CRC Construction Innovation
BUILDING OUR FUTURE

BRITE Report 2005

CRC Report: 2001-012-A

Editors Karen Manley, Mary Hardie, Robyn Keast

The research described in this report was carried out by:
Karen Manley
Graham Miller
Richard Hough
Stephen McFallan
Mike Swainston
Sue McKenzie-Smith
Don Allan
Robyn Keast
Michelle Coillet
Mary Hardie
Tim Rose

Project Leader Karen Manley

Team Members
Graham Miller
Richard Hough
Stephen McFallan
Mike Swainston
Sue McKenzie-Smith
Don Allan
Robyn Keast
Michelle Coillet
Mary Hardie
Tim Rose

Project Affiliate Graeme Taylor

Research Program A
Business and Industry Development

Project 2001-012-A:
Innovation Potential, Directions and Implementation in the Building and Construction Product System

Project Marketing Name:
The BRITE Project – Building, Research, Innovation, Technology, Environment

December 2005

Distribution List

CRC for Construction Innovation

Disclaimer

The Client makes use of this Report or any information provided by CRC for Construction Innovation in relation to the Consultancy Services at its own risk. CRC CI will not be responsible for the results of any actions taken by the Client or third parties on the basis of the information in this Report or other information provided by CRC CI nor for any errors or omissions that may be contained in this Report. CRC CI expressly disclaims any liability or responsibility to any person in respect of any thing done or omitted to be done by any person in reliance on this Report or any information provided.

Please direct all enquiries to:

Chief Executive Officer
Cooperative Research Centre for Construction Innovation
9th Floor, L Block, QUT
2 George St
Brisbane Qld 4000
AUSTRALIA
T: 61 7 3864 1393
F: 61 7 3864 9151
E: enquiries@construction-innovation.info
W: www.construction-innovation.info

Table of Contents

List of Tables

List of Figures

1. PREFACE

This internal report summarises the activities of the BRITE Project in 2005, which primarily involved undertaking six innovation case studies.

The overall objective of the BRITE Project is to improve the incidence and quality of innovation in the Australian building and construction industry. Many stakeholders in the industry are sceptical about the potential for innovation and its likely benefits. Many also lack the linkages and capabilities required for successful innovation. The BRITE Project has redressed this situation through demonstration and benchmarking activities.

Phase 1 of the BRITE project ends in December 2005 and Phase 2 of the project has been approved to run over 2006 and 2007. Phase 2 is based on the broad-based innovation data collected under Phase 1 and will focus in a more disaggregated way on a number of key issues to emerge from Phase 1. Phase 2 will adopt a learning systems approach to issues such as:

- integration of learning at project and firm levels
- use of formal evaluation techniques
- management of innovation risk
- operation of incentive structures
- client demands for service-enhancement
- scope for practitioner research
- failure as a learning process
- effectiveness of the 'systems-integrator' on projects
- reinterpretation of the construction industry as a knowledge-intensive industry, rather than simply a low-technology, mature industry
- conceptualisation of insights based on the BRITE collection of case studies

The 2005 innovation case studies highlight successful implementation practices and measured benefits. The case studies demonstrate best practice and contribute to the enhancement of industry capabilities. The case study element of the BRITE Project has been inspired by the success of the Rethinking Construction, Egan Demonstration Projects. This UK initiative has had a positive impact on building and construction industry performance in that country. The 2005 BRITE collection builds on the 2003 case studies by providing greater focus on original innovators.

2. EXECUTIVE SUMMARY

2.1 2005 Case Studies

The BRITE Project undertook six innovation case studies of building and construction projects in 2005. The purpose of the program was to demonstrate the benefits of innovation and highlight the nature of successful implementation strategies. The cases were selected following a public call in industry magazines across Australia, which resulted in approximately 50 nominations. The six selected case studies resulted in three prominent contributions to knowledge, by:

1. calculating the benefits attributable to construction innovation
2. revealing the key role played by organisational innovation (which is about the way in which work is organised)
3. documenting in detail the types of relationships that underpin successful innovation.

A summary of the case study projects is shown in Table 2.1.

The case studies cover road and commercial building projects, with three being located in NSW, two in SA and one in WA. The project budgets ranged from $13,000 to $22m. The benefits achieved on the projects are in all cases substantial. The benefits of the innovations include cost and time savings due to improvements in design and management processes, and environmental benefits.

The case studies demonstrate the occurrence of two main types of innovation in the construction industry, technical and organisational. Although all the innovations described in Table 2.1 are *technical* in nature, they were in all cases facilitated by accompanying *organisational* innovations. The case studies suggest that technical developments are initiated, designed and produced mainly by consultants (8,9,11) and manufacturers (7,12), with universities and other research centres providing assistance (7,9,12). Organisational matters, including the form of contract and establishment of relationships among team members, are most often affected by the client. The case studies have shown that important innovations have occurred in the organisation of work and team co-operation, and that this has resulted in outcomes that exceed business-as-usual (8,10,11).

Clients also promote innovation by presenting demand scenarios that push project team members beyond business-as-usual, for example through tight budgets, time lines and environmental constraints. Client requirements provided the conditions for innovation in most of the case studies (7,9,10,11,12). At the same time, clients' flexibility and value-based attitudes also create an environment conducive to innovation (8,11,12).

These results indicate that clients, consultants and manufacturers play key roles in promoting industry innovation, and that two types of innovation are important – technical and organisational. Overall, the benefits of innovation tend to be related to cost, time or environmental considerations.

2.2 Review of 2003 Case Studies

In addition to conducting the case studies shown in Table 2.1, during 2005 the BRITE team also reviewed the fortunes of another six case studies that were conducted earlier by BRITE, in 2003 (to review those case studies go to www.brite.crcci.info). The current status of innovations in the 2003 case study collection was assessed by re-surveying the original interviewees. The innovations were generally found to be performing successfully two years

Table 2.1 Summary of 2005 Case Study Projects

	Study 7	Study 8	Study 9	Study 10	Study 11	Study 12
Project Name	Gladesville Road Community Centre	Imago Site	Stadium Australia	Art Gallery of South Australia	Adelaide Oval	Tomago All-Weather Access Road
Location	Hunters Hill, NSW	East Perth, WA	Sydney, NSW	Adelaide, SA	Adelaide, SA	Tomaree Peninsula, NSW
Project Description	Stormwater management at a small community building, 400m^3	Remediating 5,800m^3 contaminated land	Two 3,500m^3 roofs over sports stadium ends	Up-grading the air-conditioning system at an art gallery	Redeveloping the eastern grounds of a sports stadium	16km road through saturated ground
Budget Estimate	$13,000	$1.8m	$10m	$100,000	$22m	$4m
Innovation Summary	Managing stormwater with storage gutters and infiltration	Saving site-remediation costs through a new waste disposal method, sprinkler and wheel wash system	Post-tensioned steel trusses to create long span roofs	Twin-coil air-conditioning to improve energy efficiency	Relationship based contract and 3D CAD to efficiently deliver complex project	Using recycled tyres to create a permeable road pavement while meeting strict environmental and community requirements
Main Benefits Achieved	26% reduction in mains water demand	13% project cost saved	50% reduction in steel weight; 25% reduction in roof erection time	30% reduction in energy consumption	50% reduction in prefabrication time; 90% reduction in requests for information	15% of project cost saved

after they were first documented by BRITE. Interviewees reported direct benefits for their organisations and the industry as a result of diffusion of information on the innovation by BRITE. Since distribution of the 2003 case studies, the innovations have been further diffused across the industry, being either directly applicable to other projects or through adapting the principles to suit new situations.

2.3 BRITE Impact on Industry

There is strong evidence that BRITE has had a positive impact on the industry over the three years of its operation (2003-2005). This is reflected by the high level of interest that has been generated within the industry for BRITE publications and activities. Over 120 articles about BRITE have been published in 46 different industry publications. In addition, 13 refereed conference articles and six refereed journal articles have been published. BRITE has also enjoyed a high response rate from the industry for surveys, case study nominations and workshop registrations.

3. INTRODUCTION

This is an internal report of the BRITE Project's activities for 2005. The goal of the Project is to improve the incidence and quality of innovation in the Australian building and construction industry.

The primary aim of the year's work was to complete six case studies of innovation in the Australian building and construction industry. Secondary aims were to maximise the impact of the research results through industry association and refereed academic publications, and to prepare an application to extend the research through further funding. The case study program was undertaken to demonstrate the benefits of innovation and show how businesses successfully implement their innovations. The main body of this report reproduces the case studies. Appendix A contains a list of academic papers produced by the BRITE Project, Appendix B contains a list of industry association articles published, Appendix C is a report prepared by BRITE on diffusion and development of the technologies and practices reviewed in the 2003 case study program, Appendix D shows interviewee details for the 2005 program and Appendix E shows BRITE impact indicators.

This report focuses on the case study program, which was successfully completed during 2005, with six booklets being produced.

3.1 Background

The case study program was driven by the interest of the Project's industry partners in improving innovation performance in the Australian building and construction industry. The program was designed to deliver six innovation case studies in A5 booklet form in 2003 and 2005. The scope of each study and the format of their reporting were driven by the experience of the Movement for Innovation (M4i) in UK. The M4i has undertaken similar activities aimed at changing industry culture to make it more supportive of innovation. Their program is considered to be very successful.

In Australia, recent innovation case study programs have been driven by the Commonwealth Government's Innovation Summit in 2000 and the initiative to map Australia's science and innovation capacity announced in November 2002. The resultant case studies (e.g. Jones and Pagan 1999; Thorburn and Langdale 2003) analyse innovation at firm-level, often in the manufacturing industry. The BRITE Project's activities expand on this work by covering innovation in the construction industry at project-level. Innovation in the context of construction project-based activities is very different – often being more reliant on relationships between stakeholders and less reliant on R&D.

Further to this, the case study program was developed in response to poor innovation performance in the industry and an understanding by industry analysts that many industry participants were skeptical about the potential benefits of innovation – particularly small and medium-sized businesses.

The booklets were developed as an educational tool, to be vigorously diffused. The diffusion side of the program was taken very seriously, with a number of avenues being pursued, including distribution of findings through industry association magazines, CRC participant magazines, case study interviewees, ACIF, the CRC's Technology Transfer Strategy, industry gatherings; and a formal launch of the case study collections in February 2004 and November 2005.

The booklets target specific audiences, including public sector clients, private sector developers, consulting engineers, architects, contractors, product and equipment suppliers, and public sector policy makers.

3.2 Scope

The case studies focus on building and construction *projects* arises because most innovation takes place in the project context. The six 2005 case studies covered the engineering and commercial building sectors of the industry, reflecting the absence of a CRC industry partner representing residential building. These sectors are the most innovative when measured by R&D expenditure, and they are therefore likely to provide good examples of the benefits to be gained from innovation.

Of the six 2005 studies, three were in NSW, two in SA and one in WA. This represented an expanded range of states compared to the 2003 collection. The 2005 studies covered two sporting stadiums, an art gallery, a small commercial building, an access road, and one case of contaminated land. The projects ranged in value from $13,000 to $22m.

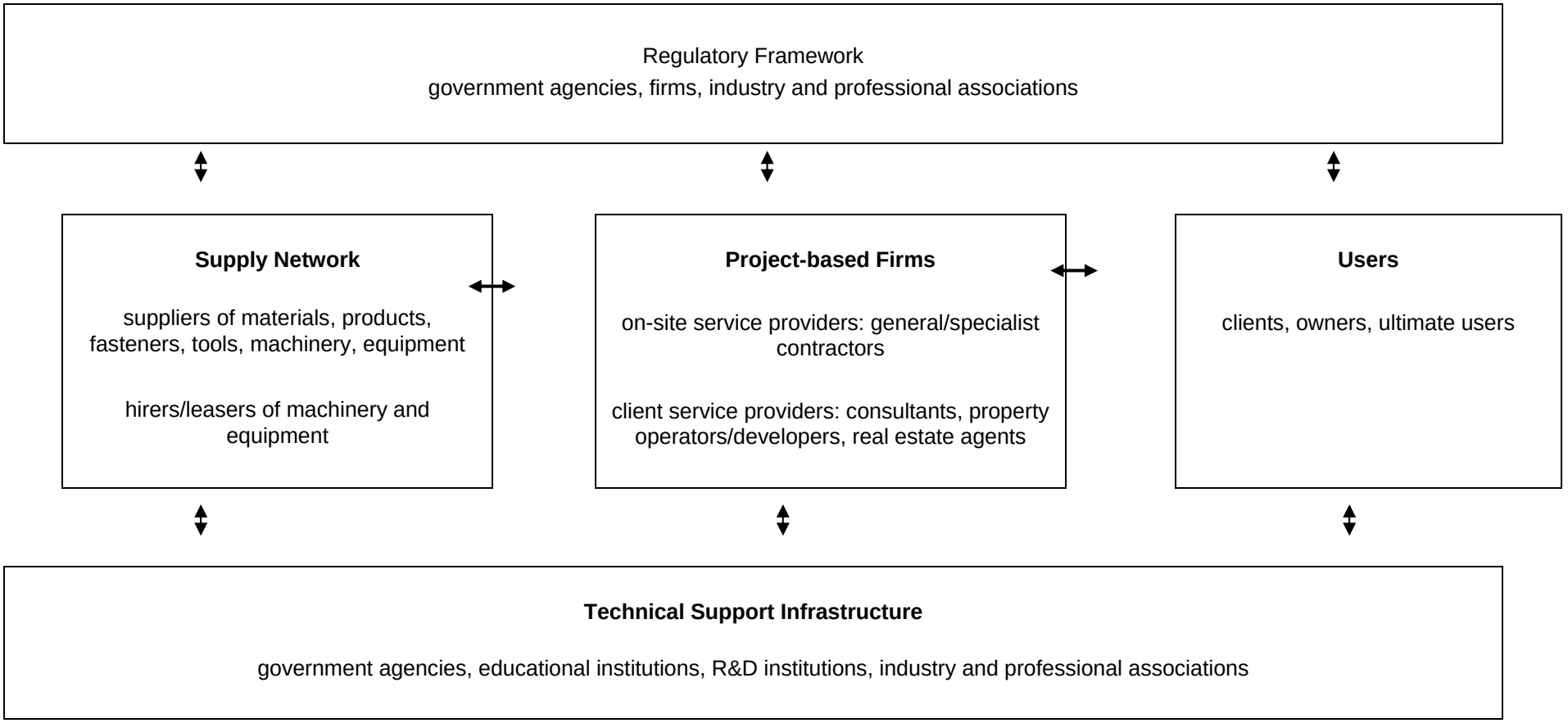
The 2005 case studies were selected after a public call across Australia through industry magazines, which resulted in approximately 50 nominations. The final six projects were selected with regard to the existence of measured benefits, the location of the study, the type of project (civil or building) and the likely cooperation of multiple stakeholders. The researchers selected studies:

- with significant measured benefits, or the clear potential to assess such benefits
- with regard to the likely usefulness of the study in highlighting innovation challenges
- with regard to the level of cooperation likely to be received from project stakeholders
- to obtain a reasonable national spread
- to obtain a reasonable balance between civil and building studies

3.3 Conceptual Framework

The case studies were interpreted according to the influential work of Gann and Salter (1998) and Marceau et al (1999). These authors emphasise the non-linear and highly interactive nature of innovation processes, in the context of a broad view of the boundaries of the Australian building and construction industry. Figure 3.1 summarises their approach:

Figure 3.1 Participants and Potential Relationships in the Building and Construction Industry



(Source: Based on Gann and Salter 1998)

Figure 3.1 provides a good summary of the relevant participants in the building and construction industry and helped in structuring of the case studies and positioning key relationships. Figure 3.1 also provided a useful analytical tool to assist in thinking about the audience(s) for study output.

While Figure 3.1 assisted in 'mapping' our case studies, we used the results of our literature review to look for key patterns in the dynamics surrounding innovation processes. This was helpful in pinpointing the elements that were key to the success of each innovation. The factors in Table 3.1 were used to guide discussion of innovation in the case studies.

Table 3.1 Key Influences on Innovation in the Building and Construction Industry

• ***Industry relationships***	➢ *power structures, interdependence, workforce structure, appropriation of benefits, craft-based unions, etc.*
• ***Procurement Systems***	➢ *form of contract, legal issues, partnering, alliances, etc.*
• ***Clients***	➢ *level of demand sophistication, etc.*
• ***Regulations***	➢ *prescriptive or performance-based, etc.*
• ***Organisational Resources***	➢ *capabilities, labour relations, margins, champions, absorptive capacity, governance structure, etc.*
• ***Structure of Production***	➢ *project-based, high interdependence, temporary teams, uniqueness of projects, learning discontinuities, innovation brokers, etc.*
• ***Industry Culture***	➢ *adversarial attitudes in the industry create a culture unsupportive of innovation*

3.4 Methodology

The case studies were based on semi-structured interviews, and background documentation including contract documentation, award submissions, academic papers, magazine articles, internal reports and workshop presentations. Each case study involved multiple interviews covering at least three different organisations on the project being analysed. Each interviewee was a senior technical or management representative and the range of interviewees covered all types of industry participants including clients, contractors, consultants and suppliers. Most interviews were conducted face-to-face, with only three being by phone. All interviewees have approved the case studies presented in this report. Appendix E lists confidential interviewee details (these should not be employed by other CRC participants without clearance from the BRITE Project leader).

The following sections of this report constitute the six case studies, as presented to the industry in booklet form with photos and graphics.

4. BRITE INNOVATION CASE STUDY NO 7: Managing Stormwater with Storage Gutters and Infiltration

A new way of dealing with urban stormwater run-off facilitates more sustainable use of available water resources. Rain storage gutters with an infiltration system offer benefits to:

- building owners and occupants
- the community
- the environment.

Selected Project Participants

Client	Hunters Hill Council
Contractor	Johnson Fisher Constructions
Sub-contractor	Rainsaver Pty Limited
Hydrology consultant	Urban Water Resources Centre, University of South Australia
Sponsor	Stormwater Trust of NSW

This report is based on interviews with Hunters Hill Council, Rainsaver Pty Limited and Urban Water Resources Centre.

The Project

After an arson attack in 2002, Hunters Hill Council decided to use the Gladesville Road Community Centre refurbishment to:

- demonstrate simple water saving devices
- show the value of retrofitting these devices to an existing building.

The project was partially funded by a grant from the NSW Stormwater Trust. It received the NSW Sustainable Water Challenge Retrofit Award for 2003, along with three other demonstration sites in the Lower Parramatta River Catchment.

The Centre reopened in November 2002 and is now part of a program that promotes community awareness of rain harvesting and water sensitive design.

The Achievement

Australian cities and towns need new strategies to counter local flooding, due to urban consolidation and increased pollution of streams and coastal waters. There is also a need to redress problems with adequate fresh water supply.

The storage gutter system addresses these problems from two angles. Firstly, it reduces reticulated water usage by substituting rainwater for purposes such as toilet flushing. Secondly, overflow water during heavy or sustained rainfall infiltrates the soil, replenishing the water table and slowing the passage of water to urban waterways.

The rain storage gutters at the Gladesville Road Community Centre, which are connected to toilet cisterns, have reduced the mains water demand by 26%. In addition, because rain

overflow is directed by a stormwater diffuser into the garden soil, 100% of the rain that falls on the roof is used on-site, except under very severe storm conditions.

Independent costing of the gutter system has confirmed that these savings can be achieved at a cost which is between 5% and 27% less than the installation of traditional guttering plus an equivalent-sized rainwater tank.

The Innovation

Rainsaver Pty Limited is a small company, largely owned by one family, which holds patents on its system for rain storage roof gutters in seventeen countries and has five full- and part-time staff. Patent searches indicate that the storage gutters may be unique and it appears there are no direct competitors as a system for the "collection and storage of water in a container at the drip line of roofs".

Frank Smith, the inventor of the storage gutter system, developed it after observing the need to better manage rainwater when living with a young family on tank water in the Nowra district of NSW. After analysing patterns of rainfall statistics from the Bureau of Meteorology, he developed an oversized gutter that would replace a water tank and use all the rainwater that fell on a roof. Instead of downpipes feeding into the street drainage system, the overflow from the storage gutters would be returned to the soil through the process of infiltration.

