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Leveraging R&D Investment for the Australian Built Environment

PRIVATE SECTOR R&D INVESTMENT: A CASE STUDY

INDUSTRY REPORT

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1. Introduction

> '*The built environment industry is a significant contributor to the Australian economy and accounts for approximately 12 per cent of Australia's total production and employment. The Allen Consulting Group advised the Council that the sector's production was equivalent to around $355 billion in 2005-06 and that just over one million people were employed in the buildings network*.' (BEIIC 2012)

The expanse and diversity of the construction industry presents a series of challenges for establishing R&D policy and guidelines, ensuring that research is translated into practical outcomes, and determining the impact of this research. Understanding the complex nature of and relationships within the industry is subject to ongoing analysis. Issues include the spread from manufacturing to service-based sub-sectors; variation in the uptake and use of technology; the predominance of SMEs which historically have a lower participation rate in innovation and R&D activities; and the traditional view of the industry as a low-intensity innovator. This complexity and diversity is evident in the survey findings reported on here.

This case study was designed to build understanding of the nature of private sector R&D investment in the Australian built environment since 2005. It complements three prior case studies of public-sector investment undertaken in 2012. This research seeks to build a more detailed understanding of the motivations, mechanisms, dissemination pathways and impact of such investment.

Traditionally the construction industry is considered as a low-tech industry with a non-R&D view of innovation (Hervas-Oliver et al., 2011). Research is typically applied, informal and incremental in approach, and often integrated into production. Much of this activity may thus fall outside the OECD's Frascatti Manual[1] definition of R&D. This is evident in data gathered from both the survey and interviews, with the question of where the line between business process improvement and R&D occurs being raised by interviewees.

2. Overview of Findings

This case study involved two parts:

Nation-wide survey – of 61 participants was conducted in late 2012(20 consultants, 21 contractors and 20 suppliers). 41 per cent were from large firms; 36 per cent from medium-sized firms and 23 per cent from small firms. Of these 55 per cent identified as being building-related firms (including architects and planners); 23 per cent involved in civil construction; 7 per cent delivering services in both areas; and 13 per cent in services engineering. Of these the rate of agreement to a follow-up interview varied: small firms 36 per cent; medium-sized firms 64 per cent and large firms 48 per cent.

Follow-up interviews were conducted with six firms:

- Ampac Advanced Warning systems – medium-sized supplier
- Hames Sharley – medium-sized architectural consultancy
- Mobile Camera Security – micro supplier
- Multi Span – medium-sized building contractor
- Nation-wide contractor – large civil and building contractor
- WPS Group – large multi-disciplinary consultancy

[1] Organisation for Economic and Community Development (OECD) (2002) Frascati Manual.

2.1. Nation-wide survey

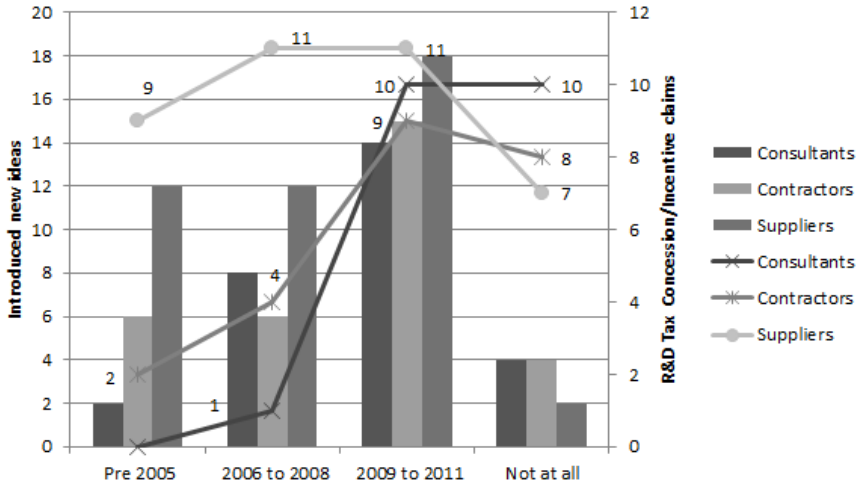
The findings of this case study illustrate the differences which exist within the industry between the sub-sectors (i.e. consultants, contractors and suppliers) (Table 1 and Figure 1) and between small, medium and large-sized firms (Figure 2).

