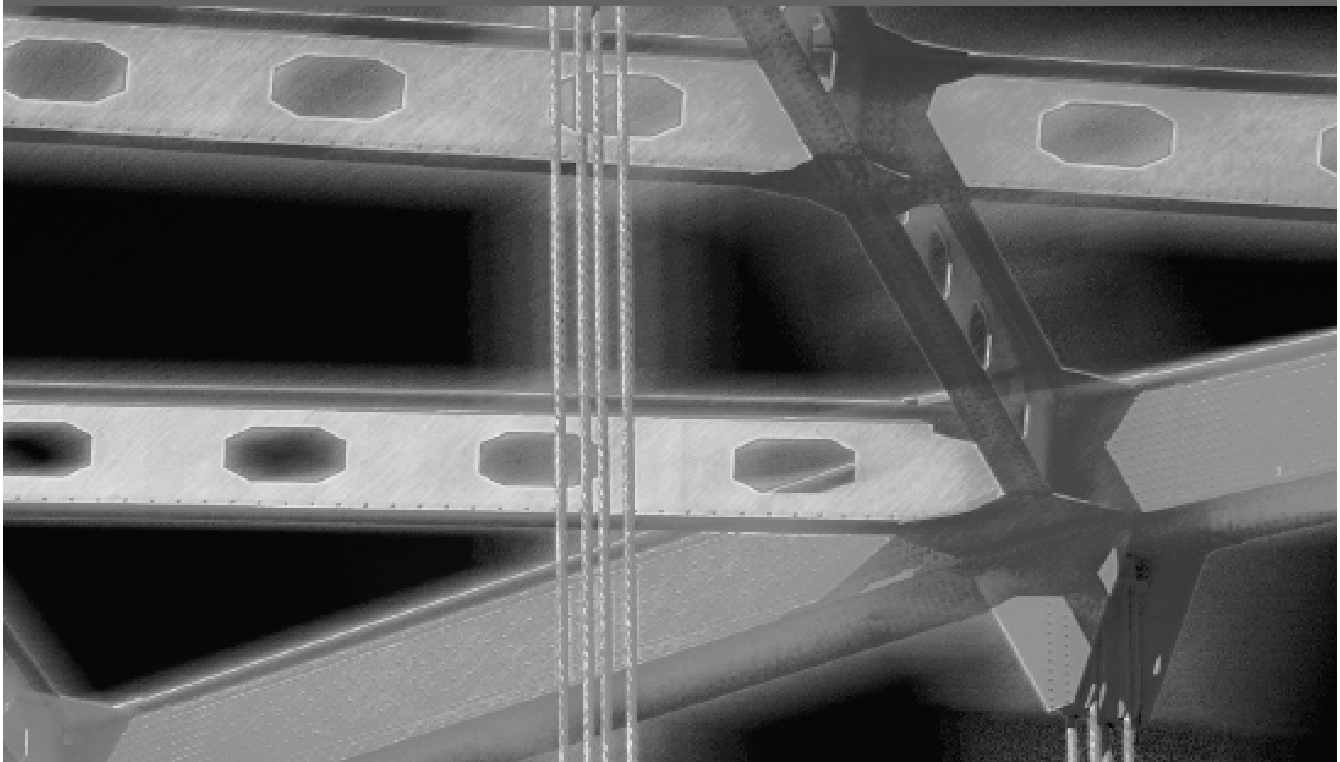
CLIENTS DRIVING CONSTRUCTION INNOVATION

BENEFITING FROM INNOVATION



Edited by Kerry Brown, Keith Hampson, Peter Brandon and Janet Pillay

CRC Construction Innovation
BUILDING OUR FUTURE

Cooperative Research Centre for *Construction Innovation*

Office: Cooperative Research Centre for *Construction Innovation*
9th Floor, L Block, QUT Gardens Point
2 George Street, Brisbane, Qld, 4000 Australia
Telephone: +61 7 3138 9291
Facsimile: +61 7 3138 9151
Email: enquiries@construction-innovation.info
Web: www.construction-innovation.info

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Contents

CONTRIBUTORS vii

FOREWORD xvi

CIB TASK FORCE 58: CLIENTS AND CONSTRUCTION INNOVATION xvii

ACKNOWLEDGEMENTS xviii

PART 1 CLIENTS DRIVING CONSTRUCTION INNOVATION

Chapter 1 Benefiting from Innovation
Kerry Brown, Janet Pillay and Keith Hampson 2

Chapter 2 Seeking Innovation: The Construction Enlightenment
Peter Brandon 5

PART 2 MEETING CLIENTS' NEEDS

Chapter 3 Innovations as Proof of Value for Money: The Horizon Alliance
Stephen O'Brien 13

Chapter 4 Combined Evaluation of Workplace Performance using Occupants' Subjective Assessment and Objective Measurement of Environmental Conditions: A case study
Brian Purdey and Mark Luther 20

Chapter 5 Streamlining Local Government: Evaluating an eGovernment initiative in south-east Queensland
Craig Furneaux, Nik Vassilev, John Burgess, Kerry Brown and Michael Ward 28

Chapter 6 Designing a Workplace that Embodies Client Values
Robert Backhouse and Steve Coster 39

Chapter 7 Satisfying Client Expectations in a Project through Innovative Procurement Routes
Adekunle Sabitu Oyegoke, Malik Khalfan, Peter McDermott and Michael Dickinson 45

PART 3 PROCUREMENT AND RISK MANAGEMENT

Chapter 8 Can Project Alliance Contracts Truly Provide Value-for-Money Outcomes?
Charles MacDonald 52

Chapter 9 The KOSMOS Programme: Stimulation of Innovations with the Right Procurement Strategy
Pascal Mousset and Carlita Vis 57

Chapter 10 The Competitive Impacts of Leveraged Training Outcomes
Siobhan Austen and Richard Seymour 61

Chapter 11 **Relationships as Risk and the Need for their Effective Management in Projects**
Graham Scott 67

Chapter 12 **Procurement Risk Management and Planning: Methods for monitoring supply markets for the public sector**
Abraham Ninan and Tony Plucknett 74

Chapter 13 **Alliances in Australia: A long-term joint venture?**
Steve Rowlinson and Fiona Yan Ki Cheung 84

PART 4 IMPROVING EFFICIENCIES THROUGH INFORMATION AND COMMUNICATION TECHNOLOGIES

Chapter 14 **'Space' at 1 Bligh: Smart and green with building information modelling**
Rodd Perey 89

Chapter 15 **Estimating Indoor Air Quality Using Integrated 3D CAD Building Models**
Selwyn Tucker, Stephen Brown, Stephen Egan, Fanny Boulaire, Lidia Morawska and Congrong He 94

Chapter 16 **Model-Based Estimating for Concrete Bridges: A feasibility study**
Kwok-Keung Yum, Thomas Froese, Guillermo Aranda-Mena, Willy Sher and Nigel Goodman 101

PART 5 CONSTRUCTION HEALTH AND SAFETY

Chapter 17 **Leaders in Safety**
Helen Marshall 111

Chapter 18 **Developers Delivering Safer Projects by Measuring What They Value**
Linda Sokolich 113

Chapter 19 **Towards Harmonisation: Accreditation schemes and construction OHS**
Janet Pillay 116

Chapter 20 **Harmonisation of OHS Regulation in Australia: An evaluation of three initiatives**
Kerry Brown, Craig Furneaux and Don Allan 120

Chapter 21 **Communication as the Catalyst for Enhanced Safety Outcomes: A multi-stakeholder perspective**
Lynette Sperling, Michael Charles, Rachel Ryan and Kerry Brown 128

Chapter 22 **Safety Culture: A multilevel assessment tool for the construction industry**
Brett Mayze and Lisa Bradley 136

Chapter 23 **The Use of Lead Indicators in Safety Culture Research: Measuring construction industry safety performance**
Don Dingsdag and Herbert Biggs 146

Chapter 24 **Development of a Practical Guide to Safety Leadership: Industry-based applications**
Herbert Biggs, Don Dingsdag and Colette Roos 154

PART 6 FACILITIES MANAGEMENT

Chapter 25 **FM Exemplar Project: Sydney Opera House**
Stephen Ballesty 159

Chapter 26 **An Exploration of BIM Opportunities at the Sydney Opera House**
Robin Drogemuller, Paul Akhurst, Richard Hough and Stuart Bull 163