The storage gutters come in three sizes: a small model (15 litres/metre) suitable for retrofit projects; a medium model (25 litres/metre) for new houses and a large version (48 litres/metre) for heavy demand situations. The gutters are made from folded steel colorbond sheet, however, there are plans to have them roll-formed to reduce manufacturing costs. This plan has been aided by a close relationship with the steel supplier.

The gutters are fitted with lids, and leaf guards for easy maintenance. Medium and large gutters are fixed to roof trusses with purpose-designed internal steel brackets. Lengths are joined with rivets and silicone sealed. The gutters are then coated internally for improved water tightness.

Currently, *Rainsaver* or its franchisees usually install the gutters. The installers provide plugs at suitable points for plumbers to connect the gutters to toilet cisterns or other outlets. Overflow holes are situated where excess water can flow directly into garden beds. Alternatively, the gutters are connected to a diffuser system that transfers the water to areas of the garden with suitable soil porosity and permeability.

Site characteristics are assessed before the installation, and the infiltration area needed for the roof catchment is calculated.

In times of low rainfall or high usage, the storage gutters can be recharged from the mains water supply if they are connected to a toilet or washing machine.

The Gladesville Road Community Centre project demonstrates that water storage gutters are capable of replacing existing roof gutters, downpipes and rainwater tanks. They also reduce the need for stormwater retention systems. They do this while returning moisture to the soil to aid vegetation growth and replenishing the water table.

The Benefits

The savings in mains water usage achieved by storage gutters depend on the:

- amount, distribution and intensity of rainfall
- water usage by the occupants of the building
- collection area of the roof.

Assuming a 200 m^2 building with average occupancy levels, Professor John Argue of the Urban Water Resources Centre at the University of South Australia estimates that water storage gutters could save between 30% and 60% of mains water usage, depending on

gutter size and location, each year over the life of the gutters (estimated to be a minimum of 15 years).

Water stored in the gutters is gravity fed to toilet cisterns. The gutters can also act as an emergency water supply for the householder if a water main is broken. It is also possible to fit an activated carbon filter to the gutter outlet and feed a filtered drinking water tap. In a bushfire, storage gutters can provide emergency water supply for fire fighting and they can be used to create a curtain of water around a building under threat from bushfire.

As an integral part of the roof plumbing system, storage gutters are less aesthetically intrusive than rainwater tanks and pumps. They require no ground space on a restricted site and they collect 100% of the water falling on the roof, as opposed to water tanks which commonly only collect from the roof plane facing the side where the tank is located.

Storage gutters can reduce stormwater run-off during a rainstorm by up to 85%. Most installations, including the one at Gladesville Road Community Centre, have natural on-site infiltration of excess stormwater from the roof. There is no need for a separate detention tank and little need for downpipes. As a consequence there is less water flowing into the street gutter system. This makes the gutters an effective mitigation measure against urban flooding. Along with the use of 'Water Sensitive Urban Design', storage gutters allow for the elimination of much of the costly piped stormwater drainage systems that are typical of suburban subdivisions.

Benefits to the building owner include:

- reduced consumption of mains water resulting in lower bills
- little maintenance and longer gutter life due to leaf guard system
- less need to water the garden due to the overflow infiltration system.

Benefits to the community include:

- lower demand for reticulated water leading to less pressure to build new dams
- less need for piped street drainage and area retention systems and consequently lower cost of developing land for housing
- greatly reduced cost of stormwater management and flood mitigation.

Benefits for the environment include:

- a more natural level of water infiltration into the soil
- replenishment of the water table in urban areas
- reduction in nuisance flooding and in the erosion hazard from high speed run-off in storms.

The Implementation Process

A key driver in the adoption of water storage gutters at the Gladesville Road Community Centre was Hunters Hill Council's desire to improve stormwater management in their Sydney harbour-front municipality. Council officers gained a grant from the NSW Stormwater Trust for four demonstration projects in the Lower Parramatta River catchment area. The Gladesville Road Community Centre renovation was one of the four demonstration projects.

After investigating cutting-edge water-saving techniques, Hunters Hill Council identified water storage gutters as a system with great potential and a means to educate the community about suburban stormwater management. Both the water storage and the management of infiltration were significant issues. The inventor, in turn, was keen to demonstrate the validity of the system for a non-domestic application.

The medium sized gutter (25 litres/metre) was selected for the community centre, where it is used to flush all toilets. One section of guttering feeds a pond that is planted with macrophytes to improve the water quality and provide habitat for frogs. A solar powered pump runs a small fountain in the pond. When the water storage gutter reaches capacity, a diffuser directs overflow into garden beds where the water can infiltrate back into the soil. Except during extremely heavy rainfall, no stormwater runs off the site. To date, no rain has left the site.

More generally, implementation has been assisted by the inventor's strong connections with university research bodies concerned with water resources. Professor John Argue of the University of South Australia and Dr Chris Walsh of Monash University have worked on validating the theory behind the need to reform stormwater management practices. The inventor has delivered papers and exhibited at conferences such as the 'Cities as Catchments Conference' in Adelaide in 2004, as a way of informing local and state government authorities and persuading them to have the system included in stormwater management codes.

Regulations also play a key role in making implementation possible. In NSW, BASIX, the new environmental planning scheme for housing, allows credit for installing water storage gutters towards the required 40% water reduction target. In South Australia, from 2006, all new houses must have 1000 litres of rainwater storage connected to a toilet cistern. These legislative changes are driving adoption of the innovation at a state level, although, as discussed below, inventors and innovation champions often need to persuade regulators that proposed changes will be beneficial.

Overcoming Difficulties

The main difficulty experienced at the Gladesville Road Community Centre was managing the rate at which the toilet cisterns refill. In a community centre, as opposed to a private residence, there are periods of peak load on the toilets, for example, at the end of meetings. At first the cisterns did not fill quickly enough to handle this peak load. Some adjustment of the system was necessary to make it work effectively. Larger inlet pipes would be used in any future application of a similar nature.

In addition, the position of the gutter overflows had to be adjusted so that they did not fall in areas where Centre users were likely to walk. This was done with diffusers to take water into the front and rear garden beds. These post-occupancy changes have optimised the system.

Generally, storage gutters are well received by consumers as an alternative to rainwater tanks. However, the inventor has experienced some difficulty communicating their other important role in managing overflow stormwater infiltration. In some areas, notably in South Australia, unmanaged gutter overflow is not permitted because of possible interaction with the footings of the building. This obstacle was overcome at Gladesville Road Community Centre by diffusers.

Innovations like the water storage gutters are a departure from standard practice and local building regulations are still largely based on prescriptive standards, which can be a barrier to implementation. This means that acceptance by local authorities is often critical to their adoption. The inventor of the storage gutters has liaised with local council officers over a long period of time to reduce their perception of risk, by seeking to demonstrate that water storage gutters can be used to lessen stormwater nuisance flooding rather than increase it.

The system has also met with resistance from builders. The gutters need to be fixed level, rather than with falls to downpipes as is the case with traditional gutters. Builders need to understand how the system works before they install the gutters, rather than discovering

critical requirements, such as the need for accurate roof edge lines, after installation. Installation problems have largely been overcome by refining the detail of the gutter fixing bracket design, based on feedback from builders.

Some builders still resist change but this is being overcome by successful demonstrations such as the Gladesville Road Community Centre. The inventor is also developing educational packages so that storage gutter installation can be included in TAFE courses on roofing and roof plumbing. This is considered likely to reduce industry resistance to the system.

Lessons Learned

- Regulators play an important role in influencing opportunities to implement innovations.
- Inventors and commercialising companies often need to convince regulatory authorities of the validity of their offerings – and this requires considerable patience.
- Small firms are key players in driving industry innovation.
- A pressing environmental need such as stormwater management can be a powerful driver for innovation.
- Links with research bodies can be useful in developing innovations and independently validating their worth.
- Trade education has to be sufficiently flexible to accommodate new technological and systems developments.
- The successful introduction of an innovation that changes widespread industry practice is likely to require a long term commitment from the innovation champion.

5. BRITE INNOVATION CASE STUDY NO 8: Saving Site-Remediation Costs

A number of incremental innovations on the Imago project to clean-up a contaminated site in Western Australia have delivered significant savings for the client.

The innovations included:

- in-house designed sprinkler system to control dust
- in-house designed wheel-wash system to manage the spread of contaminated material beyond the site
- in-house designed concrete coffin to encase Class V contaminants and allow their disposal at a Class IV facility
- minimisation of contaminated material through a planned screening program
- adoption of best-practice monitoring equipment.

Together, these incremental innovations and the adoption of best practice are estimated to have saved over $200,000 for the client, compared to business-as-usual.

Selected Project Participants

Contractor:	Marsh Civil
Environmental Engineer:	ENV Australia
Contract Superintendent / Civil Engineering Consultant:	Wood & Grieve Engineers
Geotechnical Engineer:	Coffey Geosciences
Client Representative / Project Manager:	Clifton Coney Group
Client:	East Perth Redevelopment Authority (EPRA)
Waste Management Facility:	Red Hill Waste Management Facility operated by the Eastern Metropolitan Regional Council (EMRC)

Organisations consulted in preparing this report: EPRA, Marsh Civil, ENV, Wood & Grieve, Clifton Coney, EMRC.

The Project

The East Perth Redevelopment Authority (EPRA) reports to the Western Australian Minister for Planning and Infrastructure and is charged with revitalising under-utilised inner urban land, often contaminated by previous industrial uses. The Imago project was a forward works contract awarded by the Authority to clean-up a small 5,800m^2 land parcel in the inner-city precinct, Claisebrook Village, East Perth. The contract was based on Lump Sum and Schedule of Rates components. The tendered sum was $1.35m over a three-month period and, after the unexpected discovery of coal tar, the project was delivered for $1.8m in May 2004, to a six-month program. Although project time and cost increased, 13% of potential business-as-usual costs were saved on this small project, under a conventional contract, due to good organisational and personal relations between the project team.

The Achievement

During the Imago site remediation works, and despite a rigorous environmental testing program, coal tar was unexpectedly discovered. Coal tar is a high level Class V contaminant, and the associated cost and time delays of removing the unexpected find had the potential to disrupt EPRA's land release program. The contractor, environmental consultant, engineer, project manager, and land-fill facility, all small or medium-sized organisations, went beyond business-as-usual to deliver the increased scope of work at minimal cost. They also achieved outstanding environmental outcomes, which were recognised by a National Case Earth Award for Environmental Excellence in 2004. The team was motivated to achieve these outcomes to deliver a cost effective project for the client, thus enhancing their reputations in a small market with few highly qualified participants. The project has created a new waste disposal path for hazardous wastes in WA, suggesting that the savings can be repeated on new projects with similar features.

The Innovations

The key innovation on this project was a new waste disposal methodology, while other significant innovations included new sprinkler and wheel wash systems, together with the adoption of advanced monitoring equipment (eg. SMS-enabled dust monitors). Although none of the innovations are world-firsts, all are largely new to Australia.

Waste Disposal Methodology

An excavator with a skeleton bucket was used to excavate the coal tar material, allowing large lumps of it to be separated from the uncontrolled fill material. The contaminated stockpile was then raked to further separate the coal tar. This process, which was designed by the engineering consultant, reduced the quantity of contaminated material to be removed from the site. The soil screening and recycling plan was based on dividing the soil into three categories: (1) 'easily re-usable on site', (2) 'subject to testing and possible re-use on site', and (3) 'clearly unsuitable as fill material'. Business-as-usual would not have involved this separation process.

Coal tar on the Imago site was in liquid and solid forms, and was classified as Class V waste after testing. In Western Australia, contaminated waste can be classified from Class I to V – with Class V being the most hazardous. There are no waste disposal facilities in Perth that can accept Class V material; the closest appropriate facility is in Port Hedland, 1600 kms away. As a large quantity of this material (250 tonnes) was to be removed, alternative disposal methods were sought. After negotiations with the Eastern Metropolitan Regional Council (EMRC) and the Department of Environment (DOE), the coal tar was placed in $1m^3$ bulka bags, which were placed on pallets and loaded onto a flat tray truck and transported to the State's only Class IV disposal cell at the Red Hill Waste Management Facility, where it was encapsulated in concrete.

The contractor proposed the bulka bags as they reduced the volume of waste by compaction and were safer than loading the waste directly into a lined truck. Rather than placing the 200 bags in one large concrete chamber at Red Hill, the EMRC and the environmental consultant designed 67 smaller concrete coffins with a minimum of 150mm of concrete walls to contain only three bags each, which reduced torsional cracking. This encapsulation brought the classification of the material down to a Class IV waste, allowing it to be processed at Red Hill. Using the local facility, rather than Port Hedland's, saved extensive transport costs.

Treating material to make it less hazardous and therefore acceptable at local landfill facilities (which are typically not licensed to accept Class V materials) is not uncommon on the east coast of Australia. It is however, relatively new to Perth. The method used on the Imago site was concrete encapsulation, whereas on the east coast, a more expensive pelletisation process is used, mixing coal tar with concrete to immobilise it. A number of industries across

the world encapsulate toxic waste in concrete and bury it in landfill. However, this method is used rarely in the Australian construction industry, and appears to have never been undertaken by the civil industry in WA.

Sprinkler

The contractor designed, constructed and implemented a watering system to control nuisance and contaminated dust emissions on the site and to compact the ground. A 63mm poly distribution line was attached to the perimeter site fencing. Minor lines feeding sprinklers on star pickets were placed on the distribution lines. The six large sprinklers were connected to the pipe by tapping bands and could be shut off and moved around to suit weather conditions and construction activities. The pressure at each sprinkler head could be varied.

The sprinkler system ensured that all the exposed surfaces were wetted down at all times, eliminating the chance of fine particles getting into the air. Because the sprinklers could be moved easily, they were used to water newly exposed areas during excavations.

Such sprinkler systems are new to both WA and the east coast of Australia. Standard practice is to use watering carts, which would have been more expensive on the Imago project, and problematic because of their size relative to the small site. The sprinkler system is more flexible, as each head can be adjusted to suit the pattern of work.

Wheel Wash

To ensure that no contaminated material left the site on truck undercarriages, the contractor designed, constructed and implemented a specialised wheel washing system, which was placed at the site exit. Trucks were driven onto a raised removable metal grate over a holding tank. The tyres, undercarriage and body were cleaned automatically by high pressure sprays. The excess material and water passed through the grate into the holding tank. As the base of the tank was installed on an angle, the contaminated material fell to one end, allowing it to be appropriately managed. Water in the tank was pumped out and used to control dust in remediation areas.

Automated wheel wash systems are often used on the east coast of Australia, and occasionally in WA. However, the contractor opted to build their own system because:

- current systems are too large and inflexible to work efficiently on cramped sites
- there are few suppliers leasing such systems in WA, and none were available at the time
- they could produce it at minimal cost in their own workshop
- the compact modular pieces used in construction can be easily transported and erected on future sites, which will save leasing costs.

None of the above innovations contravened existing intellectual property rights, nor gave rise to new rights. The disposal methodology was an organisational innovation, with ‘soft’ intellectual property, which has no legal status. The contractor has not sought to patent the sprinkler or wheel wash innovations, possibly because they are simple advancements that would be difficult to protect under a patent.

The Benefits

Collectively these innovations saved $227,000 on the project, representing 13% of the final project sum.

Waste Disposal Methodology – saved $118,000

The coal tar was separated from other material to minimise the amount of waste, because every kilogram saved offered a significant reduction in disposal costs. At Red Hill, disposal costs were $512 per tonne, while at Port Hedland, they would have been $984 per tonne. Without the screening process, there would have been roughly five times the volume of contaminated material. Even calculating the benefit of the waste disposal methodology conservatively, (assuming the same quantity for disposal), the client saved approximately $118,000.

Sprinkler – saved $61,000

The new sprinkler system provided dust control and ground compaction, where standard practice was to hire a water cart. The sprinkler saved approximately $71,000 in water cart hire charges on the project, while costing only $10,000 to set-up and maintain.

A further benefit of the sprinkler system was safety. The site is very small (80m x 70m), with up to 15 staff active at any time. The elimination of a large machine like a water cart reduced the hazard of mobile machinery working around site staff.

Wheel Wash – saved $48,000

The only available alternative to the in-house system was to manually clean the trucks on-site with a high-pressure hose, which is business-as-usual on small sites. This however, would have resulted in a less thorough job than the automated system, requiring more sweeping of neighbouring roads. The manual system would have been backed-up by the use of a road sweeping truck operating once a day, whereas the automated system only required back-up road sweeping once a week. On this basis, the innovation saved the client approximately $48,000.

Dust Monitor – reduced dust complaints

The cutting-edge SMS-enabled dust monitor, which was specified by the environmental consultant, provided direct messaging to the environmental consultant and other team members when dust levels rose above warning levels. Common practice is to use a flashing light, which is difficult for an environmental consultant to monitor. The SMS system notified multiple project participants immediately, and was expected to prompt more careful behaviour from the contractor, due to increased transparency. Indeed, a comparison of the number of dust complaints from the public during the Imago project and a similar project, showed two complaints on Imago and 23 on the other project. It is likely that the SMS system played a role in this difference.

Maximising the Benefits

The value of all the innovations will be maximised through on-going diffusion. The encapsulation process to reduce Class V waste to Class IV has now become part of the standard service offered by the waste facility, while the contractor intends to use the sprinkler and wheel wash systems on future projects, and the environmental consultant is now specifying SMS-activated dust alarms on all projects where a dust alarm is needed. The waste facility is also designing an improved Class IV cell to help meet the expanding demand.

The Implementation Process

Waste Disposal

The overriding driver for the innovations was a crisis – the surprise discovery of large amounts of coal tar and the high costs associated with removing it. The problem nearly doubled the original project sum and term, even with the innovations. When the coal tar was

discovered there was a risk that the costs of site remediation would exceed the value of the property.

Remediating former industrial land in an existing built environment is a challenging task, which often requires innovation to be pulled through the supply chain. The team working on the Imago project were able to build on their existing relationships to make this task easier. The coal tar issue had to be dealt with quickly and under pressure, and that it was effectively resolved is testament to the quality of relationships underpinning the team. EPRA is a repeat client in the industry and all the team members had worked for them before, and wanted to do so in the future. The team was very keen to minimise the impact of the problem on the client, and the client was happy with their performance.

The waste disposal methodology was the most important innovation in terms of risk and potential cost reduction, and the most difficult to implement. The project team wanted to avoid the very high costs of transporting the waste to Port Hedland, and needed instead to make it acceptable to the local Class IV facility. This meant activating a largely dormant route in the regulations, and satisfying the relevant agencies.

Extensive building foundations were found when the coal tar was discovered. The fact that the contractor was busy removing the foundations reduced the cost of the time it took to negotiate access to the Red Hill facility for the coal tar. This was because under the contract, the contractor had to be paid for labour and equipment, whether they were working or not. The team was under pressure to ‘think quick’ and keep the contractor moving. Indeed, without the geotechnical problems to usefully engage the contractor, cost may have been minimised by sending the contaminants to Port Hedland. The Port Hedland facility operates under an old approval and before Imago there had been no incentive to seek a new approval.

It took about six weeks for the project to receive the approval to dispose of the coal tar in a new way. On the east coast, similar approvals can take six months. This difference in time is probably due to the urgent nature of the Imago situation, together with the cooperative approach taken to negotiations between the environmental consultant, project manager and the agencies setting regulations or guidelines – Environmental Protection Authority, DOE and EMRC.

The disposal methodology innovation was developed ‘on the run’. Seeking an approval for a largely new methodology, under considerable time pressure, was a highly problematic task. It was the scope of the expected savings that underpinned the client’s support of the negotiations. The other innovations – sprinklers, wheel wash and monitoring equipment – were more straightforward and therefore easier to implement.

Sprinkler and Wheel Wash

The sprinkler and wheel wash innovations were partly driven by delays in the start of the project, which meant that conditions were drier and windier than expected, however the material being removed also contained asbestos fibres, making dust control an essential component of the works. The contractor had time to plan their response to these difficulties. They also have an in-house design team and workshop, which allows them to efficiently produce simple money-saving innovations.

The contractor directly employs staff, rather than using a labour subcontractor or casual day labourers, and they believe this is a key part of their ability to generate ideas for innovation. The contractor notes that although direct employment can be more expensive in up-front costs, having a stable, experienced workforce saves them money in the long run as ‘the policy protects the company’s reputation’. Whereas subcontracted or day labourers may lack the incentive to pass on ideas for improvement, the contractor relies on loyalty and a formal ‘Idea of the Month’ program to drive innovation. The idea program appears to reinforce

advantages over competitors who rely on external labour, and resulted in the sprinkler and wheel wash innovations.