Table 1 – Summary of survey findings by firm type

	CONSULTANTS (20 off)	CONTRACTORS (21 off)	SUPPLIERS (20 off)
MOTIVATION FOR INVESTING			
Top drivers	Market, profit & productivity	WH&S, productivity, market, environment, profit & education & training	Market, profit & productivity related, and WH&S
NATURE OF INVESTMENTS			
Top 3 fields of investment	Sustainable design, computer graphics & construct. management	Civil eng., computer information systems & construct. management	Sustainable design, materials eng. & architecture
Top Past Investments	Systems & Process Innovation & BIM	Systems & Process Innovation	Materials
Top Future Research Area	BIM	Systems & Process Innovation	Sustainability & materials
Development of ideas	Inside the firm	Inside the firm	Inside the firm
Key sources of ideas when from outside	Conferences, seminars, www & journals	Partners, clients & suppliers	Clients, partners, competitors, www, conf. & seminars
Reasons for sourcing ideas from others	Better target areas or investment & outcomes	Increase the impact of the investment	Better target areas or investment & outcomes
DISSEMINATION			
Pathways for dissemination	Strategic partnerships, then other consultancies	Consultants	Contractors and sub-contractors
Dissemination mechanisms	Education & training; & industry associations	Internal education & training, & industry associations & awards	Internal education & training; industry assoc. & awards; & publications
Changes made as a result of R&D	Changes to service delivery	Changes to construction & operating processes	Changes to delivery; & construction & operating processes
IMPACTS			
Impacts of R&D activity	Market & outcomes	Market & outcomes	Profit, market & outcomes

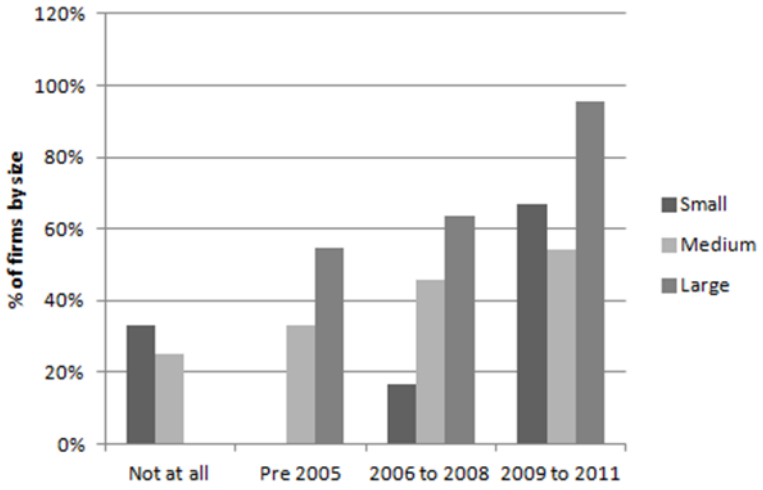
Engagement in R&D has continued to increase in the past decade (Figure 1), especially in consulting firms, with suppliers having a significantly higher rate of R&D over the entire period.

Figure 1 - Introduction of new ideas correlated with R&D tax concessions/incentive claims



R&D Tax concessions/incentives were not reported as a driver for R&D investment, but the literature suggests that structure imposed by the claim process may contribute to increased levels of successful R&D. Small firms reported a lower level of activity (Figure 2), with the majority of small firms have not claimed any tax concession/incentive.

Figure 2 - Introduction of new ideas by size of firm



The ***source of new ideas*** was predominantly internal resources. Consultants then turn to website, journals, conferences and seminars; contractors to their clients, partners and suppliers; and suppliers to a cross-section of all these sources.

Differences were found in the ***key drivers*** between sub-sectors. For consultants and suppliers, market-related issues (e.g. being at cutting edge, improving responsiveness to customer, & increasing market share), productivity (increasing efficiency, improving quality and improve IT capabilities & capacity) and profit (increasing revenue and reducing costs) ranked highly as key drivers. For contractors, WH&S followed by productivity, market-related and environmental issues received the top rankings. Drivers were consistent when looked at by size of firm.

The Built Environment Industry Innovation Council[2] (BEIIC) highlighted that innovation in Australia occurs primarily in firm-based silos, inhibiting the sharing of innovation. The survey found that firms ***disseminate knowledge*** through industry associations and their immediate supply chain: consultants with partners and other consultants; contractors with consultants, sub-contractors and service providers; and suppliers with contractors and partnerships.