Chapter 27 **Diagnostic Process Based on Fuzzy Logic for the Management of Bridges Exposed to Aggressive Environments**
Srikanth Venkatesan, Sujeeva Setunge, Tom Molyneaux and John Fenwick 168

Chapter 28 **Effective Condition Monitoring and Assessment for More Sophisticated Asset Management Systems**
Abdulkader Sharabah, Sujeeva Setunge, Ralph Godau and Chris Karagiannis 174

PART 7 INDUSTRY DEVELOPMENT

Chapter 29 **Knowledge and the Boundaries of the Firm: Implications for the construction industry**
Peter Galvin, Stephane Tywoniak and Janet Sutherland 183

Chapter 30 **Exemplars of Successful Innovation Delivery by Small and Medium Construction Enterprises**
Mary Hardie and Karen Manley 190

Chapter 31 **Climate for Enhancing Innovation Diffusion: Pathways to Improved Business Performance**
Kriengsak Panuwatwanich, Rodney Stewart and Sherif Mohamed 197

Chapter 32 **Environmental Sustainability as an Innovation Driver Among Small- and Medium-sized Construction Companies**
David Thorpe, Neal Ryan and Michael Charles 205

PART 8 SUSTAINABLE CONSTRUCTION FOR THE FUTURE

Chapter 33 **EnviroDevelopment: Inspiring and delivering sustainable developments**
Kirsty Chessher, Tanya Plant and Brian Stewart 214

Chapter 34 **Social Sustainability in the Implementation Process of Low-Energy Houses**
Wiktoria Glad 219

Chapter 35 **Developing Frameworks and Processes to Enhance Sustainability Deliverables in Infrastructure Projects**
Soon Kam Lim and Jay Yang 225

Chapter 36 **Lifecycle Assessment: The sustainability power tool**
Aruna Pavithran 230

Chapter 37 **Implementation of an Organisational Innovation: The case of partnering in Sweden**
Kristian Widén, Ola Andersson and Rasmus Johansson 235

Chapter 38 **Industry Capacity Analysis: A new methodology for public road infrastructure development in Queensland**
John Bateman 241

PART 9 BENEFITING FROM INNOVATION

Chapter 39 **Key Lessons and Conclusions**
Keith Hampson, Kerry Brown, Janet Pillay and Peter Brandon 249

INDEX 252

Contributors

Paul Akhurst

Paul Akhurst is the former Director of Facilities at the Sydney Opera House. Paul was recently involved in a CRC for *Construction Innovation* project examining facilities management as a business enabler. Titled the Sydney Opera House FM Exemplar Project, the research focused on creating solutions for managing the built environment from a digital modelling, services procurement and performance benchmarking perspective.

Don Allan

Don Allan is the Director of the Building Policy Unit of the Queensland Department of Public Works, Australia. In this capacity he is responsible for building policy and advice, government and industry relationships and industry supplier base development. Don is also a member of the CRC Governing Board and is Deputy Program Director, Program A: Business and Industry Development.

Ola Andersson

Ola Andersson is a PhD candidate in the Department of Economics at Lund University, Sweden. He also teaches in the field of economics to an undergraduate and postgraduate audience.

Guillermo Aranda-Mena

Dr Guillermo Aranda-Mena is a Research Fellow and Lecturer in the School of Property, Construction and Project Management, RMIT University, Melbourne, Australia. Guillermo's research interests include workplace architecture, organisational psychology, Internet project collaboration, multimedia training technologies, interoperability in building modelling, and eBbusiness adoption in AEC/FM.

Siobhan Austen

Dr Siobhan Austen is an Associate Professor in the Department of Economics and Finance at Curtin University of Technology, Australia. Siobhan is also the Deputy Director for the Centre for Research on Applied Economics and Co-Director of the Women in Social and Economic Research (WiSER) unit. Her current research projects include demographic change and its impacts on the labour market, particularly those examining older workers' economic security, the consequences of demographic change for women's employment, social and economic indicators, pay equity in public sector labour markets, and the effects of divorce on women's labour supply.

Robert Backhouse

Robert Backhouse is the Managing Director of HASSELL, based in Melbourne, Australia. Robert has been responsible for major projects throughout Australia and Asia. His success has resulted from working with clients ranging from large corporate projects to residential and hospitality developments. Robert's reputation in interior design is built on award winning projects and publication in leading Australian journals such as Inside, Artichoke, InDesign and Belle. He has been responsible for workplace projects including VicUrban, AGL and Maddocks where evolving organisational culture and design innovation are the driving issues. Currently, Robert is involved in workplace projects for ANZ, BHP Billiton and Suncorp.

Stephen Ballesty

Stephen Ballesty is a Director of Rider Levett Bucknall, and heads their Advisory services division. Stephen has been an active member of the Facility Management Association of Australia since 1994, active in the NSW Branch, and joining the national Board of Directors in 2001. In addition to being FMA Australia's Immediate Past Chairman,Stephen was appointed by the Australian Government as a member of the Strategic Industry Leaders Group for the FM Action Agenda in 2004 and chaired the Innovation Working Group. He currently serves as Deputy Chairman of the FM Action Agenda Implementation Board and was the CRC for *Construction Innovation* Project Leader on the FM Exemplar Project: Sydney Opera House.

John Bateman

John Bateman is the Manager of Procurement Delivery for the Program Procurement Division, Queensland Department of Main Roads, Australia. John has also worked as a lawyer in private practice, specialising in the areas of commercial law and intellectual property.

Herbert Biggs

Dr Herbert Biggs is an Associate Professor in the School of Psychology and Counselling, Queensland University of Technology, Brisbane, Australia. Herbert is also a senior research consultant to CARRS-Q and has an extensive background in organisational psychology and rehabilitation counselling. His research interests include organisational change, occupational stress, rehabilitation counselling, therapeutic models in the counselling process, competency attainment in driving tasks, fatigue and vigilance in industrial settings, and occupational health and safety in the construction sector.

Fanny Boulaire

Fanny Boulaire is an engineer in mathematics and modelling for the Sustainable Ecosystems division of CSIRO, Australia. Fanny's work focuses on developing and implementing mathematical models of infrastructure and environmental systems, applied to the urban environment.

Lisa Bradley

Associate Professor Lisa Bradley is the Head of School of Management, Queensland University of Technology, Brisbane, Australia. Lisa's research focuses on employee selection, gender in the workplace, performance appraisal, research methodology, workplace communication and work–life balance.

Peter Brandon

Professor Peter Brandon is the Director of the Think Lab at the University of Salford, UK. Peter is also the Director of Strategic Programmes in the School of the Built Environment and University Orator. He has played a significant role in UK Construction Research Policy including Chairman of the UK Science and Engineering Research Council Panel for construction, Chairman of the UK Research Assessment Exercise Panel for the Built Environment (1996 and 2001), member of the first UK Foresight Panel for construction, member of the UK Construction Research and Innovation Strategy Panel and Chairman of the Leading Research Universities Policy Panel. Peter is a Trustee and Vice Chairman of the RICS Research Foundation. Professor Brandon's research interests range from construction economics and management, and information and knowledge-based systems for construction and sustainable development.

Kerry Brown

Professor Kerry Brown is the Director of the Strategic Human Dimensions program within the Centre for Integrated Engineering Asset Management, and is based within the School of Management, Queensland University of Technology, Brisbane, Australia. Professor Brown's research is concentrated in areas of change management, networks, work–life balance, gender and careers in the public sector, public management and policy, government–community relations and public sector employment relations. She is a member of the editorial board of the *International Journal of Small Business and Globalisation* and the Queensland Editor of *Public Administration Today*.

Stephen Brown

Dr Stephen Brown is a Principal Research Scientist with Sustainable Ecosystems at Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO), where he leads research into indoor air quality and assists in CRC for the *Construction Innovation* projects 'IAQ Estimator' and 'Regenerating Construction'. His tertiary education and expertise are in the areas of analytical and industrial chemistry, occupational hygiene, building and material sciences and air quality, areas in which he has been involved for over 30 years. He has carried out research into smoke and toxic gases in building fires and (recently) bushfires, control of asbestos hazards in buildings, indoor air exposure to volatile organic pollutants (and other pollutants such as respirable particles, house dust mites, oxidants), assessment of pollutant emissions from manufactured products, and guidelines for indoor air quality and sustainable buildings.