The three or four ideas put forward each month are discussed by management; implemented if appropriate; advertised in a quarterly internal newsletter distributed to all staff; and stored in a database. Each 'Idea of the Month' winner is rewarded with a prize. Management also de-briefs staff who nominate unsuccessful ideas. This is done to underline the value of all ideas, even unsuccessful ones, so that staff maintain their enthusiasm to contribute.

Dust Monitor

The idea to use best practice monitoring equipment on the Imago project was not driven by the contractor's site staff, but rather by:

- Rising costs of environmental pollution
- Increasing community concerns
- Increasing pressure on regulators
- Tighter regulations
- Demand-pull innovation by machinery manufacturers
- Education of suppliers by manufacturers
- Recommendations from suppliers to consultants and contractors.

Beyond this, the features of the Imago site also drove the adoption of best practice monitoring equipment. The site is in a very congested urban area and the proposed redevelopment had raised some community concerns, so that dust movement was a sensitive issue.

The environmental consultant and the contractor have good relationships with a Perth supplier of advanced occupational health, safety and environment monitoring equipment. The supplier is linked to a large Australian company with international operations, providing 'risk management solutions'. Hence, the supplier acted as a conduit for information from around the world about advanced equipment. The supplier also works for transnational mining companies in WA, facilitating transfer of knowledge between industry sectors. The Imago team exploited the supplier's knowledge and adopted the latest equipment to maintain the reputation for advanced practice they had earned with the client on previous projects.

Overcoming Difficulties

Team Challenges

The process underpinning the new waste disposal method was not straight forward. The officers initially encountered by the Imago team at the local facility were understandably sceptical – nervous about making technical decisions outside standard practice. However, considerable time was spent by the team in meetings with the facility to change attitudes. The main issue then became searching for an engineering solution that would meet the facility's needs and the requirements of DOE. Once these agencies were on board, they moved quickly to assist with the team's proposal.

Contractor Challenges

The contractor found that they had relied too heavily on verbal understandings and the coal tar crisis has encouraged them to rethink their procedures and keep better records. They also plan to improve their approach to time management by reducing the 'down time' of on-site staff through more efficient human resource planning. Indeed, efficient time management is important, as extra risks such as poor weather and accidents are associated with a longer

project period. These changes are expected to help the company ‘to better cope with surprises’.

Client Challenges

There are strong drivers in place that encourage clients to manage risk within a single project. However, the Imago project highlights that risk might be best managed across a portfolio of projects.

Waste Facility Challenges

In the past, the local waste facility has experienced problems with waste being treated before disposal at the facility. In several instances, such pre-treatment has been poorly conducted. To prevent this potential problem on the Imago project, they treated waste themselves – this time with concrete encapsulation. This in-house treatment gave the facility better control over quality, which is important to them as they have infinite responsibility for the waste. By encapsulating on-site, transport costs were also reduced.

Lessons Learned

- project crises can be a key driver of innovation
- a small market with few advanced participants can lead to closer relationships, loyalty and innovation to deliver savings for clients
- site based problems are a key driver of innovation, especially when contractors directly employ staff, rather than subcontract them, and when contractors have implemented formal ‘idea schemes’
- formal idea schemes operated by a project-based business help it integrate learnings into business processes and diffuse innovations (which maximises their value to the business)
- in running idea schemes, it is important for a business to value unsuccessful ideas, to maintain the enthusiasm of staff
- in-house capabilities, such as highly skilled staff and well-resourced workshops, support the innovation efforts of a business
- challenging projects pull innovation through the supply chain
- changing community values and associated regulatory changes are key drivers of innovation
- manufacturers are a key driver of innovation because their on-going production methods are better able to support R&D, giving them an advantage over businesses engaged in project-based production
- suppliers are key knowledge brokers, passing on ideas from manufacturers to project-based businesses
- front-line staff appear less able to entertain innovative ideas than more senior staff and this can cause problems for innovation champions seeking support for their ideas

6. BRITE INNOVATION CASE STUDY NO 9: Post-tensioned Steel Trusses for Long Span Roofs

Large, unobstructed clear spans were achieved by a post-tensioned steel solution in the Telstra Stadium roof reconfiguration. The solution reduced the cost of the roof and minimised loss of seat revenue during the construction period, compared to business-as-usual.

Selected Project Participants

Client	Stadium Australia Trust
Head Contractor	Multiplex Constructions
Structural Designer (Roof)	Murray Ellen formerly of Bigspace Technologies Pty Ltd, now at s2 Corporation
Builder and Truss Fabricator	Ahrens Construction
Consulting Engineer	Sinclair Knight Merz
Architects	HOK Sport+Venue+ Event joint venture with Bligh Lobb Sports Architecture
Detail Engineer	SW Healey and Associates
Coatings Supplier	Ameron Coatings

This report is based on interviews with: Telstra Stadium, Murray Ellen and Ahrens Construction.

The Project

Telstra Stadium (formerly Stadium Australia) was reconfigured in 2003 to remove the temporary seating in the north and south terraces, which had been used for the 2000 Olympic Games and Paralympic Games. Two new 3,500m² roofs for all-weather accommodation were constructed over the stadium ends. The seating stands on the East and West sides of the playing field were placed on moving frames so that the arena could be quickly adjusted for rectangular and oval settings.

The reconfiguration cost $80 million, with the roofing component being around $10 million, and was completed without disruption to the scheduled events at the stadium. The post-tensioned system for the roof was adopted to overcome difficulties that a business-as-usual design was likely to cause.

The Achievement

The construction system for the new roofs allowed the project to be completed on time and budget, keeping loss of seat revenue during construction to a minimum.

The project was completed in time for the 2003 Rugby World Cup, despite a tight timeline for design and construction. The truss members were prefabricated and assembled on the ground outside the stadium, so the concourse around the ground was relatively unobstructed on match days. The two main trusses were erected in a single week, within a six month construction program that saw no serious injuries to workers. The end result is what is believed to be a world-first post-tensioned steel roof for a sporting stadium.

The project was awarded the 2004 ASI Structural Engineering Steel Design Award for NSW and the ACT.

The Innovation

A post-tensioned roof was adopted to avoid problems that were likely to be encountered with a more conventional steel roof. A more conventional roof was likely to require every connection node to be propped until the roof was completed. A forest of large props was likely to block sightlines, reducing the seating capacity by roughly 9,000 seats at each end of the stadium during construction. Cranes were likely to have been stationed on the arena, killing off significant areas of turf. A post-tensioned roof avoided these potential problems.

The principles of post-tensioning have long been understood by structural designers, but they have not often been applied to steel frame structures. The behaviour of a structure can be predicted by applying loads to a theoretical "string line" - compression domes have been designed this way for centuries. Traditionally, loads simulating the self weight of the dome were hung from a string. The shape taken up by the string was plotted and inverted to form the design of the dome. The tension in the string line was measured and this determined the thickness of the dome structure.

A similar process was used for the stadium roof, using 3D computer modelling instead of the physical string line. In this case, the string line shape was not inverted but accepted as the form of the main catenary trusses. There was no need for inversion because the tension and compression properties of steel are strong enough to support the load (unlike a masonry dome, which has very little tensile strength).

The string line approach does not, however, deal with deflection, so sophisticated software was used to model the loads in the members and deflections in the structure. The string line is represented by the post-tensioned cables in the truss bottom chords. These cables are loaded by hydraulic stressing to resist the external forces acting on the structure.
All the prefabricated members which make up the trusses are straight lines or simple curves so that, while a very large truss is produced, the components are easily transported and lifted into place. Once assembled, the truss was in effect proof-tested by the stressing process. The approximately six kilometres of stressing cables in the bottom chords of the trusses were stressed by hydraulic jacks then fixed in place with high strength grout once they were in position.

The connecting joints for the post-tensioned roof structure are all simple "butterfly", "half moon" and "end plate" connections, so the truss sections can be quickly and easily bolted together on site. The trusses were assembled in two relatively small areas on the concourse outside the stadium. A 400 tonne and an 800 tonne crane on the concourse were used in tandem to lift the main trusses into place. Smaller cranes with long reach capacity completed the assembly, also from outside the stadium. This included the secondary trusses and the 10m x 10m framed polycarbonate panels that finished the roof.

The stored energy in the stressed cables reduces deflection under load. This allowed the main trusses to span the 114 metres between the existing roofs without any intermediate support or propping during construction, leaving the seating under the roofs available for scheduled events.

The Benefits

The main benefits of the post-tensioned roof design and lean construction methods at Telstra Stadium can be compared to a more conventional steel roof design and construction methodology. Estimated reductions include:

- 50% in the weight of steelwork needed to span the roof opening, and associated transport costs
- $3m to fabricate and erect the structural steel
- 25% in erection time

- 40% in production time for the steel fabricator.

From the point of view of the stadium management, the chief benefit was that loss of seat revenue during the 2003 NRL, AFL and Rugby Union football season was minimised to the greatest extent possible. More conventional approaches would have required some seating areas to be fenced off for at least six months, as has been seen at some other major sporting venues. The revenue gained from approximately 18,000 seats that were kept available over the six month construction period is estimated to be $2.7m.

The sporting public had the benefit of continued use of the stadium during the roof reconfiguration period without any obstruction to sightlines in any of the stadium seating. People had continued access to most of the public areas around the stadium during construction. This maintained an important recreational resource for the city of Sydney.

The roof has been compared to the shape of the brim of an “Akubra” hat and is widely accepted as an aesthetically pleasing solution to a difficult geometric problem. The client gave high importance to the new roof looking like a natural extension of the existing roof, and this is thought to have been achieved.

The Implementation Process

Tight timelines and the need to keep the stadium operating were the key factors driving the use of innovative technology for the Telstra Stadium roof reconfiguration. The Structural Designer submitted his solution to the design team as an economic way of achieving the stadium roof before the deadline of the World Cup. The booming construction industry meant that it was difficult to find a local steel fabricator to do the work at short notice. However, the relatively small size of the prefabricated components meant that they could be produced in Adelaide and shipped to Sydney at a competitive price. Managing the supply chain in this way, in response to market conditions, helped to minimise project costs.

Indeed, risk management is a critical issue in implementing “cutting edge” technology. The Structural Designer on Telstra Stadium chose to manage the stressing of the cables himself. Effectively, he acted as a hybrid between a specialist sub-contractor and a consulting engineer. Contractual arrangements were tailored to suit this dual role, which is unusual in the construction industry. The Structural Designer also requires intellectual property payments for the use of his system, a practice which is rare among construction contractors, though increasingly accepted by industry clients, particularly those who understand the value of intellectual property.

The Structural Designer sought to maximise the advantages of his solution and reduce the risk. He maintains an active research and development program, despite heading a small firm with only six employees. In order to leverage his efforts, he develops associations with university research bodies who test and validate his processes.

Overcoming Difficulties

The redesign of the roof structure meant that the builder and truss fabricator had considerable work to strengthen the four existing support points, which now carry the load of the new roofs. This was complex and difficult work that had to be performed from underslung scaffolding. The effectiveness of this work was underpinned by good relationships between project team members.

Prefabrication of the structural members required very careful measurement of the opening between the existing roof structures. Steel expands and contracts as the temperature changes, so the size of the opening varies, and this had to be catered for in the fixing system. Advanced 3D laser technology was supplied by the consulting engineer to survey the existing structure. Stickers were placed on the structure and several measurements

taken to determine the average dimension of the span. The main span expanded by 18mm in the course of one day. The main trusses were set in place at 1pm when the temperature reached 26º Celsius, which was the mean temperature for the arches. There was no opportunity to alter the trusses once they were in place, so it was essential to accurately measure the dimensions and tolerances for the joints.

All the workshop drawings for the steelwork were recorded in 3D CAD, as were all the fieldwork measurements. These two data sets were correlated in the CAD system. The task would have been almost impossible as little as 10 years ago, without the 3D modelling for the complex geometrical shapes.

The assembly and erection of the framing involved several scheduled stages. Priority was given to maintaining the stadium's program of five major events during construction and this restricted operations significantly. Good relationships underpinned coordination of all the players involved, and direct chains of responsibility for the work were essential to its successful completion.

Lessons Learned

- Innovative structural technologies require close attention to quality control and careful installation practices, to manage risk.
- When the expertise to successfully implement a technology is highly specialised, the specialist needs to closely supervise the installation.
- Putting a fair value on the intellectual property in a construction innovation can mean developing systems of remuneration that are quite different from the standard contractor to sub-contractor fee structure.
- 3D modelling technologies allow the fabrication of complex geometrical forms that would otherwise be impractical.
- Complex shapes and new technologies often require a fresh approach to calculating and validating structural systems.
- In-house research and development can be effectively supplemented through relationships with universities and other research bodies.
- Market conditions can drive supply-chain innovation.
- The nature of a client's business, particularly on brownfield sites, can put constraints on a project, thus sponsoring innovation.

7. BRITE INNOVATION CASE STUDY NO 10: Twin-Coil Air Conditioning at the Art Gallery of South Australia

The locally developed Shaw Method of Air Conditioning (SMAC™) adopted by the Art Gallery of South Australia for their West Wing in 2004 appears to significantly improve energy efficiency and reduce variation in temperature and humidity levels.

Project Participants

Client – South Australian Department of Administrative and Information Services (DAIS) on behalf of the Art Gallery of South Australia

Head Contractor – Transfield Services (Australia) Pty Limited

Subcontractor (Commissioning/Programming SMAC) – Air Con Serve Pty Ltd

Subcontractor (Installing SMAC) – A. G. O'Connor Pty Ltd (trading as O'Connors)

SMAC Patent Holder/Commercialisation – AirCon Design Today Pty Ltd

Design Mechanical Engineer – Connell Mott MacDonald

Corporate Adviser for Facilities and Asset Management to the Art Gallery – South Australian Department of the Premier and Cabinet - Arts SA (DPC-ARTS)

Organisations consulted in preparing this report: Art Gallery of South Australia, Air Con Serve Pty Ltd, A.G. O'Connor Pty Ltd, Connell Mott MacDonald, DPC-ARTS, DAIS and Energy Division, South Australian Department of Transport, Energy and Infrastructure.

The Project

The Art Gallery of South Australia holds a significant Australian art collection. Located in a heritage building, over time the Gallery has expanded to include new wings and services such as a restaurant, function rooms and bookshop. The scale and scope of these operations and the volume of visitors to the Gallery had combined to challenge the existing air conditioning system.

The patented SMAC twin-coil system of air conditioning was installed to modify the system in the new West Wing of the Gallery. The project team was engaged under a Design, Construct and Commission contract, and completed the installation in August 2004.

The Achievements

The SMAC system appears to be one of the first twin-coil systems in the world with series pipe circuiting, which optimises performance. Its application at the Art Gallery of South Australia is only the third use world-wide.

Preliminary estimates related to the installation at the Gallery indicate:

- reduced energy consumption
- associated reductions in greenhouse gas emissions
- less variation in temperature and humidity levels

The Gallery project was completed in three months, inside the required time line. There was no interruption to Gallery activities and the project was completed within budget at a cost of $180,000 (which included repair work to the existing system).

The Innovation

The new twin-coil system is the fifth and last of a number of air conditioning innovations developed by the late Dr Allan Shaw, formerly of The University of Adelaide. The innovations aimed to reduce energy usage and enhance air conditioning performance.

An ongoing relationship forged through common interests resulted in control of the innovation being handed from the inventor to the commercialising company. The key shareholders of the commercialising company are the inventor's family and the two project subcontractors.

The new system differs from conventional air conditioning processes in that, rather than drawing untreated outside air and then cooling it within the total air system, incoming outside air is pre-treated (dehumidified and cooled) by a separate, outside air coil before merging with inside air. Supply air is treated by the second coil, which belongs to the original conventional system.

The twin-coil system prevents the need to use energy twice to overcool and reheat air in order to maintain humidity in the occupied space, and monitors and adjusts humidity levels, providing better control.

The new technology appears to be the only twin-coil system patented world-wide using series pipe circuiting to maximise efficiency. It is based on earlier work of the inventor, which employed parallel pipe circuiting. The series system is more efficient, as the same water goes through both coils, halving the pumping energy required.

Three key components give the system its competitive edge:

- the dual coil that separates the process of treating latent loads (typically to remove moisture from outside air) and sensible loads (typically internal air which is dry)

- series pipe circuiting, which maximises the system's efficiency

- the control system that provides integrated control of humidity, temperature and chiller operation to ensure that air treatment processes optimise energy performance at all times.

The new twin-coil system builds on existing practices and has minimal impact on other components, while at the same time promising to deliver significant improvements in performance.

The Benefits

1. Since its commissioning at the Gallery in August 2004, the performance of the twin-coil system has been closely monitored by the project's mechanical engineer, as well as through a recently developed computer-modelling program which tracks energy consumption, temperature, and humidity. Early results indicate that the application of the new technology to the existing air conditioning system in the West Wing has achieved the goals of reduced energy consumption and increased humidity control. For example, the Gallery has seen an average monthly gas consumption reduction of 30% over the period September 2004 to March 2005, which is believed to be attributable to the twin-coil system.

2. Through its temperature and humidity control processes, the new system has achieved improved control over temperature and humidity fluctuations in the Gallery. This is an

important condition for protecting the artwork and is a key requirement to secure future, and especially more prestigious exhibitions. A related, but unexpected outcome accredited to the new system is its ability to limit the impact of outdoor air entering from large glass doors on humidity levels.

3. The installation of the twin-coil system did not interrupt the daily operation of the Gallery. This was important, as the Gallery was hosting an important international exhibition at the time, which could not be shifted or stored elsewhere.

4. Since the twin-coil system builds on other systems, and therefore requires limited modifications to existing infrastructure, the innovation has been described as 'simple and easy to install' by contractors and does not require additional skills or training for installation. By using much of the existing ducting and piping infrastructure, the technology keeps costs to a minimum, so that they can be more quickly recovered.

5. The twin-coil system can be used in the retrofit of existing air conditioning systems, as well as in new buildings and facilities.

6. The system is effective in dry climates, such as in South Australia, and in high humidity climates, such as in Thailand.

The patented twin-coil system was also installed at the Barmera Hospital in South Australia in 2002 and in the Headquarters Building of Siam Cement in Thailand in 2004, with energy savings and enhanced air conditioning performance being reported for both sites. The twin-coil system at the Barmera Hospital received the 2002 National Electrical and Communications Association Award of Excellence (Specialist Division) in Australia.

The Implementation Process

The Gallery pursued installation of the twin-coil system to reduce energy expenditure and to gain better control of fluctuating temperature and humidity conditions. This project was another stage of ongoing energy efficiency initiatives implemented by the Gallery's energy stakeholder committee. Reinforcing these internal drivers, and providing funding for the project, was a whole-of-government policy program, the Energy Efficiency Action Plan (2002), which committed the South Australian Government to reducing energy consumption in all government buildings.

The company commercialising the new technology has extensive experience as an energy management contractor in South Australia, particularly in the arts community, and a reputation for developing energy saving initiatives. For these reasons, the stakeholder committee put a request to the company for an energy-reducing proposal, after considering other options.

In summary, the development and installation of the twin-coil system at the Gallery arose from the client's:

- desire to capture energy savings
- need to improve humidity and temperature control
- requirement to meet government policy and standards
- willingness to explore alternative methods of air conditioning.

The sub-contractors were responsible for the design, construction and installation of the twin coil system. The task of designing and building the new components was assigned to the consulting engineers, while installation was undertaken by the mechanical contractor. The design drew on the client's expertise and that of related stakeholder agencies. For example, since artwork is subject to strict humidity level requirements, the client suggested that the

project team consult with a specialist art conservation agency, as input to the design process.

In effect, the above arrangements constituted a short-term joint venture between the stakeholders, which facilitated information sharing as well as enhanced problem solving and planning. Importantly, working in parallel rather than sequentially through the project phases meant that the new system was designed and built almost simultaneously, reducing lead-times and contributing to timely completion.

The project team acknowledges that successful progression of the project through the design, tendering, construction and installation stages was greatly facilitated by long-term working relationships between the stakeholders.