In terms of the ***impact of R&D activity***, all sub-sectors reported market-related & improved project outcomes as the top impact, followed by: consultants & suppliers noting profit; and contractors process change.

Changes made as a result of R&D *(related to Key drivers)* *Consultants* – changes made service delivery *(Key driver - market-related)* *Contractors* –construction/operational processes *(Key driver – improve WH&S)* *Suppliers* –service delivery & construction/operational processes *(Key driver – market-related)* Least impact for all on business structure

Detailed findings are provided in the *Case 4 Phase 1 Research Report*.

[2] Built Environment Industry Innovation Council (BEIIC) (2012) Final Report to the Government, Canberra: Commonwealth of Australia.

2.2. Follow-up interviews

The intent of the follow-up interviews was to contribute to a richer understanding of current private sector R&D investment in Australia. Interviewees were selected for interview on the basis of: willingness to participate; achieving a cross section of respondents by size and sector; a reasonable level of R&D activity based on their survey responses. Interviews were conducted between May and July 2013. Due to small sample size generalisations are not possible.

Slaughter[3] provides some initial relevant definitions regarding the nature of innovation:

Incremental – resulting in modest improvement in product, process or system with no or minor changes in links to components or systems. A local champion with no specific resources is required and results can be readily evaluated.

System – is a combination of innovations which are integrated to provide new functions or attributes entailing a high degree of technological uncertainty/interface complexity, and can significantly advance the state of knowledge. This often requires special resources and a high degree of testing and trials. Results need to be evaluated at a system-wide level requiring comparison to objectives rather than existing alternatives

Radical (transformative) – is a significant new concept or approach, often rendering previous solutions obsolete. The innovation requires extensive testing and prototyping, with specialist resources and coordination. This can result in a new way of thinking about how to achieve objectives and provide opportunities to learn more about nature of new tech for future application.

Slaughter also discusses architectural and modular innovations, though these were not evident in the firms interviewed (Table 2).

Table 2 – Nature of innovation by firm

Nature of innovation	R&D Activity	Comment
Incremental	Ampac-fire warning systems	Pace and scale defined by certification needs
	WPS-Future cities	
	Cont.-mobile computing	Both incremental & transformative
System	MCS-smart trailers	Consolidates range of tech. for innovative product
	Multispan-project innovations	New products for innovative project solutions
Radical (Transformative)	Hames Sharley-EBD	EBD approach to provision of health facilities based
	WPS-Future cities	Lateral solutions to define city solutions
	Multi Span & Cont.-mobile computing	Transformative when applied firm-wide

Primary motivation - product & service development.

This research reinforces previous findings that highlight performance rather than cost reduction as the motivation for R&D (Slaughter, 2000). On-going product development and service improvement (with a focus on the client) to improve market share was a primary aim of the majority of interviewees. In one firm, productivity was the driver.

International leadership was also important: (i) in order to expand the export market for products; and (ii) for leadership in service provision.

Five or the six firms considered R&D to be embedded in the corporate culture.

[3] Slaughter, E. S. (2000) 'Implementation of construction innovations', Building Research & Information, 28 (1): 2-17.

Key mechanisms - collaboration & knowledge/technology transfer.

The competitive nature of the industry is considered to be a barrier to knowledge transfer[4]. Collaboration was typically noted within firms' immediate supply chains whether domestic or international, multi-disciplinary, or with clients, suppliers, colleagues, peers and researchers.

Knowledge and technology transfer occurred from other sectors including from IT (both industry and consumer-based) and the health sector (building on international best practise[5]. led by Roger Ulrich and the Centre for Health Design in the US.

The need for a knowledgeable and supportive client with a fundamental level of embedded knowledge and ability to recognised the opportunity for improvement was also important for two of those interviewed. This is particularly pertinent for government clients who can support industry-wide innovation; remove procurement impediments; and influence construction firms to implement innovative practices through regulation and pre-qualification processes (Hardie and Newell, 2011).

Peer-review was highlighted by one interviewee as an important mechanism for their R&D process.

Dissemination pathways - varied & at times difficult or non-existent.

BEIIC (2012) highlighted that innovation in Australia occurs primarily in firm-based silos, inhibiting the sharing of innovation. Findings tend to reinforce this with for R&D outcomes to be distributed primarily within the firm or their immediate supply chain.