Stuart Bull

Stuart Bull works for the Arup Group, one of the world's largest independent multi-disciplinary design and consulting firms. Stuart was recently involved in a CRC for *Construction Innovation* project examining the role of building information models in facility management.

John Burgess

John Burgess is the Director of the Employment Studies Centre at Newcastle Business School, University of Newcastle, Australia. John is also an Associate Professor in the School of Business and Management, University of Newcastle. His research interests include non-standard employment, gender and work, labour market policy and workplace bargaining.

Michael Charles

Dr Michael Charles is a Senior Lecturer in the Graduate College of Management, Southern Cross University, Gold Coast, Australia. Michael's research interests include infrastructure, energy and transport policy, political, economic and business history, public policy and administration, risk and crisis management, and popular culture.

Kirsty Chessher

Kirsty Chessher is the Business Development Manager for EnviroDevelopment at UDIA, Queensland, Australia. Kirsty has most recently worked for a range of environmental consultancies and has also worked at the Port of Brisbane conducting environmental monitoring procedures.

Fiona Cheung

Fiona Cheung is a postgraduate student with the Institute for Sustainable Resources, Queensland University of Technology, Brisbane, Australia. Fiona's research focuses on relationship management, and how it may contribute to a more sustainable construction industry.

Steve Coster

Steve Coster is the Managing Director for DEGW Australia and New Zealand. Steve is an architect by training and has previously worked in architecture firms in Melbourne and London. His recent work includes the strategic briefing and development of design strategies for Google's new workplace in Sydney, Multiplex's new Sydney offices, the new headquarters of SA Water in Adelaide, the ANZ Bank campus in Melbourne, Maddocks Lawyers' workplace in Melbourne, and new office and civic accommodation for the Gold Coast City Council.

Michael Dickinson

Michael Dickinson is a PhD candidate at the University of Salford, UK. Michael's research focuses on public procurement drives and innovation in construction procurement.

Don Dingsdag

Dr Don Dingsdag is a Senior Lecturer in the School of Natural Sciences, University of Western Sydney, Australia. Don has extensive experience in occupational health and safety, industrial relations and human resource management. He has conceptualised, developed and delivered over 80 OHS adult education and training modules across four universities in areas of OHS law, occupational health practice, safety management, risk assessment/management, auditing, and safety systems. Don works closely with the NSW Supreme and District Courts to conduct investigations, research and develop expert witness reports for common-law workplace injury and public-injury claims and conduct factual investigations for plaintiff and defendant matters. Don's research focuses on operational management roles in the manufacturing and retailing sectors, OHS policy development, risk management, and behavioural competencies and training strategies in the coalmining, energy, construction and public transport industries.

Robin Drogemuller

Robin Drogemuller is a Professor of Digital Design in the School of Design, Queensland University of Technology, Brisbane, Australia. Robin has contributed to the development of the IFC interoperability standard and coordinated the ICT program within the CRC for *Construction Innovation*. He has nine years experience as a Team Leader for the Integrated Design and Construction Systems team in the CSIRO Division of Manufacturing and Infrastructure Technology. Robin's research interests include ontology based demand support systems, urban development, automated code checking, CAD and design systems.

Stephen Egan

Stephen Egan is a Senior Software Engineer within Sustainable Ecosystems' Urban Systems Program at Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO). Stephen has worked with the CRC for *Construction Innovation* on a number of projects, including SpecNotes and viewer extension, learning systems for intrastructure life prediction, LCADesign commercialisation, technical activities associated with commercialisation, and estimating indoor air quality.

John Fenwick

John Fenwick is the Executive Director for Structures, Queensland Department of Main Roads, Australia. John has recently been involved in a CRC for *Construction Innovation* project focusing on sustainable infrastructure for aggressive environments.

Thomas Froese

Thomas Froese is a Professor in the Faculty of Civil Engineering, University of British Colombia, Canada. Professor Froese teaches in the areas of construction engineering and management, construction methods, project management for engineers, the development of computer applications for civil engineering, and computer-integrated construction seminars.

Craig Furneaux

Craig Furneaux is a PhD candidate in the School of Management, Queensland University of Technology, Brisbane, Australia. Craig has extensive experience in building organisational capabilities, training, curriculum design and development, and management consulting. More recently he has engaged in a number of research projects that analyse public policy, particularly the impact of public policy on organisations and industries. Craig is also interested in research in economic sociology, organisational learning, procurement, strategic management and networks.

Peter Galvin

Dr Peter Galvin is the MBA Director at the Graduate School of Business, Curtin University of Technology, Australia. Peter teaches in the areas of business strategy and international business. His research interests include competitive business strategy, innovation, product modularity, and interorganisational networks.

Wiktoria Glad

Wiktoria Glad is a visiting scholar at the Insititute for Sustainable Futures, University of Technology, Sydney, Australia. Wiktoria has a background in geography, environmental studies, sociology, and political science. Her research interests include socio-technical systems, energy systems in buildings, sustainable construction, sustainable technology, process-oriented research, knowledge management, learning, systems theory, science and technology studies, space-time geography and interdisciplinary research.

Ralph Godau

Dr. Ralph Godau is the Manager of Asset Services at Brimbank City Council, Victoria, Australia. Ralph has completed research into infrastructure management at RMIT University and has recently been involved in a CRC sponsored project examining asset management systems.

Nigel Goodman

Nigel Goodman is a Physical Chemist in the Integrated Urban Water Systems research group at the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia. Nigel's research interests include surface chemistry and colloid science, corrosion and electrochemistry, desalination and water treatment, and building science and sustainable design.

Keith Hampson

Dr Keith Hampson is the CEO of the CRC for *Construction Innovation* with responsibilities for crafting a blend of commercial and public good outcomes on behalf of industry, government and research organisations across Australia. Dr Hampson retains expertise in the areas of innovation, strategic technology management, construction information technology, construction project procurement strategies and advanced construction techniques.

Mary Hardie

Mary Hardie is an Associate Lecturer and Course Advisor in Undergraduate Construction in the School of Engineering, University of Western Sydney, Australia. Mary is a registered architect with more than 25 years experience in this field. Her research interests include environmentally sustainable project delivery, particularly successful project delivery by small construction firms.

Congrong He

Dr Congrong He works at the International Laboratory for Air Quality and Health, at Queensland University of Technology, Brisbane, Australia. He has recently been involved in a CRC for *Construction Innovation* project examining 3D CAD building models.

Richard Hough

Richard Hough is a Principal with the Arup Group, one of the world's largest independent multi-disciplinary design and consulting firms. He is a leading structural engineer who works closely with architects to achieve integrated design outcomes. He has been a Director of the firm's UK practice, Manager of the Californian and the NSW practices, and is presently Arup's Design and Technical Leader for Australasia. Richard is a Professor of Multidisciplinary Design at the University of New South Wales.

Rasmus Johansson

Rasmus Johansson works at Skanska in Sweden. Rasmus has recently been involved in a research project examining partnering and organisational innovations.

Chris Karagiannis

Chris Karagiannis works for city council on matters relating to asset services. Chris was recently involved in a CRC for *Construction Innovation* funded project examining sophisticated asset management systems.

Malik Khalfan

Dr Malik Khalfan is a Research Fellow at the Salford Centre for Research and Innovation in the Build and Human Environment, Salford, UK. Malik's research interests include concurrent engineering, readiness assessment of concurrent engineering in construction, sustainable construction, knowledge management, supply chain management, and partnering and strategic alliances. In 2000, Malik was awarded the CIOB Innovation Award for the best research paper.

Soon Kam Lim

Soon Kam Lim is a PhD Scholar of the CRC for *Construction Innovation* at Queensland University of Technology, Brisbane. In 2006, Soon Kam was acknowledged as the Outstanding Young Malaysian and, following this, in 2007, was selected as one of 30 finalists for the Outstanding Young Persons of the World. His research focuses on enhancing sustainability deliverables in infrastructure projects.

Mark Luther

Associate Professor Mark Luther is the Consortium Director of the Mobile Architecture and Built Environment Laboratory at Deakin University, Victoria, Australia. He also teaches courses in building environmental services including lighting and acoustics. Mark is an active member of the Built Environment Research Group within the School of Architecture and Building.