Finally, the commercialising company encouraged the adoption of the technology, which is in these early stages of diffusion, by waiving the normal licence fees. This is because these early projects help the company to demonstrate the benefits that can be realised. The company also reduced the client's risks associated with a new and relatively untried approach, by guaranteeing energy savings and by undertaking to rapidly return the air conditioning system to its conventional state, should any problems occur.

Overcoming Difficulties

Despite increasing interest, the twin-coil system has not been widely adopted in Australia or overseas, being limited thus far to two South Australian government buildings and the building in Thailand. A key reason for this lack of uptake appears to be the highly competitive nature of tendering processes for construction projects, which means there is no time or incentive for exploring alternatives to conventional practices.

Credibility

The commercialising company has been frustrated by a lack of opportunities to showcase the technology which has resulted in limited data to provide evidence of its claimed benefits. This is slowly changing and a useful and necessary evidence base is in the process of being built, by ongoing external monitoring of twin-coil installations and the commercialising company's specialist computer program, which models energy consumption. The data will help potential clients and designers compare costs and make decisions.

Promotion of the Innovation

The lack of a well-considered marketing and implementation strategy, particularly as it applies to commercial procurement, was also identified by the commercialising company as limiting the uptake of the innovation in earlier days.

The method of championing the technology also needed to be changed, moving from a reactive, confronting approach to a more patient, consultative way of overcoming structural and cultural barriers. There is now a more concerted effort to engage with prospective users, including consulting engineers, and provide information on the product at an early stage in the design process.

This has been coupled with a new marketing strategy that means the twin-coil system can be used by a client, without ties to the patent-holding organisations. In the past, the commercialising company tried to enforce a tied arrangement, where their contracting arm had to be used to install the system. This lack of flexibility may have hindered adoption.

It appears that an expanding support base is currently spreading responsibility for championing the technology and this has contributed to broader industry acceptance of its potential.

Commercialisation & Intellectual Property

Although a university provided the educational environment and technological resources necessary to research and trial earlier versions of the technology, another type of vehicle was required to take the twin-coil system to the market. Much of the development and financial commitment for marketing the twin-coil system has been provided by a private company dedicated to its commercialisation.

The technology is patented, but it is also relatively simple, which increases the chance of other companies copying it. As the commercialising company is a very small multiple-family business, there is some risk of a deliberate breach of their patents, on the assumption that a family company could not afford to protect them. The commercialising company is managing this risk by trying to rapidly build its reputation as a leader in the field and by seeking partnerships with larger firms more capable of protecting the intellectual property.

Making the most of Opportunities

Rising energy costs globally, and the South Australian Government's policy for reduced energy consumption, provide strong incentives for consultants to explore alternative air conditioning options.

Further, the implementation of the technology at the Gallery was possible because repairs were needed on the existing air conditioning system. Repair and upgrade work is problematic because the chilled water system usually needs to be turned off, potentially exposing the art works to great temperature and humidity variations. This work needed to be scheduled in cold weather, and the Gallery reduced its risks by undertaking repair and upgrade work together.

Finally, the relationship that the commercialising company had previously built up with the Gallery contributed to their appointment.

Lessons Learnt

Local firms, innovators and advocates

- Small, local companies can be innovation leaders, although they often seek relationships with larger companies to expand their resource base, especially for the protection of patents.
- Innovation requires both champions (those people prepared to work at supporting a new idea) and sponsors (those people linked to resources, influence and legitimacy).
- Aggressive championing and negotiation is often less effective than a relationship-building approach to innovation diffusion.
- Persistence in championing an innovation until the idea achieves broader acceptance is an important, but also wearying, requirement.
- Effective prior working relationships between key stakeholders can provide a basis for exploring innovative options.
- A marketing strategy that provides flexibility may contribute to the uptake of the innovation – innovators and their representatives can often be too controlling.
- Different skill sets are required for invention versus commercialisation of an innovation – perhaps necessitating that the inventor relinquish control during the commercialisation phase.

Clients

- Knowledgeable and engaged clients facilitate the adoption of innovation because they can cross-check information and make informed decisions.
- Involving specialist third parties or stakeholders in design decisions can make innovation more relevant in a particular application, enhancing outcomes.

Innovation process

- Innovations don’t have to involve major costs or significant disruption to existing system components to produce extensive benefits.
- Long-term whole-of-life considerations can drive innovation adoption.

Innovation Environment

- Government policy changes are a key contributor to the uptake of innovation.

8. BRITE INNOVATION CASE STUDY NO 11: Better Project Outcomes with Relationship Management and 3D CAD

An innovative procurement process provided the high level of cooperation necessary to extensively redevelop the Adelaide Oval within a highly compressed timeframe and on budget. The project delivery system supported a range of innovations, including advanced use of 3D CAD.

Client	South Australian Cricket Association (SACA)
Architects	HASSELL Pty Ltd
Structural Engineers	Connell Mott MacDonald
Head Contractor	Built Environs Pty Ltd
Primary Subcontractors	Taiyo Membrane Corporation (formerly BirdAir)
	Samaras Structural Engineers
	SA Precast Pty Ltd

Organisations consulted in preparing this report: SACA, Built Environs, HASSELL Pty Ltd, Taiyo Membrane Corporation, Finlaysons Lawyers and Connell Mott MacDonald

The Project

During 2003, SACA commissioned a major project to redevelop the eastern side of the grounds at Adelaide Oval, to extend its competitive standing as a national and international sporting and events facility. The project provided three spectator stands covered with tensile membrane roofs, storage bunker facilities, a video replay screen, event control rooms, a new gatehouse, relocation and restoration of the heritage-listed Victor Richardson Gates, and landscaping works.

Completed at a cost of $22M, this complex project was delivered on budget and within a tight design and construction timeframe, over a seven-month construction period prior to the World Cup Rugby.

The Achievement

The time, cost and quality outcomes of the Adelaide Oval Redevelopment project have earned it awards across a range of disciplines including:

- Master Builders Association, Award for Excellence 2004
- Australian Institute of Building, Professional Excellence Awards 2004
- Royal Australian Institute of Architects (SA), Award of Merit 2004
- Engineers Australia, Excellence Award 2004
- Association of Consulting Engineers Australia, Award of Excellence 2004

- Australian Steel Institute (SA), Architectural Steel Design Award 2004
- Property Council (SA), Commendation Award 2005

The Innovation

SACA and the project team decided that a conventional procurement approach would not deliver the level of cooperation and innovation required to fast-track the design and construction processes, nor to respond proactively to emerging problems. In response, a hybrid contract was adopted containing managing contractor and cooperative contracting elements. Operating under a lump sum management fee arrangement, the managing contractor contributed to the review of contract documentation and provided advice on the practicality and 'buildability' of the design, then managed the construction process, including the sub-contractor packages.

This hybrid contract encouraged greater integration of the supply chain than under a more traditional contract, promoting a higher level of cooperation between team members, including sub-contractors. In this regard, the contract listed the client's requirements as:

- a 'best for project', integrated approach
- aligned objectives for all stakeholders and the project team members
- a clear understanding of the roles and responsibilities of all stakeholders and team members
- open and honest communications between all parties
- innovation and intelligent risk-taking to achieve exceptional results.

Unlike traditional contracts, where participants can try to maximise their own gain and minimise their risk, the specification of these behaviours sought a more collective approach to problem solving and risk allocation. 'Specifying' the behaviours rather than 'negotiating' them might have worked against the client, however the contract was effectively backed up by regular collaborative meetings, a free flow of communication, and social events, such as barbeques and attendance at cricket games, to support the desired behaviours.

The cooperative intentions of the contract were reinforced by a full day workshop at the start of the project which aimed to encourage 'best-for-project' thinking. The full project team, including sub-contractors, attended the workshop. The sound relationships that developed allowed parties to explore options and resolve conflict rather than turn to the contract for solutions.

A key element of the project was the early engagement of those specialist sub-contractors who delivered tensioned steel roof structures, precast elements, and tensile roof membranes. Their expert knowledge was sought early to enhance the design, and reduce time for finalising it before going to tender. They were engaged under a two-stage preferred subcontractor arrangement, which encouraged and rewarded their input to the design process, while protecting the client from opportunistic behaviour and price increases.

The more harmonious relationships and greater sense of commitment to the project engendered by the contract and associated relationship-building activities encouraged the uptake of innovative ideas and practices which may not have emerged under a more conventional contract.

Key among these was using 3D CAD for structural and fabric design, detailing, engineering, sun shading, fire engineering, wind analysis, shop drawings, and subsequent documentation. By extending the conventional visualisation and presentation application of 3D CAD to provide a 'virtual design environment' in which all parties were working on a shared model,

the three early sub-contractors were able to undertake shop drawings simultaneously, which reduced lead time for construction.

The 3D CAD system:

- minimised documentation time and output
- minimised technical queries between consultants and contractors
- reduced errors by virtual representation of the end product
- negated the risk of misalignment of core construction components like the pre-cast and steel roof support elements
- identified potential constructability problems.

This is one of the first times that 3D CAD documentation has been made readily available by design consultants to contractors for construction, on a project in Adelaide. Across Australia, only the most complex projects are likely to use it this way. 3D CAD emerged 10-15 years ago in complex industries such as aeronautics and ship building. Its up-take globally in the construction industry has been limited by the training requirements across the supply chain and the power of personal computers.

Finally, the relationship-building elements of the contract, and particularly the early inclusion of sub-contractors, are also relatively rare in Australia and overseas. Managing contractor contracts and relationship-based contracts have emerged globally over the past decade as a means of improving project outcomes. In Australia, such approaches have been trialled with success from the mid-1990s, and are increasingly being adopted by repeat public sector clients. However, private sector clients have been slower to adopt them, which makes the SACA project particularly novel.

The Benefits

The project team considers that this challenging project was completed on time and within budget because of the relationship-based procurement strategy and ‘best-for-project’ thinking adopted. The project also had no lost time or accidents during its 300,000 hours.

Focusing on the use of 3D CAD to create a virtual design environment, the following benefits have been estimated compared to a traditional 2D environment:

- reduction in ‘Requests for Information’ of over 90%
- reduction in site errors, which could have meant rework costs of up to $100,000 and a week’s lost time
- reduction in prefabrication time of 50 % because:
  - 3D modelling saved a month during shop detailing, as the three early trades were able to work concurrently on their shop drawings
  - there was a reduction in the cost of transferring 2D fabrication drafting to 3D.

The Implementation Process

Both the 3D CAD and innovative procurement model owe their adoption to the complexity of the Adelaide Oval redevelopment. Trialling these new approaches may not have been justified on a more straightforward project.

3D CAD

Very early in the design stage, it was decided that using 3D to document the specifications for the pre-cast concrete, structural steelwork and tensile fabric would expedite the design and construction process. The complex curvilinear shapes of the tensile membrane roofs in particular required 3D resolution at a high level so that fabrication of the elements could proceed simultaneously, without the need for the components to be corrected or reworked during assembly on site.

The architectural and structural engineering firms each developed a complete 3D model, which were subsequently merged to facilitate quick and accurate changes to the design. The final model was sent to the main sub-contractors for manufacture.

Some of the smaller sub-contractors did not have the technical abilities to access and fully utilise the virtual design model, so some 2D drawings were produced. The amount of extra work involved was minimal because the 3D model could be used as the basis for drawings generated in 2D.

The use of the 3D CAD model contributed significantly to on time delivery of the project within an extremely tight design and construction schedule.

Innovative Contract

A key driver for the good relationships that developed on the project was the cooperative procurement model, which in turn, was driven by the client's concern in relation to the importance of meeting extremely tight time frames. The client felt that conventional contractual arrangements may have limited their ability to influence and contribute to the on-going process. The client also knew of the positive experiences of public sector clients who had used more innovative contracts successfully.

While no systems and procedures had to be dramatically altered or adjusted to implement the cooperative contracting approach, changes in culture and attitude were required. Participants needed to shift from an individual to a team orientation, in terms of contributing to the whole project and not just looking after their own interests. On the other hand, widespread implementation of 3D CAD will require changes in industry systems, procedures and culture.

Overcoming Difficulties

Risk of failure

Failure to deliver the upgrade on time was likely to cost SACA the World Cup Rugby contract; and the reputation of all participants, particularly the managing contractor, would have been compromised. Along with the partnering style of contract method, the 3D computer modelling helped to reduce this risk by improving the integration of design through to construction shop drawings, using the same complex 3D CAD models.

Different way of working

Because cooperative contracts represent a departure from traditional arrangements, there was a risk that not all participants would fully align themselves with the intent of the contract. This concern was addressed by a start-up workshop, regular relationship-focussed project meetings and social events. The 3D modelling also promoted cooperation because it gave all participants equal access to information. Exposure to relationship-based contracting has affected participants positively; they appear to be translating the learnings and experiences to their roles on subsequent projects.

Heritage venue

The project attracted significant interest from the media and the public as Adelaide Oval is regarded as an international icon with significant heritage value. In the early stages of the project, there were some community doubts about the redevelopment design, particularly the spectator stands. In response, 3D computer models showing a virtual representation of the completed facility were used to demonstrate how effectively the design achieved a contemporary feel in keeping with the scale of the heritage environment, while achieving the sun shading specifications and safety standards (such as fire egress) required. This process helped alleviate early concerns.

Continued operation of venue

The client wished to continue operating the venue during the construction period, hosting state cricket matches and the tourism visitor program. Potential clashes between the construction and venue schedules were overcome through the allocation of significant resources to the planning process. The onsite building coordinator reviewed operations daily, and at times hourly, and there were regular meetings and information exchanges between all project participants. Subsequently, the redevelopment work was completed without disruption to the daily operation of the venue.

Technological and cultural limitations

3D modelling appears to be broadly accepted by industry participants as an essential ‘integrated design through to construction’ tool. However, the uptake rate has been relatively slow. Only a small proportion of firms, in the trade sector in particular, are willing or able to invest in the resources required. Many don’t have the technical skills or computing capacity to fully capitalise on the technology. Industry commentators note that cultural resistance to change is constraining adoption rates. Various knowledge brokers in the industry are addressing this problem. In Australia these include the Cooperative Research Centre for Construction Innovation, Universities and the TAFE system.

Lessons Learned

- Private sector clients can benefit from adopting cutting-edge contracting methods trialled by repeat public sector clients.

- Having expert advice on constructability from subcontractors during the design phase helps fast track production.
- Parties in relationship-based contracts can be motivated to solve problems in a more efficient manner than under traditional contracts.
- Cooperative contract approaches require a shift in the mindset of participants.
- 3D modelling can be used as a seamless ‘design through to documentation and shop drawing’ mechanism, helping to drive improved project relationships and outcomes.

9. BRITE INNOVATION CASE STUDY NO 12: Using Recycled Tyres to Construct an Access Road over Saturated Terrain

Selected Project Participants

Client:	Energy Australia
Head Contractor/Project Manager:	Keller Civil Engineers
Environmental Consultant:	Environmental Resources Management Australia
Specialist Sub-Contractor:	Ecoflex Civil Constructions
Design Consultant/Technology Supplier:	Ecoflex Australia
Certifying Engineer:	Snowy Mountains Engineering Company (SMEC)
Tyre Supplier/ Recycler:	C&R Tyre Recycling

This report is based on interviews with Energy Australia, Keller Civil Engineers, Ecoflex Constructions, Ecoflex Australia, and C&R Tyre Recycling.

The Project

The Tomago all-weather access road was a $4m project commissioned by Energy Australia as part of a larger $40-50m project to upgrade electricity supply from Tomago to the Tomaree Peninsula in New South Wales. The Tomago road project called for a 16 km stretch of pavement which:

- required that there be no excavation, compaction or levelling of the ground, to avoid: exposure of acid sulphate soils; disturbance of heritage sites, flora and fauna; and impact on private land
- created a load bearing capacity of 60 tonnes for crane traffic during construction of an electricity transmission line
- was permanent and required little maintenance
- had a low profile to preserve visual amenity
- was water permeable horizontally and vertically, to minimise impact on the ecosystem.

The value-based open tender selection process resulted in the contract being awarded to a team that used patented Ecoflex E-Pave Units in a recycled-tyre reinforced pavement design. This new method offered considerable benefits over conventional macadam pavement. The project was completed in October 2004, after a seven month construction program.

The Achievement

The client consulted the community for four years to determine the most acceptable alignment for the Tomago road. The community's favoured option traversed acid sulphate soils, wetland areas, 190 private properties, 10 archaeological sites and several national park sections. The project was thus environmentally, culturally and politically sensitive.

The winning tender offered an alternative design based on a proprietary construction process that better met the client's requirements and saved 15% over the conventional macadam design. In the bigger picture, the project also absorbed six percent of NSW's annual waste tyre stream, which would otherwise have gone to landfill.

The Innovation

The patented tyre-reinforced permeable pavement was developed specifically for water saturated conditions, where the ground has low load bearing capability. The method is one of the few in the world that uses robust engineering systems to take advantage of the structural value of recycled tyres in a quality controlled environment.

The inventor grew up on a cattle property, where he often saw tyres being used to build roads which did not perform well. He later conceived that this performance could be improved by applying engineering principles and quality control processes. The pavement he developed is based on this early idea and his 30 years' experience in the civil construction industry. The pavement is built with Ecoflex units, which comprise:

- an approved recycled tyre
- a sidewall
- free-draining rock fill.

The recycled tyre consists of an approved tyre with the side-wall cut out at a precise location. An approved tyre is one that: has a solid rubber tread with even thickness, passes strength and rigidity tests, has no exposed steel, and has not been stripped for re-treading. The cost competitiveness of the technology is underpinned by the adaptation of a $10,000 machine that efficiently and effectively removes the sidewalls. The sidewall is then put inside the tyres on-site to improve their tensile strength.

The tyres are placed on geofabric laid directly on the ground, and arranged in a honeycomb pattern which helps minimise the gaps between the tyres, thus helping to maintain the pavement's structural integrity. Each tyre is butted up to adjoining tyres, again so that fill does not infiltrate gaps and weaken the pavement. A topping layer is then applied to interlock the fill material. When constructed according to quality control procedures, there is no need to fix adjoining tyres to maintain the pavement's trafficability over time. The Tomago road comprises 75,000 truck tyres processed and laid in this way.

On the Tomago project, the client considered alternative pavement methods. Conventional construction methods were rejected for reasons outlined below in the Benefits section. Other new proprietary products from Australia and overseas were also considered. They all provided the fill-containment function offered by the recycled tyres, but the client found the costs much greater and the likely performance lacking.

The Benefits

In the absence of Ecoflex, the Tomago project would probably have used a macadam pavement, which comprises layers of broken stone, compacted into a hard surface. Because much of the terrain is often water saturated, and because excavation was not an option, a macadam pavement would have been very wide and high. To achieve a four metre wide trafficable surface, the pavement would have been seven metres wide and one metre high, while the proprietary pavement is only four metres wide and 300mm high.

The new approach is less costly, has less impact on the environment, and provides greater visual amenity. The recycled tyres contain the rock fill and prevent it from spreading, which is particularly advantageous on projects where excavation is problematic because of water-saturated or environmentally sensitive conditions, such on the Tomago project.

For the Client

The proprietary system cost approximately 15% less than the conventional approach, significantly reducing the client's project costs, while achieving environmental and social objectives.

For the Environment

The technology supplier estimates that the cost of creating and operating an urban landfill facility in Australia is $100-$150 per tonne of waste. Applying the bottom end of this range, the Tomago project saved the community approximately $400,000 in land fill costs.

Environmental benefit was also provided because the recycled tyre approach required 60% less fill material than a conventional pavement on the project. This meant a reduction in fuel consumption to mine and transport fill. According to the technology supplier, this saved 2,110 tonnes of greenhouse gas emissions.

For the Technology Supplier

The performance record of the proprietary recycled tyre approach, especially on the Tomago project, has impressed the client. This has contributed to their considering development of a 'period contract', which is expected to offer a negotiated fee for unique products used on specified small projects, for a given time period. This arrangement avoids repeated open tendering for work where it is known that there is a unique product offering superior efficiency over available alternatives. For the technology supplier, this preferred status would be a reward for the considerable investment they have made in research and development (R&D), to develop a product that is apparently without peer.

The Implementation Process

Over the past 10 years, the inventor and other stakeholders have invested $4m in R&D and spent seven years obtaining patents in most industrialised countries for a range of recycled tyre innovations, including the tyre-reinforced pavement. Over the past five years, 150 mostly small pavement projects have been undertaken, largely in the civil and mining industries.