Industry-wide dissemination pathways were limited, and primarily through industry associations such as the Australasian Procurement and Construction Council (APCC), the Australian Construction Industry Forum (ACIF), Master Builders Australia (MBA) and the Association of Consulting Architects Austral9a (ACA). Such associations and organisations provide existing pathways with opportunities for expansion. For the micro business the product itself was the only avenue. This is problematic in a mature industry which should exhibit effective pathways for the dissemination of new knowledge. Hardie and Newell (2011) note the importance of intra-industry connections that are not related to specific project delivery to uphold ethical standards, to provide independent verification and testing, and public representations.

This wider dissemination of knowledge is important to build overall capacity for the industry to absorb new knowledge[6]. The value of such intermediaries, such as industry associations or research brokers, in undertaking *technology watch, technology roadmapping, business intelligence and alike* is acknowledged. Whilst some such activity is conducted in Australia, in centres such as the Sustainable Built Environment National Research Centre (SBEnrc), no overarching industry-wide strategy exists in Australia to provide a structure for the dissemination of construction-related R&D.

Impacts, benefits & measurement

Market leadership, increased market share (return and new business), improved products and time savings were highlighted as positive benefits from R&D undertaken. Based on interview responses, benefits align with original motivations and expectation.

With the exception of the not-for-profit NABERS and Green Building Council rating and performance indicators, there is a lack of formal metrics against which to monitor performance, with those reported being varied and not rigorously tracked. Without measurement and analysis to better understand impact, justifying future investment in R&D remains problematic.

[4] Hardi, M. & Newell, G. 2011. 'Factors influencing technical innovation in construction SMEs: an Australian perspective.' Engineering, Construction and Architectural Management 18 (6): 618-636.
[5] led by Roger Ulrich and the Centre for Health Design in the US see Ulrich R. (2006) 'Evidence-based health-care-architecture', Lancet Vol.368, pp538-539.
[6] Spithoven, A., Bart C. &Knockaert, M. (2010) 'Building absorptive capacity to organise inbound open innovation in traditional industries.' Technovation 30 (2): 130-141.

Several challenges exist for the construction industry in maximising the impact of innovation including:

- non-recurring sub-contracting approach typical in much of the industry
- duration and one-off nature of many major projects
- time-lag in realising benefits and impacts of R&D
- lack of funding for follow-up analysis such as post-occupancy evaluations and longitudinal studies

Industry diversity also impacts on the ability to define formal metrics due to the presence of both service providers (i.e. consultants) and producers / manufacturers (i.e. contractors / suppliers). The former producing more intangible results, with IP difficult to protect and impacts, and requiring a longer time frame to assess. For example, design initiatives on the Fiona Stanley Hospital will result in longer term benefits to patients and staff and require a POE to better understand the impacts and benefits of the EBD approach. Whereas suppliers and contractors typically produce tangible products whose impact can be more readily assessed to specification. For example, Ampac undertake R&D which leads to the design and manufacture of fire indicator panels which are tested and certified as part of the production process. Recognition of these differences is important in the context of policy development, targeting impacts and establishing metrics.

Table 3 provides an overview of findings from the six semi-formal interviews undertaken.

Table 3 - Summary of Phase 2 interview findings

	Ampac Advanced Warning Systems	**Hames Sharley**	**Mobile Camera Security**	**Multi Span**	**WPS Group**	**Large nation-wide contractor**
	Medium-size supplier	*Medium-size architectural consultancy*	*Micro supplier of smart trailers*	*Medium-size building contractor*	*Large multi-disciplinary consultancy*	*Large building contractor*
Motivations	Product development; Competitive advantage; Market leadership	Client focus; Improve effectiveness & efficiency; Market leadership	Continuous development; Client focus; Integration of new tech.	Corporate culture	Corporate culture	Cost & resource reduction
Nature of R&D activity	Applied research (some pure); Incremental; Technical & process innovation	Applied research; Transformative	Applied research; Informal process; Development of unique & bespoke products	Applied research; Project, process & systems-based	Applied research; Incremental & transformative; Product development	Applied research; Incremental & transformative;
Mechanisms	Knowledge transfer from other sectors & countries Constraints: Certifications	Evidence based design; International collaboration	Market scanning; International collaboration	Collaboration with clients & suppliers; Mobile computing Challenge: accreditations	Early project engagement; Multi-disciplinary teams; Whole of life focus; Collaboration; Peer review	Supply chain collaboration; Demonstrations; Use of consumer technology; Benefit to subcontractors; R&D tax concession
Examples	Fire panels as standalone products & integrated into competitors' products	Fiona Stanley Hospital Perth	CCTV camera & solar light trailers; Speed alert systems; Mobile repeater stations	Tweed Regional Aquatic Centre; Jack Evans Boat Harbour; iPads for project & business reporting	Future cities program; tri-generation projects; Sydney Central Park development	IPad use on regional highway project as productivity tool
Dissemination	Industry associations & trade shows; Participation in Standards Australia	Difficult without central health-based resource centre in Australia	Via product	Clients & suppliers; Industry awards	Industry associations; Shared experience; Conference calls; Design portal; Social media	Internal only - targeted site visits & demonstrations
Impacts & Benefits	Market differentiation & leadership	Provides evidence to seek funding for good design; Better project outcomes	Niche product with flexible applications	Re mobile computing: Improved communications, reporting & productivity; Waste tracking	Market differentiation & recognition; Innovative products	Time savings & productivity
Metrics	ROI not specifically tracked	Past recorded EBD outcomes; Post occupancy evaluation not yet funded	Return and new business		Past metrics – R&D tax concession; Performance now monitored monthly, ROI expected in 12 months	Time savings