Charles MacDonald

Charles MacDonald is the Chief Engineer for Thiess, Australia, and has over 30 years experience in the procurement, design and construction of civil infrastructure works worldwide. Charles was recently elected Director of the Australasian Alliancing Association. He is currently engaged in a doctoral study program seeking to establish tools that will enable project alliances to achieve and demonstrate the achievement of 'value for money' in delivering project outcomes.

Karen Manley

Dr Karen Manley is a Senior Research Fellow in the School of Urban Development, Queensland University of Technology, Brisbane, Australia. Her research interests centre on innovation in knowledge economies. Karen is an economist with over 10 years experience as an academic and private consultant, specialising in the analysis of innovation and industry growth.

Helen Marshall

Helen Marshall is the Federal Safety Commissioner. In this role, Helen works with industry and government stakeholders to improve OHS performance in the building and construction industry through consultation, communication and collaboration. Prior to this appointment, Helen has worked in a variety of public service positions, and as an industrial relations practitioner. Her previous roles include Deputy Safety Commissioner, Director of Workplace Relations Advice and Education, and Commonwealth Advocate for the Defence Force Remuneration Tribunal. Helen has also worked as the Departmental Liaison Officer for the Minister for Workplace Relations, and Human Resources Manager for the Australian Customs Service.

Brett Mayze

Brett Mayze is a PhD scholar with the CRC for *Construction Innovation*, Brisbane, Australia. Brett is partnering with one of Australia's largest construction contractors in undertaking his research, which is investigating the key cultural leverage points for improving individual and group processes that enhance individual and organisational safety outcomes. Brett is an organisational psychologist who has previously worked with the Queensland State Government on a range of organisational learning and development initiatives. He also has a background in the mining, construction and heavy industries.

Peter McDermott

Dr Peter McDermott is a specialist in construction procurement at the Salford Centre for Research and Innovation, UK. Peter is a member of the Innovative Manufacturing Research Centre, and a Principal Investigator for the Research Institute for the Built and Human Environment at the University of Salford. His research interests include strategic procurement, the impact of newer forms of procurement on construction supply chains, and construction industry development.

Sherif Mohamed

Professor Sherif Mohamed is the Director of the Centre for Infrastructure Engineering and Management in the School of Engineering, Griffith University, Gold Coast, Australia. His research interests include international construction management, construction safety management, knowledge management, process improvement, project management, and engineering economics.

Tom Molyneaux

Dr Tom Molyneaux is the Director for Teaching and Learning within the Civil, Environmental and Chemical Engineering School at RMIT University, Melbourne, Australia. His research interests include impact loading and structures, masonry, and concrete.

Lidia Morawska

Professor Lidia Morawska is the Director of the International Laboratory for Air Quality and Health at Queensland University of Technology, Brisbane, Australia. Lidia also works within the School of Physical and Chemical Sciences within the same university. She has previously been an Advisor to the World Health Organisation, immediate past President of the International Society of Indoor Air Quality and Climate, and President of the Queensland Branch and Secretary of the Federal Executive of the Clean Air Society of Australia and New Zealand. In addition to air quality and the environment, Lidia's research interests include atmospheric aerosol science, human exposure, environmental and radiation physics, and sources and control of air pollution.

Pascal Mousset

Pascal Mousset is a Senior Legal Expert in the Business Operations and Procurement division at the Centre for Public Works, Ministry of Transport, Netherlands. Pascal is currently working at the French equivalent in Paris. His research focuses on procurement methods for large infrastructure projects.

Abraham Ninan

Dr Abraham Ninan is the Manager for Procurement Research for the Procurement Development and Research Branch at the Program Procurement Division, Queensland Department of Main Roads, Australia. Abraham has managed and delivered major quantitative and qualitative research projects for a range of international and local clients. Key clients include the Australian Federal Government, Australian state government departments, Brisbane City Council and leading Fortune 500 corporations across the USA, Germany and Singapore.

Stephen O'Brien

Stephen O'Brien is the Deputy Engineering Manager at the Horizon Alliance. His parent company is John Holland, where he has managed the design of Queensland design-and-construct infrastructure projects such as the Eleanor Schonell Bridge (formerly known as the Green Bridge) and the Bauhinia Railway Bridge. In a similar role at Transfield Construction, Stephen was responsible for the design of other bridges and tunnels including the Brisbane Airport Rail Link and the southern and northern structures of the New Southern Railway in Sydney.

Adekunle Oyegoke

Adekunle Oyegoke is an Associate Member of the Research Institute for the Built and Human Environment at the University of Salford, UK. Adekunle is also an Associate Member of the Salford Centre for Research and Innovation, and the Salford Research Centre for Management in Construction at the same university.

Kriengsak Panuwatwanich

Kriengsak Panuwatwanich is a PhD candidate in the School of Engineering at Griffith University, Gold Coast, Australia. His research interests include the diffusion of innovation, organisational climate for innovation, and information technology applications in construction

Aruna Pavithran

Aruna Pavithran is a business strategist, writer and entrepreneur. Aruna is Principal of Information Brokerage at Beam Solutions, Australia, and co-founder of applied research firm Lucis. Her consulting activities and research interests span the resources, transportation and property development sectors.

Rodd Perey

Rodd Perey is a qualified architect, and is Design Technology Director at Architectus. His expertise in Building Information Modelling (BIM) technology has established Rodd as a leader in the field, and he is regularly invited to speak nationally and internationally on the subject. Rodd combines his understanding of BIM with ongoing roles as project architect on a number of major projects, believing that this best allows him to expand and prove the potential of BIM in a practical real-world context.

Janet Pillay

Janet Pillay is an Adviser in the Construction Strategy Unit at Workplace Health and Safety Queensland. Janet has previously been a health and safety inspector within the same organisation, specialising in the field of ergonomics. Janet also teaches in the School of Management, Queensland University of Technology, Brisbane, Australia, and has a background in public relations. Her research interests include public sector procurement, networks, workplace health and safety, and workplace psychology.

Tanya Plant

Tanya Plant is the Manager of Strategic Policy at the Urban Development Institute of Australia (Queensland). Tanya was previously the Executive Officer of the 1200-member United Graziers Association of Queensland, South-East Division. She has also held a range of other positions within the agricultural industry. Tanya has been heavily involved in a number of industry organisations and charities and her accolades include being appointed as Ambassador for Australia's Year of the Outback 2002, the Young Australian of the Year Award for Regional Development in 1999 and being an invited attendee at the 2002 International Achievement Summit in Dublin.

Tony Plucknett

Tony Plucknett is the Director of the Procurement Development and Delivery Program at the Queensland Department of Main Roads, Australia. Tony has over 30 years' experience in the areas of strategic procurement, purchasing planning, materials management and project management at various organisational levels within the Queensland Government environment. Tony is currently responsible for organisational procurement planning, capability and performance supporting the delivery of the Main Roads Infrastructure Program.

Brian Purdey

Brian Purdey is an Innovative Business Strategist and Change Manager with an international reputation for creativity in addressing complex business problems. Recognised as a thought leader and practitioner on how to improve human performance in the workplace, he has consulted widely in the public and private sectors, and has written and presented numerous papers on this subject. Brian is an International Editor and member of the Governing Board for the *International Journal of Facilities Management*. He is a Life Member, past National Chairman and NSW Branch Committee member of the Facility Management Association of Australia (FMA) and represents the profession on the FMA NSW Education Stakeholder Group and the Productivity Working Party of the FM Industry Action Agenda. Brian is an Adjunct Professor in the Faculty of Science and Technology at Deakin University, is a member of the Academic Advisory Board for their School of Architecture and Building, and sits on the Strategic Advisory Board for their Built Environment Research Group. He is also a member of the Academic Advisory Committee for Building at the University of Technology in Sydney and Chairman of FMEDGE, a facility management registered training company.

Colette Roos

Dr Colette Roos was recently involved in a CRC for *Construction Innovation* sponsored project focusing on safety leadership in the Australian construction industry. Colette's research interests also include investigative interview techniques and how they relate to road crash incidents, and the promotion of adult resilience in employees working in high-stress occupations.

Steve Rowlinson

Professor Steve Rowlinson works in the Department of Real Estate and Construction, University of Hong Kong. Steve is a civil engineer by training, and has worked at the University of Hong Kong for the past 19 years. During this time, he has been engaged as a consultant and expert witness for a number of companies, including the Hong Kong Housing Authority and Hong Kong Government Works Bureau.