One of the key stakeholders in the technology is the tyre recycler on the Tomago project. Their interest has been driven by economic and environmental considerations. Tyre recyclers are usually paid by tyre retailers to dispose of tyres. Roughly 30% are suitable for immediate resale, export, re-treading or crumbing. The remaining 70% are typically buried in landfill after mandatory shredding to reduce volume. The landfill tyres have traditionally had no value, but most of them are suitable for use by the technology supplier.

The tyre recycler on the Tomago Project typically makes 10% profit on landfilled truck tyres, but can make 40% profit on locally sourced, approved and modified truck tyres delivered to site for the technology supplier. This is because it costs more to modify a tyre for landfill and pay the dumping fee, than to modify and deliver it for the technology supplier. Although appropriately modified tyres can be sourced by the technology supplier for nominal cost, the client pays a more substantial fee for the product, based on embedded intellectual property. The fee is priced competitively against next-best alternatives by the technology supplier, who licences the technology to recyclers or contractors.

The client created the opportunity for the proprietary product to be used on the Tomago Project by offering a value-based tender and encouraging alternative submissions. The client was motivated to do this following a pilot test of the product, which they conducted after hearing about the technology and developing a relationship with the inventor.

The pilot test seemed unnecessary to the inventor because 50 proprietary paving projects have already been completed and are operating successfully. He observes that new clients are very interested in the experience of existing clients, however at this point in the technology's development, new clients are still inclined to want their own demonstrator trials conducted.

Relationships were a key part of the implementation process. The key players – the Project Manager for the client, the technology inventor, the tyre recycler's Managing Director, and the head contractor's Managing Director are all very respectful of each other's abilities and have built up robust relationships over time. These are win-win relationships. The technology is a profitable and sustainable business opportunity for the tyre-recycler, a better way of meeting client needs for the head contractor, and it delivers economical/ sustainable project outcomes for the client. Nevertheless, all these parties became involved through a 'leap of faith'. They acknowledge that the adoption of new technology requires judicious risk taking, which in their case appears to be paying off. The client's Project Manager considers that their risks in adopting the new technology were reduced by the level of trust they had in the inventor.

Another type of relationship pursued by the inventor is with universities. He feels that the academic fraternity needs to be convinced of the benefits of the technology because their expert opinion is well regarded. He uses the Commonwealth Government's R&D tax concession to off-set the costs of university research, and has found this scheme 'extraordinarily helpful' in supporting his business.

Overcoming Difficulties

The development of the new technology has been very challenging. Firstly, the inventor's team has needed to change damaging **public perceptions** about tyre flammability and leachability, and about the effectiveness of used tyres in structural applications. These issues have been addressed through university research, and through building over 400 successful projects. Such evidence suggests that recycled tyres laid according to the Ecoflex system are largely environmentally benign, and that the technology is robust. Recycled tyres that have been modified and laid according to the Ecoflex engineering system completely outperform the simple application of used tyres for structural purposes.

Secondly, the inventor's team considers that the **regulatory/specification environment** is complex and confusing, and that public procurement policies are excessively risk-averse. These factors are seen to constrain the uptake of their technology. Indeed, these themes are commonly raised by industry commentators.

Thirdly, as the technology is new, the inventors team is very keen to ensure that all their projects perform well. This is particularly important as the technology seems deceptively simple, yet lack of attention to detail in the implementation phase can have a dramatic negative impact on performance. Hence, there is a strong focus on robust design by engineers and **expert supervision of site activities.** Every project is submitted for development application approval through the relevant government authority and hence complies with their requirements. Quality is also assured through certification of all projects by independent engineers and specialist supervision on-site.

Fourthly, the inventor's team conducts research to assess **unauthorised use of their patented system**. This is done mainly to avoid any project disasters perpetrated by unrelated organisations reflecting badly on the inventor's technology. There have been several instances discovered to date, and on each occasion a solution has been found that ensures the integrity of the project. Any disasters with recycled-tyre pavements, perpetrated by firms ineffectively copying the Ecoflex system, or using other systems could confuse the market and result in rejection of the inventor's technology.

Fifthly, the inventor's team feels that the technology has reached a level of development and market penetration where they can successfully seek a **partnership with a large established firm** in the industry. This is expected to provide additional capital to more effectively defend patents, the resources to more vigorously promote the technology, and the relationships to win more projects.

Finally, there were challenges in **project procurement**. The client's primary relationship was with the inventor, rather than with the head contractor. In this respect, the client would have been happy to receive a submission from the inventor's contracting company as head contractor, through the open tender process. However, the pre-qualification criteria precluded this. Instead, the inventor licensed Keller Civil Engineers, a larger and more experienced firm, to use the technology, and submit a bid as the head contractor. Keller's Managing Director is a long-time colleague of the inventor's.

Lessons Learned

- Patience and effective industry networking underpin the commercial potential of new technology ventures undertaken by small businesses.

- Successful market acceptance of new products requires careful monitoring and management of imitators, to avoid damage to the product's reputation.

- Clients play a key role in promoting innovation, particularly via value-based tender selection and encouraging alternative tender submissions.

- Expert supervision and quality control is required to effectively implement new technological systems and maintain a good reputation.

- Small new technology businesses may achieve greater commercial success through partnerships with larger, more established businesses, particularly through improved market penetration and protection of patents.

- Small new technology businesses can benefit from relationships with universities, particularly where research is undertaken to validate claims, and where the Commonwealth Government's R&D tax concession can be used.

- Regulatory complexity and risk-averse public procurement policies constrain industry innovation.

10. CASE STUDY SUMMARY DATA

Figure 10.1 Summary details: 12 case studies of project-based innovation for commercial buildings and roads

Overview	Study 1	Study 2	Study 3	Study 4	Study 5	Study 6	Study 7	Study 8	Study 9	Study 10	Study 11	Study 12
Project Name	William McCormack Place	Lang Park Sports Stadium	Port of Brisbane Motorway	National Gallery of Victoria – Australian Art Building	Coutts Crossing Bridge	Cattle Creek Bridge	Gladesville Road Community Centre	Imago Site	Stadium Australia	Art Gallery of South Australia	Adelaide Oval	Tomago All-Weather Access Road
Location	Cairns, Qld	Brisbane, Qld	Brisbane, Qld	Melbourne, Vic.	Coutts Crossing, NSW	Near Mackay, North Qld	Hunters Hill, NSW	East Perth, WA	Sydney, NSW	Adelaide, SA	Adelaide, SA	Tomaree Peninsula, NSW
Project Description	4568m^3 public building	Grandstand structure at a 52,500 seat world-class stadium	5km, 4-lane motorway, with 12 major new bridges	Iconic public building, 11,000m^3	Repair of 12 metre length of 90 metre long timber bridge deck	Identification and repair of faults in 200 new concrete bridge beams	Stormwater management at a small community building, 400m^3	Remediating 5,800m^3 contaminated land	Two 3,500m^3 roofs over sports stadium ends	Up-grading the air-conditioning system at an art gallery	Redeveloping the eastern grounds of a sports stadium	16km road through saturated ground
Project Budget	$17.5m	$3m	$112m	$65m	$1m	$1m	$13,000	$1.8m	$10m	$100,000	$22m	$4m
Innovation Summary												
Innovation Description	Chilled water thermal storage tank and moisture absorbing thermal wheel	Precast prestressed polystyrene voided concrete planks with formed rebates	Project delivered under an alliance contract	Fire engineering enabled use of unprotected steel	Fibre-reinforced polymer (FRP) bridge deck	Ground penetrating radar to find defects in bridge beams	Managing stormwater with storage gutters and infiltration	Saving site-remediation costs: new waste disposal method; sprinkler and wheel wash	Post-tensioned steel trusses to create long span roofs	Twin-coil air-conditioning to improve energy efficiency	Relationship based contract and 3D CAD to efficiently deliver complex project	Using recycled tyres to create a permeable road pavement while meeting strict environmental and community requirements
Problem driven or planned innovation?	Planned	Planned	Planned	Problem-driven	Planned	Problem-driven	Planned	Problem-driven	Planned	Planned	Planned	Planned
Original or adopted innovation?	Adopted	Original, Patented	Novel, but not patented	Adopted	Original, patented	Original patented	Original, patented	Adopted	Original, patented	Original, patented	Adopted	Original, patented
Incremental or major innovation?	Incremental	Incremental	Major new contracting method	Major new building method	Major new construction method	Major new bridge inspection method	Incremental	Incremental	Major new roof construction method	Incremental	Incremental	Major new method of road construction
Main benefits achieved	37% saving in energy costs	8% saving in cost of grandstand steelwork	10% project cost saved; 30% time saved	5% of project cost saved	75% saved in transport costs; 90% saved in traffic management costs	50% of project cost saved	26% reduction in mains water demand	13% project cost saved	50% reduction in steel weight; 25% reduction in roof erection time	30% reduction in energy consumption	50% reduction in prefabrication time; 90% reduction in requests for information	15% of project cost saved

Innovation Drivers:	Study 1	Study 2	Study 3	Study 4	Study 5	Study 6	Study 7	Study 8	Study 9	Study 10	Study 11	Study 12
Innovation idea route via …	Mechanical/ electrical consultant	Structural engineering consultant and plank supplier	Client	Fire engineering consultant and architect	Pre-existing research group comprising clients and suppliers	GPR consultant who had pre-existing relationship with client	Specialist sub-contractor	Environment consultant and main contractor	Steel design consultant/ specialist sub-contractor	Specialist sub-contractors	Client; architectural and engineering consultants	Technology supplier
Role played by client in innovation	Set challenging energy target	Allowed for shared savings if project delivered below GMP	Designed the innovative alliance contract	Not highlighted	Part of research group progressing the technology	Knew the expert who could solve the problem efficiently and effectively	Organised the project as a demonstrator of water saving technology	Not highlighted	Not highlighted	Technology adoption driven by the Client's energy stakeholder committee	Managed the design of an innovative contract	Knew the expert who could build the road meeting all requirements
Role played by project relationships in innovation	Supportive	Supportive	Critical	Supportive	Critical	Critical	Supportive	Supportive	Supportive	Critical	Critical	Critical
Role played by regulations in innovation	Energy rating schemes and associated government targets encouraged innovation	Not highlighted	Not highlighted	Shift to performance-based building codes encouraged innovation	Not highlighted	Not highlighted	Environment legislation drives development of new water saving technologies	Environment legislation drives development of new waste disposal methods	Not highlighted	Government energy targets drive development of new energy saving technologies	Not highlighted	Regulatory complexity makes technology certification processes problematic and hampers effective marketing
Role played by technical support providers in innovation	International professional associations provided ideas	University validated test results	Not highlighted	Not highlighted	University role in R&D critical	Not highlighted	Universities validated water saving strategy	Not highlighted	Universities validated test results	Not highlighted	Not highlighted	Universities validated test results
Key role played by small independent regional firm?	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes

Conclusions	Study 1	Study 2	Study 3	Study 4	Study 5	Study 6	Study 7	Study 8	Study 9	Study 10	Study 11	Study 12
Main innovation impetus	Client wanted to minimise whole-of-life costs	Client's contract provided innovation incentives	Client wanted improved time/cost/ quality outcomes	During the project, time and cost started to blow-out and needed containment	Client attracted by the weight and corrosion benefits of FRP	During bridge repair faults were found in new concrete beams	Client (local council) wanted to educate community re water saving technologies	During site remediation highly toxic materials were unexpectedly found	Client had tight time-line; needed to keep stadium operating during construction	Client needed to gain better control of fluctuating humidity and temperature levels	Client had tight time-line; wanted better than usual time/cost/ quality outcomes	Client was constrained by restrictive community and environmental requirements and needed new solution
Main challenges encountered	Controlling up-front costs; managing risk aversion	Managing product testing within the time available	Ensuring a supportive culture across the large client organisation	Addressing lingering safety concerns	Managing tensions between parties in the research group	Managing the risk of a highly novel approach	Adjusting technical specifications to match building requirements	Managing bureaucratic approval processes to ensure timeliness	Ensuring the precision of technical elements on-site	Managing relationships across many stakeholders	Adjusting to a more cooperative way of working	Optimising organisation of site-work to reap maximum efficiency
Key learning	Setting standards just beyond current capabilities drives innovation	Prefabricated building components offer significant advantages	Harmonious project relationships create win-win gains for all parties	Performance-based building codes create the flexibility required for innovation	Prefabricated bridge components offer significant advantages	R&D, cooperation and robust relationships drive innovation	Tougher environment regulations drive innovation	Formal firm-level 'idea schemes' help capture project-based learnings	Innovative structural technologies require close attention to quality control	Innovation requires champions; and sponsors linked to resources	Early involvement of sub-contractors in design improves constructability	Expert supervision, quality control and control of imitators safeguards reputation

- All projects were completed between 2000 and 2005
- All projects were for repeat public sector clients, except No. 11, which was undertaken for a one-off private sector client.
- GMP = guaranteed maximum price
- Project budget includes the savings gained via innovation over business-as-usual project cost
- Incremental/major innovation exist along the same continuum. The distinction shown here is defined by the extent of technical departure from current practice, rather than by impact. For example, many incremental innovation have big impacts.
- Benefits are expressed as savings compared to 'business-as-usual' estimated costs
- All planned innovation was driven by challenging client requirements

This table combines details of the 2003 and 2005 case study programs. It will provide input to a number of journal articles under BRITE Phase 2.

11. CONCLUSIONS

The 2005 case study program was completed successfully thanks to a combination of hard work, team cooperation and good fortune. To a large extent, the success of the project depended on our ability to encourage cooperation and timely responses from our interviewees. The most challenging process was that of moving from the first case study draft to a fully approved draft suitable for publication. This involved complex and time consuming deal-brokering activities, and for one of the case studies, management of conflict between project participants. A strategic approach to these issues ensured publication of the studies and protected the integrity of the content.

Overall, the case studies reflect the key innovation influences to emerge from our review of the academic literature, namely industry relationships, procurement systems, clients, regulations, organisational resources, structure of production, and industry culture. One of the key benefits of the case studies is that they demonstrate the *dynamics* of these influences in *local* real world examples.

The 2005 case study program was informed by learnings gained through the 2003 program, for example:

- More emphasis was placed on locating and documenting cases of innovation driven by *problems* on projects, or to document failed innovation, as such circumstances are an important component of innovation processes. However, as was anticipated, this was difficult due to reluctance on the part of project participants to discuss their 'failures'. Nevertheless Case Study Eight investigates problem-driven innovation, as do Case Studies Four and Six.

- In order to obtain greater understanding of innovation processes, longer interviews were conducted in 2005, while a minimum of three rather than two organisations were consulted. Overall, 40 interviews were conducted in 2005, while only 20 were undertaken in 2003.

- The 2005 program contained a greater emphasis on the challenges faced by patenting organisations, thus more fully addressing the variety of potential innovation processes.

- During the 2003 program, it was found that personal interviewing elicited superior compliance from interviewees compared to telephone interviewing, and so the emphasis on personal interviewing continued in 2005.

- The case studies capture a static picture of each innovation at a particular point in time. Part of BRITE's work during 2005 involved adding value to the 2003 program by reviewing the evolution of the innovations over the intervening period. Results of this investigation are summarised in Appendix C

Key stakeholders in the project are very enthusiastic about the content, format and educational potential of both the 2003 and 2005 case study booklets. Indeed, over 1,000 copies of the 2003 collection have been distributed to industry participants via government clients, industry associations, conference organisers and CRC HQ. Appendices A and B also reveal robust diffusion of both case study and survey results through academic and industry channels. Readers interested in the contributions of the BRITE project to innovation *theory* are encouraged to review the academic publications. Appendix E lists some soft indicators of

industry impact, while STEM Partnership is currently conducting a formal impact analysis of BRITE activities for CRC HQ.

Results from BRITE Phase 1 have revealed important areas for further research. The BRITE team proposed a Phase 2 of the project to the CRC Research Board in 2004 and successfully convinced the Board to fund a further two years of study. Phase I of BRITE collected broad-based innovation data which indicate a number of areas requiring further investigation. These revolve around the industry's learning capacity as a key input to successful innovation, and include:

- integration of learning at project and firm levels
- use of formal evaluation techniques
- management of innovation risk
- operation of incentive structures
- client demands for service-enhancement
- scope for practitioner research
- failure as a learning process
- effectiveness of the 'systems-integrator' on projects
- reinterpretation of the construction industry as a knowledge-intensive industry, rather than simply a low-technology, mature industry
- conceptual insights based on the 12 case studies

Further research will involve tracking innovation in action over the lives of two construction projects, as well as conducting an interview survey of organisations identified as 'high innovators' during BRITE Phase 1. The focus of these activities is to drill-down into issues such as those listed above to gather more in-depth data about innovation processes.

12. REFERENCES

CBPP (Construction Best Practice Program) (2001) The Construction Performance Driver: A Health Check for Your Business. UK: CBPP.

Gann, D. and Salter A. (1998) 'Learning and Innovation Management in Project-Based Firms', 2nd International Conference of Technology Policy and Innovation, Lisbon, August 3-5.

Jones, A. J. and Pagan , J. (1999) Case Studies on Innovative Australian Firms (Examples). Canberra: Department of Industry Science and Resources.

Marceau, J., J. Houghton, P. Toner, K. Manley, E. Gerasimou and N. Cook (1999) Mapping the Building and Construction Product System in Australia. Canberra: Department of Industry, Science and Resources.

Thorburn, L. and Langdale, J. (2003) Embracing Change: Case Studies on How Australian Firms Use Incremental Innovation to Support Growth. Canberra: Department of Industry, Tourism and Resources.

13. GLOSSARY

ACIF Australian Construction Industry Forum

BRITE Building, Research, Innovation, Technology, Environment

Brownfield sites are areas that have been previously used for industrial or commercial purposes, and which may be contaminated by low concentrations of hazardous waste or pollution, but have the potential to be cleaned up and reused.

Catenary curves (of the steel trusses) take the shape of a flexible chain hanging from each end and supporting only it's own uniform weight. The slope of the curve is greatest at each end where the load is highest.

Diffusion of innovation The spread of new ideas through culture/society.

DOE Department of Environment

EMRC Eastern Metropolitan Regional Council

EPA Environmental Protection Agency

Innovation The process of making changes to products, processes or services by introducing a new technology or using existing technology in a new context. Innovations can be either radical or incremental changes.

Procurement refers to the process of acquiring goods and services with consideration given to total cost, quantity and timing of supply.

Retrofitting Fitting of new parts or technologies after completion of the original construction.

SMAC Shaw Method of Air-conditioning

SMS-enabled (Short Message Service) Allows notification or alerts in the form of a short text message to be sent from the enabled electronic device to a mobile phone.

Stakeholder Any organisation, government entity or individual with an interest in the success of an organisation (the client) delivering a project. Stakeholders influence programs, products, and services.

Appendix A - ACADEMIC PAPERS PUBLISHED

BRITE has published 13 refereed conference articles and six refereed journal articles over Phase 1, as detailed below:

Refereed Journal Papers

Hardie, M., Miller, G., Manley, K. and McFallan, S. (2006) 'Innovation performance and its impact on profitability among different groupings in the Australian construction industry', *Australian Journal of Construction Economics and Building,* forthcoming.

Blayse, A. and Manley, K. (2004) 'Key Influences on Construction Innovation', *Construction Innovation*, Vol 4, No 3, pp 1-12

Manley, K. (2003) 'Frameworks for Understanding Interactive Innovation Processes', *International Journal of Entrepreneurship and Innovation,* Vol 4, No 1, pp 25-36.

Manley, K. (2002) 'Partnering and Alliancing on Road Projects in Australia and Internationally', *Road and Transport Research,* Vol 11, No. 3, pp 46-60.

Manley, K. and Marceau, J. (2002) 'Integrated Manufacturing-Services Businesses in the Australian Building and Construction Sector', *Australian Journal of Construction Economics and Building*, Vol 2, Issue 1, pp 1-12.

Manley, K. (2002) 'The Systems Approach to Innovation Studies', *Australian Journal of Information Systems*, Vol 9, No 2, pp 94-102.

Refereed Conference Papers

Manley, K. and McFallan, S. (2005) 'The Relationship between Business Strategies and Successful Innovation', *The Australian Sociological Association Conference*, Hobart, Australia, 5 – 8 December.