3. R&D Profile - Ampac Advanced Warning Systems

Australian manufacturer & exporter

Ampac was established in 1974, and today design, manufacture and export world-leading fire detection and alarm systems for commercial, industrial and multi-residential complexes. They commenced operations as an audio supplier developing their first fire systems product in the mid 1980's, and established an internal R&D function in the mid 1990's. Ampac now distribute nationally and export to markets in New Zealand, Europe, the Middle East, Africa and Asia. This privately-owned company has a workforce of 150 people located at a custom-designed high-tech manufacturing facility in Balcatta, Perth. The R&D team of 12 includes hardware and software engineers, a circuit board designer, and product testers.

Ampac predominantly undertake applied research, but some pure research also occurs as a result of employees identifying innovative technology not already in the public domain or the industry. New technology from other sectors relevant to the product is identified and research undertaken to explore potentials and ensure that both the product and the company viability will benefit from implementing any new technology. Innovation occurs in both product & process-related areas with .R&D being undertaken as to new processes, different types of hardware and/or different software techniques.

The company's motivation for on-going innovation is to maintain competitive advantage in an industry where product features are driven by new technology, and customers often driven by the desire for the cheapest most compliant product. Market share and leadership are thus maintained through adding product features. Development is incremental due to certification needs, which for example in the UK has taken twelve to eighteen months in the past to finalise. Certification costs and approval timeframes restrain the innovation process as product development is limited by the guidelines of the original approval.

Dissemination occurs through country-based industry associations, mostly in the form of trade shows. Locally, the company also has a role on the Standards Australia.

Return on investment is not specifically tracked. In many cases the developed product itself does not provide a discrete return on the investment due to low volumes, but is integrated into packages with other imported detectors and products from which profit is derived. Thus the Ampac product provides market differentiation and leadership rather than financial return.

"All the products come from the R&D - our main line and the main driving force behind the company is the R&D".

4. R&D Profile - Hames Sharley

An evidence-based design approach to health service delivery

Hames Sharley is a Australian-wide design consultancy established in 1975. They are a knowledge-based organisation providing advice to assist clients to develop 'the right solution by looking at their model of delivery of health care and how we can help them to actually deliver that in a more effective and efficient manner'.

A key driver for this approach is to be at the leading edge in the provision of health care facilities. To achieve this, an evidence-based design approach has been adopted, drawing on both in-house and external sources of R&D. This approach provides clients with value-added knowledge and information to address potential project risk in a more comprehensive manner. As part of this they consider the impact of the physical design on the client's business and the impact of these decisions on both construction and on-going operational costs. This requires a broad team including architects specialising in health; health service planners and administrators, nurse planners, and other medical people.

An evidence-based approach drives decisions in many sectors. Roger Ulrich's s foundational work in relation to health care facility design this field commenced in 1984. Hames Sharley have utilised Evidence Based Design for all their health projects since Roger Ulrich's findings were published. In 2007 Hames Sharley were commissioned as part of the Fiona Stanley Hospital Design Collaboration (Hames Sharley, Silver Thomas Hanley and Hassell) to design the Fiona Stanley Hospital in Perth, a $2B tertiary campus due to be opened in 2014.

