the National Guidelines for Information Modelling (CRC CI 2009 a&b) is to provide the context for a nation-wide dialogue leading to development and adoption of industry-wide standards to 'facilitate much better flexibility and opportunities for collaboration in BIM than would otherwise be the case' (CRC CI 2009a:3). Current practice in BIM will be impacted in three ways. *Technological* considerations will be terms of software and hardware limitations; implementation; the need for greater interoperability and integration of software; exchange protocols; and file sizes. *Process* implications will relate to work practices and relationships; the need for common practice guidelines; new jobs and skill sets; different time frames for adding to models; information management; and project team co-location at critical phases. *Policy* implications include the need for industry standards; organisational commitment; and resources for implementation (CRC CI 2009a:3).

7. Conclusion

This project will significantly advance the knowledge base in a number of disciplines including innovation, construction and management research (i.e. dynamic

capabilities, absorptive capacity), as well as the foresighting and roadmapping. The project will also build an extensive knowledge base of underlying drivers and key success factors for R&D investment and innovation in the building and construction industry in Australia.

Research outcomes will make a substantial contribution towards focusing both public and private sector investment in the coming decade, in areas of significance to industry. This will be achieved through the historical analysis of Phase 1; case study explorations of Phase 2; the pursuant industry roadmap and policy guidelines (Phases 3 and 4).

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