Hardie, M., Miller, G. and Manley, K. (2005). 'Innovative connecting system for precast planks on a major sports stadium', *International group for Lean Construction (IGLC) 13 Conference,* Sydney, Australia, 18 – 20 July

Hardie, M., Miller, G., Manley, K. and McFallan, S. (2005). 'Experience with the management of technological innovations within the Australian construction industry', *Proceedings of PICMET '05 Conference,* Portland, Oregon, USA, 31 July – 4 August

Hardie, M., Miller, G., Manley, K. and McFallan, S. (2005). 'The Quantity Surveyor's Role in Innovation Generation, Adoption and Diffusion in the Australian Construction Industry', *QUT Research Week,* Brisbane, Australia, 4 – 8 July

Manley, K., Blayse, A. and McFallan, S. (2005) 'Demonstrating the Benefits of Construction Innovation', *'Creating and Entrepreneurial Economy: The Role of Enterprise and Innovation', International Research Conference*, University of Waikato, Hamilton, New Zealand, 7 – 8 July

Manley, K. and McFallan, S. (2005) 'The Impact of Business Strategies and Business Conditions on Innovation', *'Creating and Entrepreneurial Economy: The Role of Enterprise and Innovation', International Research Conference*, University of Waikato, Hamilton, New Zealand, 7 – 8 July

Rose, T. and Manley, K. (2005) 'A conceptual framework to investigate the optimisation of financial incentive mechanisms in construction projects' *CIB W92/T23/W107 International Symposium on Procurement Systems: The Impact of Cultural Differences and Systems on Construction Performance*, February 7th – 10th; Las Vegas, NV USA

Manley, K., Blayse, A. and Swainston, M. (2004) 'Implementing Innovation on Commercial Building Projects in Australia', *'Clients Driving Innovation' International Conference*, CRC for Construction Innovation, Gold Coast, Australia, 25-27 October

Manley, K. and Blayse, A. (2004) 'Innovation In The Australian Road Construction Industry – Making Better Use Of Resources', *New Zealand Institute of Highway Technology, Towards Sustainable Land Transport Conference*, Wellington, New Zealand, 21-24 November

Manley, K. and McFallan, S. (2003) 'Innovation Rates and Drivers in the Road Industry: The Case of Queensland, Australia', *Joint International Symposium of CIB Working Commissions W55, W65 and W107, Singapore, 22-24 October*.

Manley, K. and McFallan, S. (2003) 'Innovation Adoption Behaviour in the Construction Sector: The Case of the Queensland Road Industry', *2nd International Conference on Innovation in Architecture, Engineering and Construction*, Loughborough University, United Kingdom, 25-27 June.

Manley, K. and McFallan, S. (2003) 'Knowledge Flows in the Road Industry – Queensland's Experience', *21st ARRB and 11th REAAA Conference*, Cairns, Australia, 18-23 May.

Hampson, K., Drogemuller, R. and Manley, K. (2002) 'Building an ICT Infrastructure for a National Research Centre', *CISEMIC -eSmart Conference*, University of Salford, United Kingdom, 18 - 21 November.

Appendix B - INDUSTRY MAGAZINE ARTICLES PUBLISHED

During BRITE Phase 1, 126 articles were published in the industry media and through partners' communication networks, reaching over two million readers through half a million copies distributed. About 70% were published in the general media (87 articles) and 30% in project partners' and project associates' media (39 articles).

Forty-six different publications or organisations were involved, from across the property and construction sector. Some organisations manage a number of communication channels, eg website, electronic newsletter and journal, all of which typically carry information about BRITE. Of these 46 publications or organisations, 60% published BRITE material more than once (six times being the highest number, and fifteen of them publishing four times or more).

Table B.1 Focus of Articles

TOPIC	NUMBER	%
2005 Case Studies - general	28	19%
2005 Case Study Launch	25	17%
Survey Results	25	17%
Survey Results Launch	13	9%
2004 Case Studies - general	9	6%
2004 CS Launch	9	6%
Case Study 1	8	6%
Survey in the Field	4	3%
Case Study 2	4	3%
Case Study 6	4	3%
Karen's article- ABS & BRITE data	3	2%
Case Study 7 Rainsaver	2	1%
Case Study 3	2	1%
Case Study 4	2	1%
Case Study 5	2	1%
Summary of First Six Studies	2	1%
Michelle's article- 2004 Case Studies; Survey results	1	1%
Case Study 12 Ecoflex	1	1%
BRITE Project	1	1%

The table overleaf shows more details about the articles.

Table B.2 Details of Articles Published

Number Published	Publication	Publication Type	Frequency	Publication Date	Circulation	Audience	Title of Article	Focus of Article
130	**Master Builder Victoria**	magazine	5 / year	**Oct/Nov 06**	5,000	builders Victoria	One of 2005 Case Studies; copy deadline TBA	2005 CS xx
129	**Master Builder Victoria**	magazine	5 / year	**Aug/Sep 06**	5,000	builders Victoria	One of 2005 Case Studies; copy deadline TBA	2005 CS xx
128	**Master Builder Victoria**	magazine	5 / year	**Jun/July 06**	5,000	builders Victoria	One of 2005 Case Studies; copy deadline 28 Apr	2005 CS xx
127	**Master Builder Victoria**	magazine	5 / year	**Apr/May 06**	5,000	builders Victoria	One of 2005 Case Studies; copy deadline 17 Feb	2005 CS xx
126	**Master Builder Victoria**	magazine	5 / year	**Feb/Mar 06**	5,000	builders Victoria	One of 2005 Case Studies; copy deadline 6 Jan	2005 CS xx
125	**National Building News Monthly**	magazine	monthly	**Dec-05**	7,500	bldrs; developers; architects; ind bodies		2005 Launch
124	**Roads Magazine**	magazine	monthly	**Dec-05**	5,000	road consultants & contractors, suppliers		Ecoflex CS
123	**QUT BeeLine**	magazine	bi-annual	**Dec-05**	12,500	BEE alumni overseas & Aus; industry		Survey Results 2005 Case Studies
122	**CEN ConstructionEquipmentNews.net**	daily online news service	daily	**Nov-05**	2,000	contractors, suppliers	**Innovation the aim**	2005 Launch; Case Studies

	Publication	Publication Type	Frequency	Publication Date	Circulation	Audience	Title of Article	
121	**National Building News Monthly**	magazine	monthly	**Nov-05**	7,500	bldrs; developers; architects; ind bodies	**Launch of new BRITE Innovation Case Studies (Keith Hampson's column)**	2005 Launch; Case Studies
120	**FM Magazine**	magazine	bi-monthly	**Oct/Nov 05**	6,900	facility managers	**2005 BRITE Innovation Case Studies Launch**	2005 Launch
119	**Master Builder Victoria**	magazine	5 / year	**Oct/Nov 05**	5,000	builders Victoria		Summary
118	**Office of Aus Safety & Compensation Council; Dept Employment & Workplace Relations**	e-calendar		**Oct-05**		all including SMEs	**Making Innovation Happen on Construction Projects**	2005 Launch
117	**CRC Update Newsletter**	e-newsletter	bi-monthly	**Oct-05**	3,000	all industry	**Launch of new BRITE Innovation Case Studies**	2005 Launch
116	**CRC Website - Events**	website		**Oct-05**			**Launch of BRITE Innovation Case Studies 2005**	2005 Launch
115	**cnbr-l**	e-Newsletter		**Oct-05**		construction researchers	**[CNBR message] Invitation to Launch of BRITE Innovation Case Studies 2005 (Australia)**	2005 Launch
114	**Qld Master Builder**	magazine	bi-monthly	**Oct-05**	10,600	builders Qld	**Innovation Case Studies - 2005 Launch**	2005 Launch
113	**Qld Master Builders Assocn**	email message		**Oct-05**	100	builders Qld		2005 Launch
112	**CCF Newsletter Qld**	e-Newsletter	monthly	**Oct-05**	1,054	civil contractors		2005 Launch
111	**Engineers Australia Enewsletter Qld**	e-Newsletter	monthly	**Oct-05**	10,500	engineers	**Making Innovation Happen on Construction Projects**	2005 Launch

	Publication	Publication Type	Frequency	Publication Date	Circulation	Audience	Title of Article	
110	**Engineers Australia**	website		**Oct-05**		engineers	**Launch of BRITE Innovation Case Studies 2005**	2005 Launch
109	**ACEA Newsletter QLD**	newsletter	monthly	**Oct-05**	240	consulting engineers		2005 Launch
108	**AIQS e-newsletter**	e-newsletter		**Oct-05**	100	quantity surveyors		2005 Launch
107	**DMR List of Prequalified Contractors & Consultants**	snail mail		**Oct-05**	400	DMR pre-qualified road & bridge consultants & contractors		2005 Launch
106	**DPW Prequalified Contractors & Consultants**	email message		**Oct-05**	550	DPW pre-qualified building consultants & contractors	**Invitation: Launch of the 2005 BRITE Case Studies of Innovative Projects**	2005 Launch
105	**Aust Inst Project Management**	e-newsletter		**Oct-05**		project managers Qld		2005 Launch
104	**bcme**	magazine	2-monthly	**Oct-05**	18,000	commercial construction players		2005 Launch Rainsaver Case Study
103	**Qld Govt World Expo website**	website		**Oct-05**			**One of these initiatives is the BRITE project…**	BRITE Project
102	**Construct Monthly (AIB)**	e-newsletter	monthly	**Oct-05**	6,000	construction managers; specifiers; govt		2005 Launch
101	**RAIA Website**	website		**Sep-05**		architects	**2005 BRITE Innovation Case Studies** in Events	2005 Launch

	Publication	Publication Type	Frequency	Publication Date	Circulation	Audience	Title of Article	
100	**AIB Qld Chapter**					construction managers; specifiers; govt		
99	**AIB Aus Inst Bldg Website**	website		**Sep-05**		construction managers; specifiers; govt	**CRC for Construction Innovation - BRITE Project Studies - A project to increase the rate of innovation in the construction industry**	2005 Launch
98	**CEN ConstructionEquipmentNews.net**	daily online news service	daily	**Sep-05**	2,000	contractors, suppliers	**Innovation affects us all**	2005 Launch
97	**Master Builder Victoria**	magazine	5 / year	**Aug/Sep 05**	5,000	builders Victoria	**Concrete Planking Innovation Saves over $300,000 on Major Sports Stadium**	CS 2
96	**Contractor**	magazine	monthly	**Aug-05**	11,000	contractors, suppliers	In Environmental excellence feature - **A BRITE future**;	Rainsaver Case Study; 2005 Launch
95	**Construction Contractor**	magazine	monthly	**Jul-05**	8,600	contractors, suppliers	**BRITE Project removes barriers to innovation**	Special article- 2004 Case Studies; Survey results
94	**Master Builder Victoria**	magazine	5 / year	**Jun/July 05**	5,000	builders Victoria	**Outstanding Whole-of-life Gains without Higher Up-front Costs**	CS 1
93	**SDI Magazine**	magazine	quarterly/bi-annual	**Jun-05**	10,000	business leaders, multipliers, clients of SDI's centres and events	**Are you a company of BRITE sparks?**	Survey Results; 2005 Case Studies
92	**Climate Control News**	magazine	monthly	**Jun-05**	7,000	heating, ventilation, air con contractors & suppliers		Survey Results; 2005 Case Studies

	Publication	Publication Type	Frequency	Publication Date	Circulation	Audience	Title of Article	
91	**ACEA NSW magazine**	magazine	periodically	**Jun-05**	900	consulting engineers NSW		Survey Results
90	**DPW Contact**	magazine	monthly	**May,June 05?**	3,600	staff of QDPW		Survey Results
89	**QUT Bee Website**	website		**Jun-05**		BEE alumni overseas & Aus; industry	**BRITE Innovation Survey Results - High Innovators the Way**	Survey Results 2005 Case Studies
88	**Voice Data Electrical (NECA)**	newsletter	monthly	**May-05**	5,000	national; electricians, communications elecs	**How Innovative are we?** and **Innovators being Asked to Step Forward**	Survey Results; 2005 Case Studies
87	**Master Builder Victoria**	magazine	5 / year	**Apr/May 05**	5,000	builders Victoria	**Performance-Based Building Codes and Fire Engineering Yield Innovative Design Solution**	Case Study 4
86	**Master Builder Victoria**	magazine	5 / year	**Apr/May 05**	5,000	builders Victoria	**Construction innovation Potential**	Karen's article
85	**Building Australia**	magazine	8 issues/yr	**Apr-05**	15,602	bldrs, contrs, archs, designers, engs	**Aussie Contractors outperform Kiwis**	Karen's article
84	**CCF Newsletter Qld**	e-Newsletter	monthly	**Apr-05**	1,054	civil contractors		Survey Results
83	**Master Builder WA**	magazine	5 / year	**Mar/Apr 05**	5,000	builders WA	**The BRITE Innovation Survey** and **Construction Innovators- please step forward!**	Survey Results; 2005 Case Studies
82	**AAPA magazine**	magazine	quarterly	**Mar 05 ??**		asphalters		Survey Results
81	**Stormwater Industry Association**	newsletter	monthly	**Mar-05**	1,300	association members in Aus & NZ	**CRC for Construction Innovation calls for Innovators**	2005 Case Studies
80	**CEN ConstructionEquipmentNews.net**	daily online news service	daily	**Mar-05**	2,000	contractors, suppliers	**Lies, damned lies and …**	Karen's article

	Publication	Publication Type	Frequency	Publication Date	Circulation	Audience	Title of Article	
79	**Glass Australia Magazine AGGA**	magazine	quarterly	**Mar-05**	7,000	glass manufacturers, suppliers	**Construction Innovators - Please Step Forward**	2005 Case Studies
78	**CRC Update Newsletter**	e-newsletter	bi-monthly	**Mar-05**	3,000	all industry	**Construction Innovators - Please Step Forward**	2005 Case Studies
77	**EcoLibrium (AIRAH Journal)**	journal	monthly	**Mar-05**	4,200	refrig, air con, heating contractors, suppliers	**Innovative Building Projects Sought**	2005 Case Studies
76	**bcme**	magazine	2-monthly	**Feb-05**	18,000	commercial construction players	**Construction Innovators- please step forward**	2005 Case Studies
75	**Master Builder Victoria**	magazine	5 / year	**Feb/Mar 05**	5,000	builders Victoria	**The BRITE Innovation Survey** and **Construction Innovators- please step forward!**	Survey Results; 2005 Case Studies
74	**API Enews**	e-Newsletter	bi-monthly	**Feb-05**	7,500	valuers, property advisors and analysts		2005 Case Studies
73	**Construction Contractor**	magazine	monthly	**Feb-05**	8,100	contractors, suppliers	2 articles: **Must Innovate to Succeed** and **Innovators Step Forward**	2005 Case Studies ; Survey Results
72	**EcoLibrium (AIRAH Journal)**	journal	monthly	**Feb-05**	4,200	refrig, air con, heating contractors, suppliers	**Innovation trends revealed**	Survey Results
71	**Property Australia**	magazine	monthly	**Feb-05**	10,000	property developers	**Innovate or perish**	Survey Results
70	**FM Magazine Website**	website		**Feb-05**		facility managers	**Construction Innovators- please step forward**	2005 Case Studies
69	**Engineers Australia Civil Ed**	magazine	monthly	**Jan-05**	20,000	engineers	**Construction Innovators**	Survey Results
68	**InnovationXchange Network**	website		**Jan-05**		innovators	**QUT BRITE Innovation Survey Seeking Construction Innovators**	2005 Case Studies

	Publication	Publication Type	Frequency	Publication Date	Circulation	Audience	Title of Article	
67	**CCF Newsletter Qld**	email		**Jan-05**	1,054	civil contractors		2005 Case Studies
66	**Australian Property Journal**	journal	quarterly	**Jan-05**	7,500	valuers, property advisors and analysts		Case Study 1
65	**AAPA key members**	email from CEO		**Jan-05**	30	key members	**Search for Construction Innovators, MR attached**	2005 Case Studies
64	**ARF e-newsletter**	e-newsletter	3-4 weekly	**Jan-05**	1,000	ARF members		2005 Case Studies
63	**AIQS national e-newsletter**	e-newsletter	weekly	**Jan-05**	3,000	quantity surveyors		2005 Case Studies
62	**ACIF executive**	email		**Jan-05**	12	executives of ACIF members		2005 Case Studies
61	**AIRAH enews**	e-newsletter	?monthly	**Jan-05**	2,500	members and industry		2005 Case Studies
60	**ConstructionEquipmentNews.net**	daily online news service	daily	**Jan-05**	2,000	contractors, suppliers	**Innovative contractors asked to stand up**	2005 Case Studies
59	**e-news RAIA**	e-newsletter	monthly	**Jan-05**	8,000	architects	**Construction Innovators**	2005 Case Studies
58	**ConstructionEquipmentNews.net**	daily online news service	daily	**Dec-04**	2,000	contractors, suppliers	**Great Innovations**	Survey Results
57	**Contact**	magazine	4/year	**Dec-04**	5,500	all licensed elec & comms contractors in Qld		Survey Results
56	**ACEA Newsletter QLD**	newsletter	monthly	**Dec-04**	240	consulting engineers	**BRITE innovation survey results - High innovators show the way**	Survey Results

	Publication	Publication Type	Frequency	Publication Date	Circulation	Audience	Title of Article	
55	**CRC Update Newsletter**	e-newsletter	bi-monthly	**Dec-04**	3,000	all industry	**BRITE innovation survey results - High innovators show the way**	Survey Results
54	**Contractor**	magazine	monthly	**Dec 04/Jan 05**	11,000	contractors, suppliers	**Innovate or perish - full page - opinion column**	Survey Results
53	**AIQS Journal**	journal	quarterly	**Dec-04**	4,500	quantity surveyors		Survey Results
52	**Glass Australia Magazine**	magazine	monthly	**Dec-04**	3,000	glaziers, manufacturers & suppliers	**Industry News - How innovative are you?**	Survey Results
51	**RAIA Website**	website		**Nov/Dec 04**		architects	**2004 BRITE innovation survey report - High innovators in construction**	Survey Results
50	**Aus R&D Review**	journal	monthly	**Nov-04**	1,680	policy makers; insititutions/unis; 8 readers/copy, 840 circ	**Survey of construction industry innovation**	Survey Results
49	**Building Australia**	magazine	8 issues/yr	**Nov-04**	15,602	bldrs, contrs, archs, designers, engs	**2004 BRITE innovation survey results** - 3 pages	Survey Results
48	**ECA Qld ebulletin**	email	monthly	**Nov-04**	130	electrical & comms contractors - majors only		Survey Launch
47	**DMR List of Prequalified Contractors & Consultants**	email message		**Nov-04**	400	DMR pre-qualified road & bridge consultants & contractors	**Launch of Industry Innovation Survey Findings**	Survey Launch
46	**ACIF Update Newsletter**	e-newsletter	monthly	**Nov-04**	12	executives of ACIF members		Survey Launch
45	**ACEA Newsletter QLD**	newsletter	monthly	**Oct/Nov 04**	240	consulting engineers		Survey Launch

	Publication	Publication Type	Frequency	Publication Date	Circulation	Audience	Title of Article	
44	**AIQS e-newsletter**	e-newsletter		**Oct/Nov 04**	100	quantity surveyors		Survey Launch
43	**AIRAH Weekly Update**	e-newsletter	weekly	**mid Oct 04**	500	500 in Qld; 2,500 nationally		Survey Launch
42	**AMCA e-Newsletter**	e-newsletter	fortnightly	**mid Oct 04**	22	air con & mechanical contractors		Survey Launch
41	**CCF Newsletter Qld**	e-Newsletter	monthly (at least)	**Oct-04**	1,054	civil contractors		Survey Launch
40	**ASI electronic bulletin**	email from CEO to members		**mid Oct 04**	20	steel manufacturers		Survey Launch
39	**AAPA**	post		**late Oct 04**	10	Qld asphalters		Survey Launch
38	**DPW Prequalified Contractors & Consultants**	email message		**Oct-04**	550	DPW pre-qualified building consultants & contractors	**BRITE Innovation Survey Launch Invitation - 17 November 2004**	Survey Launch
37	**AGGA**	email message		**mid Oct 04**	500	glaziers, manufacturers & suppliers		Survey Launch
36	**CRC ebulletin**	email	monthly	**Nov-04**	2000	CRC contacts database	**BRITE Survey Launch**	Survey Launch
35	**DMR Interface**	magazine	9/yr	**Oct-04**	8,500	staff of QDMR and Transport	**Providing expert advice on an Australian First**	Case Study 5
34	**DPW Contact**	magazine	monthly	**Oct-19**	3,600	staff of QDPW	**BRITE light shines on Public Works**	Case Studies 1 & 2
33	**National Building News Monthly**	magazine	monthly	**Sep-04**	7,500	bldrs; developers; architects; ind bodies	**Addressing Sustainability without Compromise**	Case Study 2
32	**Roads Magazine**	magazine	bi-monthly	**Aug/Sep**	5,000	road consultants & contractors, suppliers	**3 Articles: Motorway alliance drives performance improvement, Radar helps solve bridge capacity issue; First fibre-reinforced polymer deck bridge**	Case Studies 3, 5 (partly) ,6