Neal Ryan

Professor Neal Ryan is the Pro Vice-Chancellor for Research at Southern Cross University, Australia. Neal has published extensively and has presented numerous papers in the areas of public policy, organisational change, knowledge management, procurement and outsourcing, in addition to science and technology policy.

Rachel Ryan

Rachel Ryan is a journalist and researcher who has worked in a range of print, radio and web outlets. She is currently employed as a researcher for the Rail Collaborative Research Centre, Australia. Rachel's research interests include public policy, and social and environmental issues.

Graham Scott

Graham Scott is a consultant specialising in project management, coaching, team development, negotiation, and conflict and change management. Graham has worked in the construction industry in both operational and management levels. He has over 10 years' experience as a lecturer at Queensland University of Technology in the School of the Built Environment and MBA program, Brisbane, Australia.

Sujeeva Setunge

Associate Professor Sujeeva Setunge works in the Civil, Environmental and Chemical Engineering School at RMIT University, Melbourne, Australia. Sujeeva is a senior member of IEAust, and a member of the Concrete Institute of Australia. Her research interests include concrete technology, timber particleboards as they relate to composite materials, and concrete structures, namely behaviour and performance, creep and shrinkage, and rehabilitation.

Richard Seymour

Richard Seymour is a Research Associate at the Centre for Labour Market Research, Curtin University of Technology, Western Australia. Richard's research centres on women in the workplace, the leveraging of training outcomes, and supply and demand in labour markets.

Abdulkader Sharabah

Abdulkader Sharabah is a PhD Scholar in the School of Civil and Chemical Engineering at RMIT University, Melbourne, Australia. Abdulkader's research focuses on asset management for the future conditioned state of building elements, and is sponsored by the CRC for *Construction Innovation*.

Willy Sher

Willy Sher is a Senior Lecturer in the School of Architecture and Built Environment, and Assistant Dean for Teaching and Learning at the University of Newcastle, New South Wales, Australia. Willy's research focuses on virtual environments, building information modelling, skills recording and development, and off-site manufacture.

Linda Sokolich

Linda Sokolich is the Environment, Health and Safety Manager for the New South Wales Region of Lend Lease Communities. Linda works with a number of land and built-form development projects to improve both safety management processes and safety culture within teams. She has previous experience in the industrial and chemical process industry and has over 15 years experience in the food processing sector. Her experience includes being employed as the National Process Engineering Manager and Corporate Environment Manager for Goodman Fielder, the Australian food manufacturer.

Lynette Sperling

Lynette Sperling is a scholar within the School of Management, Queensland University of Technology, Brisbane, Australia. She recently worked on a CRC for *Construction Innovation*-sponsored project titled 'Safer Construction' that adopted a supply chain perspective to improve safety in the construction industry. Lynette currently works in a communications role for the Queensland Government.

Brian Stewart
Brian Stewart is the Chief Executive and General Counsel for the Urban Development Institute of Australia (Queensland). Brian's research interests centre around advancing the credibility and integrity of the urban development industry through effective and collective representation. His research priorities include affordability, inefficiencies and process costs for development, and sustainable urban development.

Rodney Stewart
Dr Rodney Stewart is a Senior Lecturer and Researcher at Griffith University, Gold Coast, Australia. His research interests focus on engineering, construction and project management, specifically construction innovation, process improvement, modern procurement practices, water resource management, smart asset management, and engineering education.

Janet Sutherland
Janet Sutherland is the Program Manager of the Australian Leadership Awards: Leadership Development Program, an AusAID program managed by the Graduate School of Business, Curtin University of Technology, Western Australia. Prior to this Janet was a Research Associate. Her research focuses on knowledge creation and transfer, learning and leadership.

David Thorpe
Dr David Thorpe is a Senior Lecturer in Engineering and Technology Management at the University of Southern Queensland, Australia. His research interests include innovation and technology management, lifecycle infrastructure development and management, project and contract management and delivery processes, and engineering education. David has also held various positions in Brisbane City Council and the Queensland Department of Main Roads.

Selwyn Tucker
Dr Selwyn Tucker is a Research Consultant and Leader in the area of Asset Performance and Sustainability in the Manufacturing and Infrastructure Technology division of the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia. He has extensive experience in research leadership and development on a wide range of topics such as greenhouse efficient housing design, analysis of embodied energy in construction and recycling of building material, energy and operation costs budget levels for non-residential building, and development of performance indicators for building assets. Selwyn's current work includes a whole-of-life analysis of infrastructure, sustainable construction, automatic eco-efficiency assessment tools and construction process performance.

Stephane Tywoniak
Dr Stephane Tywoniak is a Senior Lecturer in the School of Management, Queensland University of Technology, Brisbane, Australia. His research interests include strategic management, and policy.

Nik Vassilev
Nik Vassilev is a scholar within the School of Management, Queensland University of Technology, Brisbane, Australia. Nik was recently involved in a CRC for *Construction Innovation*-sponsored project examining the harmonisation of eGovernment initiatives in South-East Queensland.

Srikanth Venkatesan
Srikanth Venkatesan is a Lecturer at Victoria University, Melbourne, Australia. His research interests include bridge asset management, earthquake engineering, and modelling residual service life of structures.

Carlita Vis
Carlita Vis is a Procurement Manager in the Business Operations and Procurement division at the Centre for Public Works, Ministry of Transport, Netherlands. Her research focuses on procurement methods for large infrastructure projects.

Michael Ward
Michael Ward works for the John Holland Group. Michael was recently involved in a CRC for *Construction Innovation*-sponsored project examining the harmonisation of eGovernment development applications in South-East Queensland.

Kristian Widén
Dr Kristian Widén is an Assistant Professor at the Division of Construction Management, Faculty of Engineering at Lund University, Sweden. Kristian's research interests focus on sectoral competitiveness and development in construction, innovation, and innovation diffusion in construction and project-based sectors. He is a member of the CIB Task Group 58: The Role of Clients in Construction Innovation, and has previously been involved in CIB Task Group 47: Innovation Brokerage.

Jay Yang
Associate Professor Jay Yang works in the School of Urban Development, Queensland University of Technology, Brisbane, Australia. Jay's research interests include intelligent buildings and sustainability construction, international project management, construction information technology, and smart and sustainable build environments.

Kwok-Keung Yum

Dr Kwok-Keung Yum is a Senior Research Scientist for the Urban Systems Program, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia. Kwok-Keung is one of the founding members, and technical coordinator of the IAI Australasia chapter. His research focuses on the development and use of object technology for sustainable urban development.

Foreword

This book has been sponsored by the CRC for *Construction Innovation*.

Construction Innovation is a national research, development and implementation centre focused on the needs of the property, design, construction and facilities management sectors. It develops and promotes best practice project delivery, products, resources and services that can guide project teams towards the best procurement approach for a specific project. Through research and development, the Australian property and construction industry gains a better understanding of these principles and is better informed in tailoring its delivery of projects to greater alignment of value for all the stakeholders.

Objectives of the CRC

- Enhance the contribution of long-term scientific and technological research and innovation to Australia's sustainable economic and social development.
- Enhance the collaboration between researchers, industry and government, and to improve efficiency in the use of intellectual and research resources.
- Create and commercially exploit tools, technologies and management systems to deliver innovative and sustainable constructed assets to further the financial, environmental and social benefit to the construction industry and the community.

Construction Innovation's mission

- Deliver tools, technologies and management systems that will improve the long-term effectiveness, competitiveness and dynamics of a viable construction industry in the Australian and international contexts. This will be achieved through greater innovation in business processes, strengthened human relations and ethical practices, and more effective interactions between industry and its clients.
- Drive healthy and sustainable constructed assets and optimise the environmental impact of built facilities through sound conceptual bases for economic, social and environmental accounting of the built environment, virtual building technology to examine performance prior to documentation, construction and use, and assessing human health and productivity benefits of smart indoor environments.
- Deliver whole-of-life project value for stakeholders, from business need, design and construction, through to ownership, asset management and reuse through improved communication and use of knowledge, increased productivity and value, effective delivery and management of assets.

The strength of *Construction Innovation* lies in bringing together industry, government and research partners committed to leading Australia's property, design, construction and facilities management industry in collaboration and innovation. Across Australia, our CRC has secured the input of almost 400 individuals who are delivering real benefits for our partners, the industry and our community. Together we are facing the challenge of implementing applied research outcomes to improve business.