An Evidence Based Design approach is transformative and shifts the design of hospitals from the provision of sophisticated accommodation to recognising the impact that the facilities have on healthcare delivery. For example, the brief provided indicated 27 per cent of the beds to be provided in single rooms. International research undertaken by Roger Ulrich and the Centre for Health Design shows that transmission rates of infectious diseases and length of stay can be substantially reduced if patients are in a single room. Based on this evidence and associated financial modelling the WA government took the decision to increase the percentage of single rooms to 83 per cent.

Several challenges to the broader adoption of this approach exist including: project timeframes making R&D difficult to undertake and integrate in a timely manner; difficulties for smaller firms with limited resources; the lapsed role of the public sector in some states for setting standards; the limited application of whole-of-life cycle budgeting; the lack of funding for post-occupancy evaluation to gather data to build the evidence base; and the absence of a central health-based resource centre in Australia to disseminate learnings.

Adopting an evidence-based approach fundamentally changes the approach to design, bridging the nexus between capital and operational costs, and developing evidence to assist with the justification for funding good design.

"Hames Sharley takes a holistic approach to problem solving and has a culture of creating design value through knowledge and research".

5. R&D Profile - Mobile Camera Security (MCS)

New Product finding diversity of users

MCS is a Brisbane-based micro business founded in 2007. They have privately funded the development of a range of trailers from idea to market. The initial intent was to develop a product for the security market. The product has quickly found an expanding market.

MCS provide a unique, often bespoke product to a discrete market niche. Clients including State government road agencies, mining companies, and civil contractors. Products include:

- CCTV camera trailers - as a security tool for remote sites, monitoring vandalism hotspots and traffic behaviour, and monitoring interactions between people and Segway's in NSW government trials.
-Speed alert systems - used for road construction safety
-Solar light trailers - for night works on construction sites
- Radio repeater stations - in remote locations.

The primary motivation for R&D is to maintain market leadership, with development driven by curiosity, client needs and new technology.

MCS has an informal development process based on experimentation with software and hardware components. This can be both time-consuming and costly. New knowledge is gained from websites and overseas site visits. An international collaboration is underway with PlateSmart, a Florida-based developer of numberplate recognition software. This company was found through on-line research in response to a client request (and a limited budget). A cost saving of approximately 75 per cent over the traditional solution is likely. A contract is in place and demonstrations are underway. Another US-based collaboration is for speed display signs, with MCS again adapting overseas technology to Australian conditions. Trailer hardware is typically sourced in Australia to assure quality and suitability to Australian conditions and to ensure reliability in remote conditions.

A key issue noted for a micro-business undertaking R&D is time. Targeted areas for assistance to maximise returns for time invested in R&D-related activities include: understanding R&D tax concessions; small business grant applications; access to effective networking (i.e. getting to the right people/decision-makers); and relevant learning opportunities.

Whilst the company owner has registered previous patents, none are in place for these products.

'*At the end of the day it doesn't take much for someone to get around a patent. I've already had people copy the trailers, there's not a lot I can do about it. All I can do is just do a better job than them*'.

6. R&D Profile - Multi Span Australia

Mobile computing for project and business improvement

Multi Span is a family-owned and operated, medium-sized design and construction firm with a head-office of 20 people including architects, engineers and project managers. They specialise in the industrial and commercial sectors, with projects ranging in value from $1-20M. The company has a long-term commitment to R&D dating back to the 1970's.

They consider that benefits accrue from having both design (architectural and engineering) and construction functions and this facilitates a process of continuous improvement. They undertake R&D to drive innovation for both projects and internal systems. Outcomes are often achieved through collaboration across the project supply chain, working with both clients and materials suppliers to develop and use new products.

Tweed Regional Aquatic Centre – research was required to address issues with the traditional approach to aquatic centre design. To improve life span of internal surfaces, Multi Span worked with the overseas internal wall panelling & membrane ceiling suppliers, imported product, and undertook the required R&D (including testing) for installation in local conditions. Additionally, to minimise on-site chlorine storage, a chlorine generation unit was developed in conjunction with AIS (Brisbane).

Jack Evans Boat Harbour – significant innovation was required in both the use of materials and of construction techniques to address shifting sand levels, the issue of underwater construction, and ensure low maintenance and long design life. Innovations included: (i) a 2500 sq. m. timber boardwalk on a concrete and composite fibre structure developed in conjunction with Wagners, proof-tested and backed by a 100yr guarantee; and (ii) working with a Gold Coast company to develop jetted in revetment walls with pre-cast panels jetted through the sand into the bedrock to address issues of changing sand levels.