	Publication	Publication Type	Frequency	Publication Date	Circulation	Audience	Title of Article	
31	**Climate Control News**	magazine	monthly	**Aug-04**	7,000	heating, ventilation, air con contractors & suppliers	**HVAC Innovations Lead to Big Savings**	Case Study 1
30	**National Building News Monthly**	magazine	monthly	**Jul-04**	7,500	bldrs; developers; architects; ind bodies	**Addressing sustainability without compromise** headline article in Building Innovations section; 2 pp	Case Study 1
29	**EcoLibrium (AIRAH Journal)**	journal	monthly	**Jul-04**	4,200	refrig, air con, heating contractors, suppliers	**Lessons in Innovation**; 2 pp	Summary, Case Studies
28	**Building Australia**	magazine	8 issues/yr	**Jul/Aug**	15,602	bldrs, contrs, archs, designers, engs	**Performance-based building codes and fire engineering yield innovative design solution**	Case Study 4
27	**National Building News Monthly**	magazine	monthly	**Jun-04**	7,500	bldrs; developers; architects; ind bodies	**Innovation survey - have your say** first article in Building Innovations section	Survey
26	**Concrete in Australia**	magazine	quarterly	**Jun-04**	1,600	engineers and other concrete professionals	**Ground penetrating radar finds defects in bridge beams**	Case Study 6
25	**DMR Interface**	magazine	9/yr	**Jun-04**	8,500	staff of QDMR and Transport	**Motorway alliance drives performance improvement**	Case Study 3
24	**SDI website (mag)**	website		**Jun-04**		business leaders, multipliers, clients of SDI's centres and events	**Bright idea for Construction - Energy Saver**	Case Study 1, Launch
23	**SDI Magazine**	magazine	quarterly/bi-annual	**Jun-04**	10,000	business leaders, multipliers, clients of SDI's centres and events	**Bright idea for Construction - Energy Saver**	Case Study 1, Launch
22	**Engineers Media**	website		**May-04**		engineers	**Detecting Defects in Concrete**-subheading in feature called **Concrete**	Case Study 6
21	**Engineers Australia Civil Ed**	magazine	monthly	**May-04**	20,345	civil structural engineers	**Detecting Defects in Concrete**-subheading in feature called **Concrete**	Case Study 6
20	**ACIF Update Newsletter**	e-newsletter	monthly	**May-04**	12	executives of ACIF members	**BRITE Innovation Survey Coming Your Way in April/May 2004**	Survey

	Publication	Publication Type	Frequency	Publication Date	Circulation	Audience	Title of Article	
19	**RAIA e-news**	e-newsletter	monthly	**Apr-04**	8,000	80% of Institute's members	**Innovation in Construction Case Studies**	Case Studies
18	**NECA communications**	newsletter	monthly	**Apr-04**	5,000	national; electricians, communications elecs	**Construction Innovation**	Case Studies
17	**Australian Glass & Glazing**	magazine	monthly	**Mar-04**	3,000	glaziers, manufacturers & suppliers	**Industry survey into adoption of best practice**	Survey
16	**Building Australia**	magazine	8 issues/yr	**Mar-04**	15,602	bldrs, contrs, archs, designers, engs	**CRC promotes innovation**	Case Studies 1 and 2
15	**Construction Contractor**	magazine	monthly	**Mar-04**	8,100	contractors, suppliers	**Improving performance through innovation**	Case Studies
14	**QUT BeeLine**	magazine	bi-annual; Mar & Sep	**Mar-04**	12,500	BEE alumni overseas & Aus; industry	**BRITE Project shines light on innovation**	Case Studies
13	**ConstructionEquipmentNews.net**	daily online news service	daily	**Feb-04**	2,000	contractors, suppliers	**Innovation the key for business growth**	Launch
12	**AIRAH Weekly Update**	e-newsletter	weekly	**Feb-04**	2,500	500 in Qld; 2,500 nationally	**no title- see email from Stuart 21/4**	Launch
11	**CSIRO Innovations Magazine**	e-magazine	monthly	**Feb-04**	2,300	researchers	**BRITE Innovations for Building & Construction**	Case Studies
10	**ACIF Update Newsletter**	e-newsletter	monthly	**Feb-04**	12	executives of ACIF members	**BRITE Case Study Launch**	Launch
9	**AIQS Website**	website		**Feb-04**	website	quantity surveyors	**Innovating Successfully - Construction Innovation BRITE Case Study Launch**	Launch
8	**CRC Bulletin**	e-newsletter	monthly	**Feb-04**	300	CRC Intranet people	**BRITE Launch Thurs 26 Feb**	Launch
7	**CCF Newsletter Qld**	e-Newsletter	monthly	**Feb-04**	1,054	civil contractors	**BRITE Innovation Survey Coming Your Way in April/May 2004**	Survey
6	**CCF Newsletter Qld**	e-Newsletter	monthly	**Feb-04**	na	civil contractors	**BRITE can Improve Your Innovation Performance**	Case Studies
5	**Qld Govt Website- Ministerial Media Statements**	website		**Feb-04**	website	all industry	***Media Release*- Queensland Government Launches BRITE Project**	Launch
4	**Year of the Built Environment 2004 Qld Website**	website		**Feb-04**	website	all industry	**Launch of the national BRITE project- calendar entry**	Launch
3	**ACEA Newsletter QLD**	newsletter	monthly	**Dec-03**	240	consulting engineers	**BRITE can improve your innovation performance**	Case Studies

	Publication	Publication Type	Frequency	Publication Date	Circulation	Audience	Title of Article	
2	**CRC Newsletter**	e-newsletter	bi-monthly	**Nov-03**	2,500	all industry	**BRITE surveying industry innovators early 2004**	Survey, Case Studies
1	**CRC Website**	website		**Nov-03**	website	all industry	**6 Case Studies**	Case Studies

Appendix C - FORTUNES OF THE BRITE 2003 INNOVATIONS

Introduction

This report reviews the diffusion of innovations profiled by the BRITE Project of the CRC for Construction Innovation, in 2003. A survey of the original interviewees was conducted to determine whether the innovations continue to perform well, and whether they have been adopted on new projects. Eighteen interviewees across the six case studies provided information by phone or email during August and September 2005. Five interviewees represented small independent firms. Requests by the researchers for follow-up information elicited a positive response from all the case study participants.

In general, the innovations described in the case studies are performing successfully two years after they were first documented by BRITE, and they have been further diffused since the BRITE activity. In some cases the innovation has been directly replicated, while in many others the innovation's principles have been reapplied on new projects. In all cases, the utility of the innovation has been improved over time. The participants reported that there have been direct benefits to their organisations and the industry as a result of diffusion of information on the innovation by BRITE.

Case Study No.1 - William McCormack Place, Cairns - Thermal Wheel and Tank

The achievement of an Australian Building Greenhouse Rating (ABGR) /Sustainable Energy Development Authority (SEDA) five star energy rating in a commercial office building at William McCormack Place, Cairns, demonstrated the capabilities of new energy efficient air conditioning innovations in the extreme conditions of a tropical location. The innovations achieved considerable energy savings, for no extra cost over conventional office building construction.

The Queensland Department of Public Works (QDPW) has continued to audit energy performance on William McCormack Place through the ABGR scheme. The building achieved a further five star rating for the 12 months to August 2004 (with reduced emissions compared to the previous year) and QDPW are currently carrying out the audit for the 12 months to August 2005.

Graham Messenger of QDPW reports continuing satisfaction with the performance of the building. While it is not practical to repeat the specific innovations developed for the project because of the individual nature of a building's needs, the technologies form part of QDPW's knowledge base. The concept of the thermal wheel is regarded as particularly useful in tropical locations, although there have been no further applications by QDPW to date.

The mechanical and electrical engineers for the project were MGF Consultants (NQ) Pty Ltd. Graeme Standfield, director of MGF, reports that since the initial achievement of the five star rating, the performance of the building has improved, despite the now more rigorous ABGR /SEDA formulae. Many of the features from William McCormack Place are now regularly included in MGF's larger scale office and commercial developments. The project learning from William McCormack Place contributes to the design of new installations. Over the past 12 months Mr Standfield has noticed increased adoption of the thermal storage tank. It has been observed in other consultants' work, as well as the Department of Public Work's own designs. The thermal heat recovery wheel is a feature of MGF's designs - the principles are now well known and the idea is being adopted by others.

MGF are continuously developing other innovative solutions, based on learnings from the previous project. They have come up with a system of reheat for special humidity control without resorting to the usual electric duct heaters for a herbarium at James Cook University in Cairns. This project is still in the planning stage but appears promising. A major thermal energy storage system is also proposed for JCU, which would extend the building's capacity by about 35 to 40% without adding any further central refrigeration systems.

Case Study No.2 - Clever Planks at Suncorp Stadium, Brisbane

The composite precast plank and steel beam system developed for the new Lang Park Stadium (Suncorp) was able to reduce cost and time by eliminating problematic wet trades involved in in-situ reinforced concrete. Manufacturing the planks in a factory achieved a higher level of quality control than is possible on a building site. Significant Occupational Health and Safety (OH&S) gains were also achieved in the more controlled environment of the precast yard. These benefits have meant that composite precast planks and steel beams are now considered a viable alternative to in situ concrete for similar applications.

Ian Ainsworth, Manager of Building Structures with Arup Brisbane, says that "clever planks used in combination with steel beams form a floor system that is potentially suitable for all types of building construction: multi-storey residential, hotels, sports stadia, public buildings, commercial offices, education buildings, airport terminals, hospitals etc." Mr Ainsworth stressed that the main benefits of the system are that "it does not require the formwork or propping that conventional reinforced concrete requires".

No performance difficulties, no call-backs and no problematic cracking were experienced at Suncorp Stadium and the installation is regarded by the participants as very satisfactory. Arup have not used the clever planks as yet in any other built projects, however, they are being considered in the preliminary design phase for several new projects.

Hossein Shamsei of Quikcell Technologies, manufacturers of the clever planks, confirmed that no problems have been experienced with the clever plank installation at Suncorp Stadium. His company is continuing to manufacture the planks and he considers that they have many possible applications. They are currently being used for the Macarthur Central Project, a shopping and commercial office building, on the corner of Queen and Edward Streets in Brisbane. Mr Shamsei believes that economies of scale will occur when the system becomes more well-known and is therefore used on a greater variety of projects.

Case Study No.3 - Alliance contracts for the Port of Brisbane Motorway

The Port of Brisbane Motorway Alliance was a ground breaking step in relationship contracting in the Australian construction industry. The project's successful delivery has been followed by considerable expansion in the use of various kinds of alliance contracting. This is particularly true in Queensland, which leads in the use of alliance contracting across Australia, but is also increasingly true of other states. All the project participants from POBM have been involved in further alliances since and are positive about the results that can be achieved.

Darren Weir of Leighton Contractors reports that Leighton has been involved in a number of alliance contracts since POBM. These include the Seawall for the Port of Brisbane, the Wivenhoe Alliance with Southeast Queensland Water, the Barkley Highway Alliance with the Queensland Department of Main Roads and the Inner Northern Busway Alliance with Queensland Transport. Mr Weir says that Leighton believe that each of these alliances have achieved great outcomes for all participants including the client. The projects have "demonstrated excellent value for money by achieving better than expected outcomes in many key result areas".

Dave Rankin, Transport Engineering Executive of Parsons Brinckerhoff Australia Pty Ltd reports that his company has been involved in three alliance contracts since the POBM.

These were a hydro electric project in New Zealand which did not go ahead, the Port of Brisbane Seawall Alliance and the Calder-Tullamarine Interchange Alliance with Vic Roads. Parsons Brinckerhoff is very happy with alliance contracts and the company believes that they are often the best way to deliver projects.

The Managing Director of Coffey International Ltd, Roger Olds, says that his company has now been involved with 6 wins and 3 losses on alliance bids since POBM and they see it as "a key differentiation" between the company and its competitors. Coffey have also used the principles of alliancing in other projects and Mr Old believes that he has brought the culture of alliancing back into his company's group. He says that alliances are beneficial in direct terms "but of even more value is what they have allowed us to do through a cultural shift in Coffey".

The project director on the POBM, David Wright, is now working on the Gateway Upgrade project. He feels that the POBM alliance delivered outstanding outcomes. He now believes that a process involving a combination of alliancing with some competitive aspects would be beneficial. The experience of working on an alliance project "re-emphasised the importance of common goals, strong relationships, risk/reward mechanisms" in project delivery.

Mike Swainston from QDMR believes that pure alliance contracts are still seen as the preferable form. However, in the case of the Tugan Bypass, a critical project deadline has resulted in the use of a hybrid alliance system. Here, two teams are taken through to the target cost stage. This is being trialled because time restrictions caused by the extension of the Gold Coast Airport runway mean that it would not be possible to go back and negotiate with a new team if difficulties with the selected team were encountered. This hybrid system is being strongly advocated by some consultants and it remains to be seen how widely it is used. In terms of pure alliance contracts, the QDMR has done a great deal of work in strengthening the 'value for money' aspects in order to ensure that projects continue to be delivered at a competitive cost, compared with more traditional systems.

Case Study No.4 - Fire Safety Engineering at the National Gallery of Victoria, Federation Square

Driven by the move to performance based building standards, the discipline of Fire Safety Engineering has undergone a rapid expansion in the past few years. The use of unprotected steel in the new gallery space for the National Gallery of Victoria (NGV) in Federation Square, Melbourne is an example of this expansion. Performance based solutions to fire safety issues are by nature specific to the project where they are developed, however, the concepts and processes for bare steel are transferable between projects.

The NGV has just undergone a complete annual fire test for compliance with AS1851 Maintenance of Fire Protection Systems and Equipment and the Building Code of Australia. Full sign off was achieved. There have been very few problems with the installation. On the rare occasions that a smoke detector is activated, a quantitative risk assessment is done which relies on information from the original fire engineered solution for the building.

David Barber of Arup Fire reports that the unprotected steel innovation used as part of the NGV has been used in various forms on several other projects in Melbourne, including high-rise commercial buildings such as the Southern Cross Building, the Herald and Weekly Times Building, Urban Workshop in Lonsdale Street and the Southern Cross Railway Station (formerly Spencer Street Station). Unprotected steel in a different form was also used in the Olympic Stadium at Homebush in Sydney.

Performance Based Fire Engineering is becoming commonplace across Australia for non-domestic projects. Difficulties sometimes arise when clients or developers expect that a performance based solution designed for one application can be copied for another situation. This is not the case, as each application must be considered separately. Performance based solutions do not automatically transform into new 'deemed to satisfy' solutions. Another

problem which can occur is that after transfers of building ownership, the new owners may be unaware or lose touch with the maintenance schedule that made the performance based solution work. There is currently little or no inspection of these maintenance schedules. In addition, both insurers and valuers find it hard to assess the consequences of performance based fire safety engineering, however, this difficulty is likely to ease as fire engineered solutions become more common.

Case Study No.5 - Fibre Reinforced Polymer (FRP) bridge deck at Coutts Crossing, NSW

The Queensland Department of Main Roads has 450 timber bridges under its authority which are between 40 and 100 years old. Local authorities have a further 3,000 timber bridges of a similar age. The cost of replacing these with concrete bridges would be enormous and this fact has sparked interest in innovations like Fibre Reinforced Polymers (FRP) as a means of extending their life. As a consequence research is continuing into several applications of FRP in bridges, both similar to and different from the FRP deck used at Coutts Crossing Bridge near Grafton in northern NSW.

The University of Southern Queensland Centre for Fibre Composites Design and Development (FCDD) has continued its involvement with the design of FRP bridges and replacement bridge girders. Possibly as a consequence of this, the use of FRP in bridges has been more frequent in Queensland than the rest of Australia.

John Fenwick of Queensland Department of Main Roads reports that there has been considerable use of FRPs in bridge construction since the Coutts Crossing Bridge. A road bridge has been completed at Blackbutt north of Toowoomba and a 16 metre span bridge is being designed at Nanango (also north of Toowoomba) for a heavy load route to a power station. The Nanango Bridge is scheduled for construction in 2006. The cost of FRP bridges is still higher than for a concrete or steel bridge but economies of scale are expected to make FRP more competitive in time.

FRP footbridges have been produced for National Parks in situations where their light weight means they can be carried in to otherwise inaccessible locations. Also being investigated is the use of FRP girders to replace deteriorated timber beams in old timber bridges. These new beams extend the life of the existing bridge till it can be replaced. Another system involving FRP beams and a plywood deck is being used at Somerset Dam to replace an old timber bridge. This is expected to be a new showcase project. The best method of detailing to keep the deck drained and prevent water penetration through the plywood fixings and joints is currently being determined. The use of FRP is also proving successful for spin-off products like outdoor civic furniture, tiles and bench tops.

The prototype designers for the Coutts Crossing Bridge, Wagner's Composite Fibre Technologies Pty Ltd have successfully used the technology in Australia and overseas. Neil Wagner, Company Director, reports that his company has produced two FRP pedestrian bridges for the Northern Territory; two weighbridges, one for the Northern Territory and one for Far Eastern Russia; and a road bridge for Erie County in upstate New York, with another road bridge currently being built in the US. The company won the American Public Works Association, Project of the Year Award for its 'state of the art' hybrid material bridge deck.

In contrast, in NSW the Roads and Traffic Authority has not used the technology since Coutts Crossing. According to Gordon Chirgwin, Manager, Bridge Policy, Standards and Records, this is mainly because of difficulties with intellectual property. There are no current plans for similar bridges in NSW and Mr Chirgwin says "FRP/Concrete composite decks in the manner of Coutt's Crossing will more likely be used on rehabilitation projects where weight is an issue", rather than becoming standard practice.

Case Study No.6 - Ground Penetrating Radar (GPR) to detect bridge defects in Cattle Creek Bridge, Queensland

The use of Ground Penetrating Radar to detect defects in the Cattle Creek Bridge has had a considerable ongoing effect on the Queensland bridge building industry.

GPR showed that polystyrene void formers had shifted during the concrete pour in the bridge, resulting in inadequate cover in some places. Considerable cost was involved in the repair of these defects. Safety was not compromised by the defects found in the bridge at Cattle Creek because deterioration would have been evident during inspection before any catastrophic failure occurred. However the lifespan of the structure might have been reduced by insufficient concrete cover.

Formerly concrete structures counted as a “special process” under ISO 9000 Quality Assurance programs, that is, they could not be inspected except for external dimensional tolerances. Now they can be inspected and this has shifted the goal posts for all concerned. Contractors are now aware that a technology is available that can image the inside of concrete structures.

At the Queensland Department of Main Roads, a more stringent inspection process for concrete pours has been put in place as a result of the problems experienced with Cattle Creek Bridge and consequently it is not considered necessary to check all concrete bridges with the technology. Lex Van Der Staay of QDMR reports that if a bridge shows signs of deterioration during the regular inspection program then it is anticipated that the GPR technology would be used to check its status. QDMR has used the GPR technology for bridge inspection only once since the Cattle Creek Bridge, to check several structures on the M1 between Brisbane and the Gold Coast.

However, the Cattle Creek Bridge episode has provided a boost to the concept of remote sensing and this has changed the rules of the game for the industry generally.

Richard Yelf of Georadar Research reports a considerable growth in the use of the technology since the Cattle Creek Bridge. He has used the technology on 18 Australian bridges since Cattle Creek. In one case, the technology proved very beneficial to a small bridge building company as they were able to identify the specific areas in need of restoration rather than remediating the whole project at a much higher cost. In addition, the technology has been used to inspect bridges built in the 1960s and 1970s where construction process details were not known. These structures were checked, their construction form confirmed and their present condition assessed. Further, there has been widespread international interest in the technology and consequently Mr Yelf was invited to give a guest address at the 10th International Conference on Ground Penetrating Radar (GPR 2004) in Delft, Netherlands last year.