We trust *Clients Driving Construction Innovation: Benefiting from Innovation* will provide you with powerful evidence-based research outcomes to develop and extend your own ideas for sustaining innovation in the building and construction industry. We commend this book to you.

John McCarthy
Chair
CRC for *Construction Innovation*

Keith Hampson
Chief Executive Officer
CRC for *Construction Innovation*

CIB Task Group 58:
Clients and Construction Innovation

The International Council for Research and Innovation in Building and Construction (CIB) provides for international exchange and cooperation in research and innovation in building and construction. The scope of CIB covers the technical, economic, environmental and organisational aspects of the built environment during all stages of its lifecycle (www.cibworld.nl).

Task Group 58 takes as its critical focus and starting point, innovation driven from a client's perspective. This standpoint explores innovation through a range of client-oriented approaches including interrogating construction knowledge, networking and innovation competencies, devising innovation strategies that are highly cognisant of the role and orientation of clients and improving take-up, communication and diffusion of existing client innovations.

The objective is to identify opportunities and barriers to client-driven innovation and to capture ways in which client engagement, interactions and actions affect innovation systems and processes. The learnings from the research and collaboration of members within this group will extend insights into theoretical models of innovation and inform and improve practice outcomes in relation to the construction innovation process.

This Task Group provides opportunities to meet through special sessions at international conferences and through supporting a forum for the ongoing collaborative enterprise of the Task Group. This edited book examining the role of clients in construction innovation is one of a series of deliverables to assist researchers and industry in this important process.

The coordinators of CIB TG58 are Dr Keith Hampson, CRC for *Construction Innovation*, Australia, and Professor Peter Brandon, University of Salford, UK.

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We are also grateful to the chapter contributors whose research forms the basis of this book.

We trust that this book contributes to both theory and practice in understanding and promoting the important role that clients play in construction innovation.

— Kerry Brown, Keith Hampson, Peter Brandon and Janet Pillay

Part 1
Clients Driving Construction Innovation

CHAPTER 1

Benefiting from Innovation

Kerry Brown
Janet Pillay
Keith Hampson

INTRODUCTION

The property and construction industry is highly volatile, responding to shifts in financial markets and economic futures as well as changing demographics, typically in a 'boom and bust' cycle. However, the construction industry has made significant change in adopting innovative technology and practices. A stark reminder of the speed of change within the construction industry is the emergent shift from paper-based drawings and records to sophisticated electronic systems such as 4D CAD in a few short years. Alinaitwee, Widen, Mwakali and Hanssen (2006) in their research examining innovation in construction suggest that efforts to promote innovation are at the core of current research in building as it is a critical mechanism to achieve greater productivity and competitiveness. With increasing expectations of the industry, especially regarding sustainable practices – environmental, social and economic – more work is needed. The research in this edited volume demonstrates how applied research can make a difference in delivering environmental, social and economic benefits to property, design, construction and facility management firms, the industry and the community. Increasingly, the sector is faced with demanding clients and these clients are shaping the principles, policies, practices and processes of the construction industry (Barlow 2000). However, it is recognised that while clients have a critical place in the construction sector, the extent and specification of their role is not well understood.

It is timely then, to examine the benefits of innovation from a client point of view. *Clients Driving Construction Innovation: Benefiting from Innovation* outlines the results of leading-edge research and makes it accessible to the broader construction sector. *Benefiting from Innovation* brings research featuring clients, designers, constructors and facility managers to bear on delivering cutting-edge solutions to issues and problems in constructed facilities. It showcases applied and theoretical research that has particular relevance to the construction sector. Mitropolous and Tatum (2000) in their study of information and communication technologies (ICT) adoption and innovation in the construction sector identified four forces that drive innovation: capturing of competitive advantage, process problems, technological opportunity and institutional requirements. Innovative capacity can thus be sourced from conditions of both adversity and advantage. The research in this edited volume examines innovation in a range of settings and through a variety of methodological approaches and concurs with the findings of Mitropolous and Tatum (2000). These authors suggest that innovation forces emanate from changes in policy and legislative mandate in the institutional arena such as occupational health and safety requirements from large-scale industry leaders seeking greater advantage through technology such as eBusiness and increased market share, and by solving practical issues in organisational and supply chain arrangements.

BENEFITING FROM INNOVATION

Benefiting from Innovation examines the current issues relating to harnessing the advantage of innovation in the construction sector. Improvement of industry performance through innovation and adopting leading-edge technology is a critical factor in developing a competitive and world-class industry. The chapters in this edited volume were drawn from research studies undertaken by international and national scholars, and industry experts researching in the field of construction and the built environment. Areas of research cover information technology, construction and engineering technology, and management and innovation. Each chapter included in this volume was subjected to double-blind peer review of the chapter proposal at the abstract stage and double-blind peer review of the completed chapter by scholarly experts in the various fields within construction including engineering, building technology, policy and management.

The benefits of innovation in the construction sector are suggested to flow not only to the individual firm, but to the industry and society as well (Slaughter, 1998). The link between innovation at the firm level and broader positive social outcomes comes about through diffusion and adaptation of innovation. Maintaining the flow of ideas is a critical task in developing a critical mass of research to change traditional thinking and action. This book showcases research that has the potential to transform not just individual firms and expectations about buildings and the built environment but our established social organisation.

STRUCTURE OF THE BOOK

Themes identified and examined in detail in this book cover selected areas considered to be key contributing factors to ensuring clients involved in the innovation process allow a move from simply generating new ideas to capturing the benefits of innovation in a sustained way.

The book is structured according to nine key themes critical to investigating the role of construction clients in innovation and the methods by which firms, the sector and the community are benefiting from such innovation. Each of the nine parts covers a significant current concern in construction innovation. The first part details the aims and structure of the book and presents the keynote chapter. The concept of clients driving construction innovation is presented as the overarching principle of the book and investigated through the thematic sections. The themes are reflective of the findings of *Construction 2020* that sought input from stakeholders in the construction sector to map out a desired future for the sector (Hampson and Brandon 2004).

Part 1: Clients driving construction innovation

Part 1 explores the ways in which innovation may be driven by clients in the construction industry to capture the benefits of innovative developments. Peter Brandon furnishes the keynote chapter for the book and highlights the history of innovation in the construction sector.

Part 2: Meeting client needs

The second section of the book comprises chapters that suggest ways of benefiting from innovation by meeting client requirements. *Construction 2020* (Hampson and Brandon 2004) outlined the vision for meeting client needs as relating to the design, construction and operation of facilities to better reflect the present and future needs of the project initiator, users and stakeholders. Accordingly, it is suggested that this course of action should 'take into account the need to for improved accountability and economic viability, as well as have the flexibility to adapt to future needs' (Hampson and Brandon 2004). The chapters look to alliance contracts, ICTs and workplace restructuring to deliver innovative ways of satisfying client requirements.

Part 3: Procurement and risk management

Part 3 focuses on the procurement process and the risk profile of the sector. Innovative procurement methods allow the possibility of garnering economies of scale and scope. An ability to understand and implement innovative risk strategies forms the cornerstone of good management practice. The chapters in this part focus on new ways of delivering construction projects and examining the turn to relationships and collaboration in order to achieve innovative outcomes in contracts.

Part 4: Improving efficiencies through information and communication technologies

The fourth part of the book elaborates on the greater efficiencies that ICTs can produce. Seamless communication and data transfer was highlighted in *Construction 2020* as an important aspect of the vision for the future (Hampson and Brandon 2004). Further, driven by the knowledge economy, connectivity and embedded technology, products will facilitate changes to construction processes and, significantly, to the way firms operate. Case studies demonstrate best practice and innovative ICT initiatives with studies to improve air quality, develop green building technology, and data measurement for concrete bridges.

Part 5: Construction health and safety

Safety in construction remains a considerable arena for investigation and improvement. The vision for *Construction 2020* focused on mutual respect for each other on the worksite together with improved health and safety conditions on-site. The chapters address construction safety from a range of perspectives; however, the common concern is to ensure that it is not just that dangerous incidents are reduced, but that a culture and environment of safety pervades the industry.

Part 6: Facilities management

Issues relating to facilities management are examined in Part 6. Innovative case studies are used extensively to exemplify new ways of operating facilities and drawing out the lessons for best practice.