Mobile computing for corporate and project reporting – working in conjunction with QHSE Integrated Solutions, Multi Span developed a cloud-based integrated management system with mobile computing capability for iPads. R&D commenced in 2011 and the system has been operating on-site for one year. All project activities feed into corporate level reporting with overall performance displaying on a dashboard. Access and display functions are dependent on role. Implementation required rewriting of all quality systems and re-accreditation. This has led to significantly improved communications and reporting, and will lead to productivity benefits in terms of corporate reporting. Most recently, a portal-based system is being developed to allow a client user interface for real time reporting on their projects.

'The motivation behind it is we're not just a builder … following plans. We've got that creative element to us, we explore ... we're keen to get in there and create these new ideas'.

7. R&D Profile - Nation-wide contractor

Mobile computing improving productivity for remote sites

This company is a large contractor involved in construction and asset management of building, mining and civil infrastructure. As contractors their primary motivation for R&D activities is to '*reduce the costs or the resources required to achieve a particular outcome*' reflecting their focus on competitive pricing as the key to securing future business. R&D is predominately applied with a no/low risk profile, with change characterised by incremental development.

A previous unsuccessful attempt was made to introduce mobile computing using palm pilots. Lessons were learned and the current implementation is through a '*sharply focussed set of pilots'* which rely on an enthusiastic user to implement a specific business processes on a project and then let usage grow organically. The internal strategy to improve uptake has been: project site visits to demonstrate capabilities; addressing specific project and/or site needs and a solution built and demonstrated there and then; monitoring uptake and follow-up.

The iPad is considered an ideal platform as it is a consumer device specifically designed '*for people to pick it up and figure out how to use it'*, and uptake can occur without specialist IT support. The target audience is foremen and supervisors, often without a high degree of computer literacy, who are often required to spend a couple of hours before and after each shift in the office attending to paperwork and emails they can't do whilst on remote sites.

This implementation has realised time savings of up to two hours of office time per day allowing for more productive use of time on site. The most effective uptake is found to occur where the iPad is in someone's hand all the time - '*to take it home, put mail, games and videos on, and get their kids to show them how to use it*'. In the company's experience this is the key advantage of using a consumer device over alternatives such as ruggerdised tablets and PCs.

One regional water project required the foreman to carry and complete a large binder of forms (e.g. daily pre-start & excavation checklists) throughout the week - bring back to the office to be scanned, uploaded &/or manually entered. The use of the iPads has significantly simplified this process.

On remote projects plant operators are sub contactors on a hire arrangement who traditionally complete the work and then invoice the contractor using paper dockets and daily timesheets of activity. This process has generated up to 300 dockets a day requiring subsequent data entry, resulting in a time lag for production reports, and thus calculating shift costs. This is now being automated with operators filling in and submitting electronic time sheets via a smart phone which provides the contractor with day-by-day costings. The electronic time sheet is also provided back to the sub-contractor. This uptake is now transforming both project and process activities.

In terms of return on investment, monitoring is through transactions being brought in on data capture, the usage of our dashboard product, and time savings compared to traditional processes.

8. R&D Profile - WSP Buildings Pty Ltd (WSP)

Building knowledge through sharing knowledge

WSP builds on an established company history in Australia through its acquisition of Lincolne Scott, a privately-owned firm established in 1910. Most current R&D is driven by the need to develop new products and services which build on a more recent reputation for innovative sustainable design, which provides return in terms of both market leadership and financial viability.

'It's not driven by outsiders, it's a corporate philosophy, it's part of our culture and thinking'.

Typically WSP undertake applied research which is both incremental and transformative: the former through every day improvement in designs; and the latter through targeted actions and projects such as the Future Cities program. Early engagement is a crucial part of this product and project innovation, with ESD consultants being involved from the outset of projects in order to maximise the passive design opportunities.

Important mechanisms for maximising benefits of R&D include:

- *External collaboration and peer-review* - testing ideas through peer review and a rigorous process of deconstructing designs to ensure that they will stand the test of time and that all potential operational aspects have been considered.
- *Targeting innovative business products* - Specific projects are identified and targeted for their capacity to maximise change. This uses the global WSP network to make connections and maximise the opportunity to drive change and leverage global opportunities.
- *Whole of life focus* - is considered '*mission critical'* in determining the right systems, which are often simple designs that can be well maintained over the life of the project.