Conclusion

Taken together, the first round of BRITE case studies illustrate the diversity of the innovation process and its ongoing nature. Both organisational innovations like Alliance Contracts and technological innovations like Ground Penetrating Radar can have considerable impact beyond the project where they are first used. Rapid uptake of an innovation by the industry generally is an indication of success, but not an essential one. Some innovations are very specific to the particular circumstances of the project and consequently they are not directly replicable but they may nevertheless provide lessons which are useful in related areas and for similar problems. All the case study participants who were contacted reported positive feedback from the BRITE case study brochures and were keen to see the continuation of the diffusion process for innovation stories.

Interviewees for 2003 'Fortunes' Follow-Up Report

Table C.1 Interviewees for 2003 'Fortunes' Report

Case Study Number and Full Project Title	Short Case Study Title	Case Study Interviewees	Title/Address	Date contacted	SME
1 Outstanding Whole-of-Life Gains Without Higher Up-front Costs	McCormack Place and Reduced Energy Costs	Graham Messenger	*Acting Manager* – Portfolio Branch Building Division, Qld Dept of Public Works GPO Box 2457, Brisbane QLD 4001	21/09/05	No
		Graeme Standfield	*Director* – MGF Consultants (NQ) PO Box 797N, North Cairns QLD 4870	30/08/05	Yes
2 Concrete Planking Innovation Saves over $300,000 on Major Sports Stadium	Clever Planks	Hossein Shamsai	*Managing Director* Quickcell Technology Products Pty Ltd Lot 3 Beaudesert-Boonah Rd, Bromelton QLD 4285	26/08/05, 30/08/05	Yes
		Ian Ainsworth	*Manager Building Structures* – Arup Brisbane Level 4, Mincom Central 192 Ann Street, Brisbane QLD 4000	26/08/05, 29/08/05	No
3 Motorway Alliance Drives Performance Improvement	Port of Brisbane Motorway Alliance	David Wright	*Project Director* – Port of Brisbane Motorway Queensland Department of Main Roads Level 2, Dickens St, Spring Hill QLD 4000	2/09/05	No
		Dave Rankin	*Transport Engineering Executive* Parsons Brinkerhoff Australia Limited Level 12, 348 Edward St, Brisbane Q 4000 GPO Box 2907 – Brisbane QLD 4001	30/08/05	No
		Laurie Voyer	*General Manager* – Northern Region Leighton Contractors Australia PO Box 288, Toowong QLD 4066	passed on to DW	
		Darren Weir	Leighton Contractors Australia PO Box 288, Toowong QLD 4066	1/09/05	No
		Roger Olds	*Managing Director* – Coffey International Ltd 16 Church Street, Hawthorn VIC 3122	29/08/05	No
		Mike Swainston	*Principal Policy Officer* – Queensland Department of Main Roads Level 2, Dickens St, Spring Hill QLD 4000	26/09/05	No
4 Performance-Based Building Codes and Fire Engineering Yield Innovative Design Solution	Fire Engineering	David Barber	*Associate* – ArupFire, Risk & Security Level 17, 1 Nicholson Street, Melbourne VIC 3000	30/08/05, 6/09/05	No
		Geoff Pascoe	*Manager* – Operations and Development Federation Square Management Pty Ltd Corner Swanston & Flinders Sts, Melbourne 3000	passed on to NMG	
		Noel Mangan-Georgiou	Building Services Manager Federation Square Management Pty Ltd Corner Swanston & Flinders Sts, Melbourne 3000	6/09/05	Yes

Case Study Number and Full Project Title	Short Case Study Title	Case Study Interviewees	Title/Address	Date contacted	SME
5 Australia's First Fibre-Reinforced Polymer Bridge Deck on the Road Network	Coutts Crossing FRP Bridge	Louise McCormick-Chandler	*Engineer* – Bridge Design Queensland Department of Main Roads GPO Box 1412, Brisbane 4001	Moved to new position in Darwin	
		John Fenwick	*Engineer* – Bridge Design Queensland Department of Main Roads GPO Box 1412, Brisbane 4001	5/09/05	No
		Neil Wagner	*Company Director* – Wagners PO Box 151, Drayton North QLD 4350	6/09/05	Yes
		Rod Oates	*Manager* – Bridge Rehabilitation Projects Bridge Section, RTA	retired	
		Craig Gibbons	*A Manager* - Bridge Rehabilitation Projects Bridge Section, RTA Technical Services Roads and Traffic Authority, New South Wales PO Box 3035, Parramatta NSW 2124	6/09/05	No
		Gordon J. Chirgwin	Manager, Bridge Policy, Standards & Records Bridge Section, RTA Technical Services Roads and Traffic Authority, New South Wales PO Box 3035, Parramatta NSW 2124	7/09/05	No
6 Ground Penetrating Radar Finds Defects in Bridge Beams	Cattle Creek Radar Bridge	Tony Elgar	*Principal Engineer* – (Contracts) Mackay Queensland Department of Main Roads, Mackay	29/08/05	No
		Richard Yelf	*Managing Director* – Georadar Research Pty Ltd 412 Eastbank Road, Coramba Coffs Harbour, NSW 2450	8/09/05	Yes
		Lex Van Der Staay	*Regional Advisor* – Technical Services Central Queensland Regional Office Queensland Department of Main Roads	5/09/05	No

Appendix D - 2005 INTERVIEWEE DETAILS

Table D.1 2005 Interviewee Details

Case Study Number and Full Project Title	Case Study Interviewees	Title/Address	Email	Phone
No 7: Managing Stormwater with Storage Gutters and Infiltration	Frank Smith	Managing Director Rainsaver Services Australia 9 Rothesay St MEADOWBANK NSW 2114	franksmith@rainsaver.com.au	T (02) 9807 7595 F (02) 9807 7598
	Diana Kureen	(Formerly) Bushland Environment Officer Hunters Hill Council (Now) Environmental Officer Upper Parramatta River Catchment Trust PO Box 3720 (Level 1 Macquarie Tower, 10 Valentine Ave) PARRAMATTA NSW 2124	dkureen@uprct.nsw.gov.au	T (02) 9891 4633 F (02) 9689 2537
	Don Cottee	Manager Public Works and Infrastructure Hunters Hill Council PO Box 21, HUNTERS HILL NSW 2110	pwimanager@huntershill.nsw.gov.au	T (02) 9879 9401-direct F (02) 9809 7338
	Palitha De Silva	Public Works and Infrastructure Hunters Hill Council PO Box 21, HUNTERS HILL NSW 2110	assets@huntershill.nsw.gov.au	T (02) 9879 9400 F (02) 9809 7338
	Prof John Argue	Adjunct Professor Urban Water Resources Centre School of Natural and Built Environments University of South Australia MAWSON LAKES SA 5095	John.Argue@unisa.edu.au	T (08) 8302 3131 T (08) 8379 6272 (home) F (08) 8302 3386

	Dr Chris Walsh	CRC for Freshwater Ecology Water Studies Centre Monash University, Clayton Vic 3168	Chris.Walsh@sci.monash.edu.au	T (03) 9905 4091 F (03) 9905 4196 0438 32 4390

No 8: Saving Site-Remediation Costs	Phillip Marsh	Managing Director Marsh Civil (Engineering Contractor) Lot 558 Valencia Way Maddington WA 6109	pmarsh@marshcivil.com.au	08 94599242 0418 915 083
	Brendan Hurrell	Project Manager Marsh Civil (Engineering Contractor) Lot 558 Valencia Way Maddington, WA 6109	bhurrell@marshcivil.com.au	08 94599099 0419 900721 F 08-9493-2787
	Greg Milne	Senior Civil Project Engineer Wood and Grieve (Engineering Consultant/Contract Superintendent) 16 Altona St. West Perth WA 6005	gm@wge.com.au www.wge.com.au	08 9321-9925 0418-959-661 07180959661 (??)) F 08-9481-1724
	Scott Bird	Managing Director ENV Australia, Level 7, 182 St Georges Tce, Perth WA 6000 PO Box 7480, Cloisters Square, Perth WA 6850	scott.bird@env.net.au www.env.net.au	08 9289-8360 0419-405-341 F 08-9322-4251
	John Fisher	Project Manager Clifton Coney Group Level 1, 50 Subiaco Square Subiaco WA 6008 PO Box 990, Subiaco, WA, 6008	jfisher@cliftonconey.com www.cliftonconey.com	08 9381 6288 F 08-9381-6277 0438 905 056
	Susan Gill	Communications Coordinator East Perth Redevelopment Authority PO Box 6828 East Perth WA 6892	SusanG@epra.wa.gov.au	Ph: (08) 9222 8000 F: (08) 9325 5016 Mob: 0419 036 257
	Brian Jones	Executive Manager, Engineering/Waste Management Services Eastern Metropolitan Regional Council EMRC Administration 1st Floor Ascot Place, 226 Great Eastern Hwy BELMONT WA 6104	brian.jones@emrc.org.au PO Box 234, BELMONT WA 6984	(08) 9424 2224 0417-923-107 F (08) 9277 7598

Case Study Number and Full Project Title	Case Study Interviewees	Title/Address	Email	Phone
No 9: Post Tensioned Steel Trusses for Long Span Roofs	Murray Ellen	Director S-Squared Corporation Pty Ltd Suite 163/38-48 Macarthur Street ULTIMO NSW 2007	murray.ellen@s-squared.com.au	T (02) 9212 7881 F (02) 9212 0211 0438 258 988
	Jeremy Harding	Business Development Manager S-Squared Corporation Pty Ltd Suite 163/38-48 Macarthur Street ULTIMO NSW 2007	jeremy.harding@s-squared.com.au	T (02) 9212 7881 F (02) 9212 0211 0410 187 710
	Mark Smeaton	Ahrens Construction SA General Manager William Street (P.O. Box 2) Sheaoak Log, SA 5371.	msmeaton@ahrens.com.au	T (08) 8524 9045 F (08) 8524 9007 0417 817 369
	John Kleindienst	Stadium Australia Management Ltd General Manager, Assets and Technical Services Telstra Stadium Level 3 Members' Stand Edwin Flack Avenue Sydney Olympic Park NSW 2127	kleindienstj@telstrastadium.com.au	T (02) 8765 2444 F (02) 8765 2800

Case Study Number and Full Project Title	Case Study Interviewees	Title/Address	Email	Phone
No 10: Twin-Coil Air Conditioning at the Art Gallery of South Australia	Wayne Ryan	Director Air Conserve Pty Ltd 1/56 Sydenham Road Norwood SA 5067 Also, Director Air Con Design Today	Email: aircon@airconserve.com.au	Ph (08) 83633155 Fax: (08) 83639177 Mobile: 0419 971 779
	Andrew O'Connor	Managing Director A.G. O'Connor Pty Ltd, Electrical and Mechanical Engineers Level 1, 257 Sturt Street Adelaide SA 5000 Also, Director Air Con Design Today	Email: aoc@adam.com.au	Ph: (08) 84104099 Fax: (08) 84104122 Mobile: 0412804223
	Lidia Rozman-Jones	Associate Connell Mott MacDonald, Consulting Engineers 124 Waymouth Street Adelaide SA 5000	Email: rozman-jonesl@conwag.com	Ph:(08) 82314766 Fax: (08) 82314765 Mobile: 0411190799

Case Study Number and Full Project Title	Case Study Interviewees	Title/Address	Email	Phone
No 10: Twin-Coil Air Conditioning at the Art Gallery of South Australia	Daniel Rossetto	Program Manager, Government & Business Programs Energy SA Level 16, Wakefield House 30 Wakefield Street Adelaide SA 5000 GPO Box 1671 Adelaide SA 5001	Daniel.rossetto@state.sa.gov.au	ph: (08) 82265928 fax: (08) 82041880
	Syd Bower	Manager Physical Resources, Art Gallery of South Australia, North Terrace Adelaide	bower.syd@saugov.sa.gov.au Bower.Syd@artgallery.sa.gov.au *Both email addresses operational but second is more recent and now primary contact	Ph: (08) 82077018 Fax: (08) 82077071
	Keith Bleechmore	Executive Director Air Conditioning and Mechanical Contractors Association of South Australia Inc Hilton Central, 42 Sir Donald Bradman Drive, Mile End SA 5031	keithbleechmore@amcasa.com.au	Ph: (08) 8234 2899 Fax: (08) 8234 1615 M: 0419 829 234

Case Study Number and Full Project Title	Case Study Interviewees	Title/Address	Email	Phone
Extra People from the 'stakeholder group'				
No 10: Twin-Coil Air Conditioning at the Art Gallery of South Australia	Paul Davies	Executive Officer, SENRAC, SA Department for Transport, Energy and Infrastructure (DTEI) Level 19 Wakefield House 30 Wakefield St Adelaide SA 5000	paul.davies@saugov.sa.gov.au	p 08 8204 1883 f 08 8226 5523
	Rebecca Hoskin	Manager, Capital and Facilities, Arts SA SA Department of Premier and Cabinet GPO Box 2308 Adelaide SA 5000	hoskin.rebecca@saugov.sa.gov.au	p 08 8463 5425 f 08 8463 5418
	Lorenzo Morelli	Facility Manager, Facility Management SA (Department of Administrative and Information Services -DAIS) Transfield Services PO Box 171 Kilburn SA 5084	moreliil@transfieldservices.com	p 08 8343 5420 f 08 8343 5410
	Frank Parrello	SA Department of Administrative and Information Services -DAIS) GPO Box 1072 Adelaide SA 5000	Parrello.Frank@saugov.sa.gov.au	

Case Study Number and Full Project Title	Case Study Interviewees	Title/Address	Email	Phone
No 11: Better Project Outcomes with Relationship Management and 3D CAD	Mark Harris Client	General Manager South Australian Cricket Association, Adelaide Oval North Adelaide SA 5006	Email: mharris@saca.com.au Left working for SACA on 23/9/05 Now use: Tony Brock (Commercial & Events Manager) on 8300 3814 or tbrock@saca.com.au	P: (08) 8300 3805 F: (08) 82314346 M: 0438 716 328
	Mike Deare	Chief Executive, South Australia Cricket Association (SACA) Adelaide Oval, North Adelaide SA 5006	mdeare@saca.com.au; sbowels@saca.com.au (PA)	Administration: Ph: (08) 8300 3800 Fax: (08) 8231 4346
	David Hassell	Managing Principal Hassell Architects Level 5 70 Hindmarsh Square Adelaide	Email: dhassell@hassell.com.au	Ph: (08) 8203 5222
	Chris Watkins	3D Modelling Draftsman Hassell Architects Level 5 70 Hindmarsh Square Adelaide	cwatkins@hassell.com.au	Ph: (08) 8203 5222

	David Johnson	Principal Connell Mott MacDonald Level 9, 55 Grenfell Street Adelaide, 5000	Email: johnsond@conwag.com.au	Ph: (08) 82379744 Fax: (08) 82314765 Ph: (08) 82314766 (Direct)
	David Heidenreich	Hassell Architects	dheidenreich@hassell.com.au	Ph: (08) 8203 5222
	Marianne Ivey	Personal Assistant David Johnson Principal, Connell Mott MacDonald Level 9, 55 Grenfell Street Adelaide, 5000	Email: Iveym@conwag.com.au	Ph: (08) 82379744 Fax: (08) 82314765
	Mike Lester	Director of Engineering Taiyo Membrane Corporation (formerly Birdair) 570 Curtin Avenue East, Eagle Farm, Brisbane	Email:mikel@taiyomc.com	Ph: (07) 3633 5900 Fax: (07) 3633 5999 freecall 1800 777 727 M: 0411 222 550
	Connor Newble	Project Manager Built Environs Pty Ltd 200 East Terrace Adelaide	Email: connor.newble@builtenvirons.com.au	M: 0419 851 660 P: (08) 8232 1882 F: (08) 8231 1883
	Joanne Staugas	Partner, Finlaysons Lawyers (Commercial Disputes/Construction) 81 Flinders Street, Adelaide 5000 GPO Box 1244 Adelaide 5001	js@finlaysons.com.au	T (08) 8235 7400 F: (08) 8232 2944 Ph: (08) 8235 7468

Case Study Number and Full Project Title	Case Study Interviewees	Title/Address	Email	Phone
No 12: Using Recycled Tyres to Construct an Access Road Over Saturated Terrain	Tim Edwards	Managing Director, Ecoflex Australia Commercialisation 32-34 Annie St, Wickham	bruce.fletcher@csgeng.com.au	(02) 4861 5355 0412 603 216
	Tam Niven Client	Project Manager Energy Australia Pty Ltd Wickham	tniven@energy.com.au	02 4951-9407 02 4951 0111 0439-391-022
	Garry Callinan Inventor	CEO, Ecoflex Australia Pty Ltd Managing Director, Ecoflex Civil Constructions Wickham	garry@ecoflex.com.au	02 4940-0178 0413 437 503
	Collin Harvey Tyre Recycler	Managing Director C & R Tyre Recycling Pty Ltd 36 Stenhouse Dr, Cameron Park	col@ecoflex.com.au	02 4902 6777 0418 680 710
	Chris Montague Head Contractor	Construction Supervisor Keller Civil Engineers Pty Ltd Wickham	mail@kce.com.au	0418 741 748

Appendix E - BRITE IMPACT INDICATORS

There is strong evidence that BRITE has had an impact on the industry. Such evidence is reflected in the interest of the industry in BRITE's activities, revealed in a number of indicators including:

Table E.1 BRITE Impact Indicators

Indicator	Result
Phone and email inquiries received by the BRITE Project	An average of three contacts per week, usually wanting more information about the innovations profiled by BRITE, or offering innovations to be profiled
Demand from industry magazines for BRITE material	Over three years BRITE material has been published in 46 different industry publications, with 60% of these publishers using BRITE material more than once. Indeed, fifteen of the publishers have published BRITE findings on four or more occasions
Response rate to the BRITE national innovation survey	The survey conducted in 2004 covered over 1000 businesses and was the largest construction innovation survey ever conducted in this country – it elicited a response rate of 30%, which reflects strong industry interest, especially compared to a comparable effort in Singapore which yielded a response rate of only 6%
Workshop registrations	The annual workshops held by the BRITE project have each attracted over 150 registrations, again reflecting high industry interest – an analysis of registrants shows growing SME participation over time, rising from 36% of registrants in Feb 2004 to 44% in Nov 2005
Nominations to the 2005 case study program	In five months (January to May 2005) over 50 construction firms responded to the public call for innovative projects to be case studied by BRITE, of which six were selected
Uptake in industry partner organisations	QDMR and QDPW both consider BRITE outcomes as input to their evolving policies
Innovation broker role and business networking	BRITE acts as a hub connecting industry stakeholders on a weekly basis, resulting in new opportunities for innovation

The final review for the BRITE project resulted in a recommendation that industry partners obtain official quotes about BRITE impact to be used by the CRC in public documents. At the same meeting, it was also decided that STEM Partnership would be employed to conduct a survey of BRITE impact.

14. AUTHOR BIOGRAPHIES

Dr Karen Manley is a Research Fellow, School of Construction Management and Property, Queensland University of Technology and BRITE Project Leader, Cooperative Research Centre for Construction Innovation. She has many years experience as an academic and private consultant, specialising in the application of post-neoclassical approaches to the analysis of innovation and industry growth. Recently her work has involved investigation of knowledge-flows, networking, and innovation systems, to shed light on the performance of a number of industries, including the pharmaceutical and construction industries. Her most influential work adopts a national perspective on industry performance, with reports such as *The High Road or the Low Road Alternatives for Australia's Future* having considerable impact on national industry policy.

Mary Hardie is a registered architect with twenty five years experience in private practice. For the past ten years she has been a part time lecturer in the building and construction management programs at the University of Western Sydney. Research interests include Ecologically Sustainable Development, waste minimisation in construction, passive solar design and the integration of sustainable building principles with heritage building styles.

Dr Robyn Keast is a Senior Research Fellow in the School of Management (QUT) and Research Fellow in Brite Project within the (CRC-CI). Her research interests include networked service and innovation models and public sector reforms. Dr Keast's research has been applied across national and international jurisdictions and she has published extensively in international and national journals as well as a number of book chapters.