Part 7: Industry development

Part 7 focuses on the sector-wide initiatives to improve the construction industry. Importantly, other actors besides individual firms come to the fore in this arena. The role of industry facilitators such as professional associations and government are significant influences in this context. Knowledge management and innovation diffusion across the construction sector is highlighted. The need for a sector-wide approach to small- and medium-sized entrprises (SMEs) and their vulnerability because of lack of resources and small size is also a focus here.

Part 8: Sustainable construction for the future

Part 8 canvasses ways that innovation can make a difference to the sustainability of the construction sector. The *Construction 2020* vision for sustainability is for the industry to design, construct and maintain its buildings and infrastructure in a way to minimise environmental impacts and to develop tools for minimising environmental impact. The chapters go some way to achieving this vision and extending previous research by outlining a set of tools for sustainability under the LCA banner, and by developing frameworks and models for urban sustainability.

Part 9: Benefiting from innovation

According to Slaughter (1998), the construction sector offers a unique setting with quite distinctive conditions for understanding innovation, particularly as the built environment has a specific scale, complexity and longevity of facilities that sets it apart from other business arenas. In recognising this unique contribution, the book offers insights from a wide array of topical areas within the construction sector. The book concludes with a summary of the topics and analysis of the key lessons from each of the themes. Finally, it offers some concluding comments on the challenges for the future.

CONCLUSION

The *Construction 2020* report concluded with the concern that the construction industry's future depends on its ability to exploit research and innovation in order that it 'continuously improve in line with international competition and to meet the increasing demands of clients and the community'. Key issues for the future highlighted were ICTs, sustainability and a changing construction business environment and these issues have occupied centre stage in this volume. This edited volume outlines and explores research that highlights the benefits of innovation for the construction sector. The research is presented according to key themes related to the different but critical areas for deriving benefits from innovation. It focuses on the ways to realise benefits from innovation through clients in the construction sector. It extends the knowledge base and consequent capacity of the sector to deliver productivity gains, and readers will derive a better developed understanding of the contribution of research to achieving real gains in the field of construction and the built environment and the hazards of failing to learn the lessons of poor innovation take-up and inability to build innovative capacity.

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CHAPTER 2

Seeking Innovation: The construction enlightenment

Peter Brandon

INTRODUCTION

The past forty years (roughly one working lifetime) have been a period of rapid technological progress across a wide range of human activity. It has included the development and miniaturisation of the computer, the development of the internet, massive improvement in communication, significant understanding in medicine, vast increases in our knowledge in many areas, and enormous improvements in infrastructure such as transport. This has been coupled with major reductions in cost placing them within range of many more people than was ever envisaged before. One newspaper was quoted as saying that there is more knowledge in a single edition of the *New York Sunday Times* than that acquired by the average individual living four hundred years ago. It is difficult for any individual living in the developed world today to understand what it must have been like to live just 400 years ago. Our dependence on technology enhanced by education has transformed our lives and most of us find it difficult to understand what it must have been like not to have had the facilities we enjoy today.

But what about construction? There has been incremental innovation over centuries but the industry has tended to stay within the craft paradigm where it is confident it can deliver (Sebestyen 1998) The citizens of the past would have little difficulty in understanding and participating in many of the processes the industry adopts today, at least in some of the major sectors such as housing. Perhaps the service engineering aspects would cause problems but the rest would be instantly recognisable. The industry has refined its methods, of course, and it is almost as efficient as it can be whilst it uses existing approaches. The innovations of recent years have seen a greater specialisation with new professions springing up to support the standards and give assurance to the public. Knowledge has become identified with these bodies and they, in turn, have created systems to maintain standards, usually by examination, which has had the effect of making the knowledge and practice inaccessible to those who do not pursue the professional pathway. By default the boundaries between professions and trades have become less porous and silos of knowledge have grown up often protected by law. The innovation which encouraged efficiency by specialisation has also led to fragmentation of the industry which in many cases can lead to an adversarial approach in which the best interests of the client can be lost.

For many years academics and leading industrialists have been advocating change for the benefit of all the industry. It has largely fallen on deaf ears except in some specialist sectors where the design is driving a technological revolution. However, is this about to change? Are we at a point where the pressures from clients, the competitiveness of firms, the transformation of other parts of society, is such that the industry must change and adopt some of the practices from other manufacturing industries? There are dangers in suggesting such a move as it could be that another false dawn is about to break! Is there a parallel which could be seen to be the model for innovation which might give us a clue that something dramatic might happen?

One such model might be the revolution that occurred between two hundred and five hundred years ago which led to a change in the way humans thought about themselves and their environment and which led to the transformation of the developed world. This prolonged period (by today's standards) has been labelled 'The Age of Reason' by historians and was a period rich with new knowledge. It provided the foundation for our own technological advance in all areas of society. It included such well-known names and discoveries as William Gilbert (Earth magnetism), Thomas Harriot (algebra), William Oughtred (slide rule), John Napier (logarithms), William Harvey (blood circulation), William Gascoigne (micrometer), Isaac Newton (calculus) and many others. What these visionary people did was to provide the basis for the creation of knowledge based on observation and enquiry. In order to do their work they needed to measure and develop tools for examining and testing ideas. For many centuries much of the perceived knowledge had been handed down by the state or the church without challenge. Now was the opportunity to challenge and examine whether it was true. The outcome of these advances was a series of tools for scientists to use in their enquiry. These included:

- measurement methods and tools
- scientific method based on observation and hypothesis testing
- reductionism whereby the problem could be reduced to a sufficiently small size for examination.

These, in turn, allowed an increase in precision and the development of rational thought where reason held sway over superstition and revelation. By challenging the views of the establishment it also led to the querying of the social *status quo* and encouraged revolutionary thinking where the individual had a voice and the opportunity to express his or her opinion.

This change is reflected in the change in thinking advanced by the philosophers in a new age, 'The Age of Enlightenment'. According to the Collins English Dictionary (2000), philosophy can be defined as:

> *The academic discipline concerned with making explicit the nature and significance of ordinary and scientific beliefs and investigating the intelligibility of concepts by rational argument concerning their presuppositions, implications and inter relationships…*

It seeks to answer the reason why we believe certain things. Once humankind found itself able to establish its knowledge without deference to established powers then our belief systems changed. Enlightenment reflected that change in view although many would argue that it has claimed too much. Can the rational thought of mankind explain the meaning of life? Nevertheless, it has dominated the thinking of the Western world ever since. The philosopher Immanuel Kant (1784) suggested the following explanation of enlightenment:

> *Enlightenment is man's release from his self-incurred tutelage. Tutelage is the capacity to use one's own understanding without the guidance of another. Such tutelage is self-imposed if its cause is not lack of intelligence, but rather a lack of determination and courage to use one's intelligence without being guided by another.*

The proponents of enlightenment included such luminaries as Voltaire, Gibbon, Paine, Hume, Rousseau and Berkley and together they started a series of changes in thought which has stayed with us until today. These include a:

- move from faith based on edicts of the state and church, to reason
- challenge to established tradition
- change in values which gave more credence to rigour, rationality and geometric order.

It could be argued that these changes provided a liberal stance against superstition and intolerance which provides the basis of our modern understanding of freedom. In so doing it provided the basis for democracy, religious tolerance and acceptance of scientific method as a way of establishing at least some aspects of 'truth'.

The key point is that the technology of the day transformed the thinking of vast numbers of people and this, in turn, created a society in which change could occur through examination, challenge and rational ideas. New thinking was established which was built on rational thought.

Today we face a similar revolution in our thinking processes which is challenging us in all aspects of our lives including the way we think about ourselves and each other. The rise of the machine is making us consider what we are and why we exist in a way which has not been undertaken at this scale ever before.

Construction is no exception to these changes. As a key component of our quality of life and the way we behave, it must be impacted upon by the change in thinking of the society which it serves. It must reflect the new demands of that society and one of those aspects must be the tools which that society expects to be used to achieve its requirements.

However, an examination of the industry would suggest that not much has changed over several centuries and some would claim that it has acted more like the establishment of old, and resisted change to protect its own established traditions. Authors who have pointed to this problem include James Woudhuysen and Ian Abley who wrote a book called *Why is Construction so Backward?* (Woudhuysen and Abley 2004) and, with a more positive spin, *Buildings Culture and the Environment* by a series of authors (Lorch and Cole 2003). There is a strong argument which suggests that tradition has value especially when applied across a major industry such as construction. The education of its participants, the legal and financial frameworks and the processes involved are embedded in its culture. It would be costly to change and we tamper with this at our peril.