Internal dissemination includes: (i) Weekly conference calls for ESD scientists and consultants to discuss new ideas and developments and to continuously challenge each other; (ii) the Design Portal which focusses on developing a common language across all disciplines, and provides access to 110 years of organisational knowledge including engineering data and solutions, whole-of-life information, and project examples and case studies; and (iii) thought-leadership & social media which enables ideas and knowledge across the globe to be tapped into and utilises people's intelligence and thinking to produce thought provoking topics across all disciplines. Articles are circulated monthly through an e-campaign system, and supported by social media such as LinkedIn, Twitter and Facebook.

External dissemination: Industry bodies, and virtual conferences and forums are used to promote innovative products. Sharing experiences and knowledge is considered as capacity building to produce better designs in the future. Whilst there is a recognised need to safeguard intellectual property, the vastness of the public domain has limited the ability to protect IP. Other approaches to dissemination include, for example, scripting a program on what Future Cities means to organisations to encourage others to talk about it; and promoting presentations through TEDx and YouTube.

'Innovation is more about applying a proven methodology in a different manner and delivering a different and better outcome'.

9. Conclusions

> *Real and effective change is, however, largely driven by the enthusiasm of talented individuals who simply refuse to accept that there is only one solution to a given problem*. (Hardie & Newell, 2011)

This report highlights that product and service development is a primary motivation for R&D; that a range of mechanisms are used; that dissemination pathways are limited with industry associations being the primary avenue; that impact is aligned with motivations; and that metrics to inform this impact are limited.

Of note is the lack of a whole-of-industry framework to R&D especially in terms of its diffusion and understanding and measuring the impact of R&D investment.

BEIIC (2012) recognised this shortfall and recommended the establishment of: (i) a national construction entity to facilitate such exchange; and (ii) an annual built environment research forum with an expert advisory group for built environment research. Such a body could potentially address: the need for better diffusion of research outcomes including training and skilling across the vocational education and training, university and industry training sectors; establishing a framework to better understand the impact of R&D; and identify benchmarks and metrics to enable an evidentiary approach to knowledge building.

Key issues include: to improving opportunities for micro and small-sized firms to engage in or benefit from R&D; and to address issues of competition and protecting IP which can inhibit engagement in collaborate research and which can be effectively addressed through managing network relationships[7].

Whilst collaboration is evident within the firms' immediate supply chains, it needs to be strengthened on an industry-wide basis to assist with building overall industry capacity and more effective diffusing research outcomes. Several examples exist of how this can be effectively achieved. Hames Sharley R&D activity occurs within an international network of evidence-based research environment. Til 2005 they were part of an Australian hospitals-based collaborate research centre (based at UNSW) which received research funding from state governments across Australia. This allowed the exchange of knowledge and development of best-practice guides in this field. Research brokers are important in this regard, with SBEnrc (and previously the CRC for Construction Innovation) providing an example of one such active network[8].

Research underpins innovation and advances in productivity and competiveness. BEIIC 2012

A final point of relevance to this discussion is the central importance of R&D to the long-term growth of economies and the central role of improving productivity. This link is expanded upon in the forthcoming book associated with this project, *R&D Investment and Impact in the Global Construction Industry*[9]. This furthers strengthens the need to better understand private sector investment in R&D in Australia, and then need to ensure that a robust framework is in place which more effectively diffuses the outcomes of both private and public sector R&D for the benefit of the

[7] Keast, R., & Hampson, K.D. (2007). 'Building constructive innovation networks: Role of relationship management', Journal of Construction Engineering and Management, 133:364-373.
[8] Kraatz, J.A. & Hampson, K.D. (2013) 'Brokering innovation to better leverage R&D investment.' *Building Research & Information*, 41:187-197.
[9] Hampson, K. D., Kraatz, J.A. & Sanchez, A.X. In Press 'The Global Construction Industry and R&D.' In R&D Investment and Impact in the Global Construction Industry, edited by Hampson K.D., Kraatz, J.A. & Sanchez, A.S., London: Taylor and Francis.

broader industry, the national economy and for social and environmental outcomes which are often the drivers for the original investment. Figure 3 proposed the steps required to enable this.

Figure 3 – Moving from firm-based to industry-based improvement