Despite the reluctance to move from traditional practice many authors have been forecasting and expecting change to happen for the past forty years. If the question 'If we knew what we know today, would we design an industry that acts in the way it does today?' is asked, the answer would almost certainly be 'no'. Whether we really have a better alternative that we could lay on the drawing board is less clear. However, the increase in foresight and agenda setting for research in construction in recent years (Flanagan and Jewel 2003) suggests there is a feeling that something must be done. The Australian CRC for *Construction Innovation* undertook a major exercise in visioning the future which has received widespread interest (Hampson and Brandon 2004). Through its members and engaging with around one thousand professionals from all major disciplines and site staff it identified certain aspects of technology as key enablers in providing a better, more effective industry. There is, therefore, a potential parallel with the age of enlightenment:

- Technology has created a new understanding of how things can be done in the industry harnessing advances found in other fields of endeavour.
- It has opened new opportunities for advance which were not there before the technology was developed.
- Already it is beginning to change relationships between people and the power structures of the industry.
- It has begun to change the way we think about ourselves and our industry.

All these things were forecast as the computer revolution began to develop. Christopher Evans in his book *The Mighty Micro: Impact of the computer revolution* (Evans 1979) provided a whole chapter on the decline of the professions. He argued that professions gained their status because they were exclusive repositories of information whose members had made it difficult for others to access their knowledge. Consequently, when the computer enabled knowledge to be generally available (an early expectation of the internet) then this would undermine their ability to protect their status. It can be debated as to how far this is true but nevertheless the ability of the general public to engage with any form of knowledge is undeniable. It took several hundred years for the Age of Reason to impact fully and we do not know where this current revolution will lead. Questions can be asked as to whether we are approaching an enlightenment for construction:

- Are we at a watershed for construction innovation in a similar way to that experienced following the development of science?
- Is there a focus for construction research which could transform the industry?
- Is there innovative thinking that we can identify which might provide the transformation?

If we are to answer these questions we might need to answer more specific enquiries related to the way we do our construction business. For example, we might compare the recent past with the enlightened future, as outlined in Table 2.1 below.

Table 2.1 The Past and the Possible Future

Past	Possible future
An industry based on a craft tradition	Industry based on rational thought where the primary question is 'should we be doing it this way?
Tradition is valued more than reason, based on current knowledge	New improved approaches take precedent over past methods
Industry takes its cue from its own past	Industry embraces the advances made in other industries, and is more outward looking
Change is derided	Change outside of the current paradigm is encouraged

THE NEW TECHNOLOGIES

The range of technologies is so great that it is not possible to deal with more than just a few in this chapter. They range from processes to materials, from communications to free form design and from new financial models to enhanced visualisation of both product and manufacture. However, in most of the developments it is information technology which has enabled the potential for change to take place. A quick look at the advanced design and construction schools of leading universities would reveal the use of building information models, virtual reality, augmented reality, web-based communication and a whole series of other devices such as *Second Life* and *Facebook* which suggest that even our perception of the real world is changing. Going further afield the use of computers to jack into the brain to aid those with hearing and eye defects seem to be a forerunner of what might become more widespread leading possibly to new lifestyle changes which we can design for ourselves.

It is probably true to say that no one knows with compete confidence where we are heading with the developments in information technology. If the introduction of the internet, which was not foreseen even 40 years ago (but which has transformed many aspects of human behaviour) was such an innovation then who knows what the future might bring? Nevertheless, it is incumbent on those who lead the thinking of the industry to anticipate what might happen and how this might influence what we do now. We have an obligation to ask 'Where should we look for an improvement in construction innovation?' The rest of this chapter will attempt to explore this in strategic terms through just three examples:

- management, which has the ability to intervene and make change happen
- information technology, which can provide both a vision and support for change
- engagement with the people and stakeholders, who are the ultimate beneficiaries of the innovation.

However, the theme through all these is the need to dissolve the interfaces between people, and between people and machines.

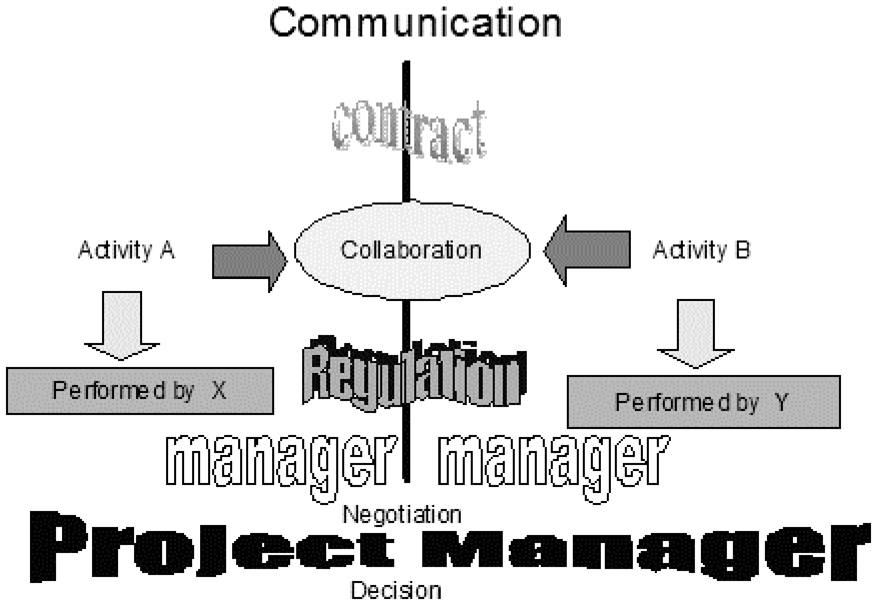
INNOVATION IN MANAGEMENT: DISSOLVING THE INTERFACES

The past two hundred years at least have seen a change in the management structure of the industry. It has gone from the design and control of the construction process under the auspices of the designer/engineer to a series of specialisations which have been created to deal with the complexity of projects and to some extent their scale. These changes were the result of innovative thinking at the time and they yielded useful results. As time progressed, however, they became fossilised around the roles people were expected to play, often reinforced by the professions that were created as they became established, and a new problem emerged. The impact was to create an adversarial position in which each role defended its boundaries and this division gave rise to potential conflict and a blame culture when things started to go wrong. The role of management is now a major one within the industry but it exists as a separate role because the interfaces between the different participants have increased and someone has to manage them. It is paradoxical that the more we manage the more complex the process appears to become. Ferry and Holes in the 1960s (Ferry and Holes 1967) found that a single item is measured up to sixteen times during the course of a contract usually by different people but not always. This is just a simple example of the interface problem but it illustrates that trust begins to diminish (otherwise we would all accept one person's view) and we need to assure ourselves that our understanding is right.

If an interface is created, the following can happen (refer to Figure 2.1):

- The two parties need to collaborate.
- They, therefore, need agreed methods of communication between them often in the form of documentation.
- They may well need to negotiate who does what and when and for what price.
- To understand what is in the mind of these parties as an agreement, a contract is drawn up to define it, and this might involve another profession.
- The engagement between the two parties may have public interest and hence the regulatory authorities then provide a new regulation to cope with it.
- The process is becoming so complex that one side decides that it is sensible to employ a manager to deal with it.
- The other side then realises that he might lose out and does the same.
- In order to facilitate the two managers a project manager is introduced to keep them in order.

Figure 2.1 The Problem with Interfaces



Of course, this is a caricature of what happens but it seems to be recognisable by many people in the construction industry.

In fact, the situation is slightly worse than that described above. Throughout the process of construction there are a large number of interfaces where knowledge is passed from one participant to another. To do this models, such as drawings, bills of quantities, specifications, are created to convey information. These, by the very definition of model, do not convey the whole of the information which the participant who creates the model actually knows. However, the next person takes the simplified information and enlarges it from his own understanding and then creates his own model which he passes on to the next consultant and the process begins again. Through this process, knowledge is created, simplified and passed on in a different form. The result is a knowledge entropy where knowledge of one type is being lost and knowledge of another type is being created. This means that any one participant only has partial knowledge of the project and this has the potential for misunderstanding leading in some cases to litigation.

The innovation required is to dissolve the interfaces wherever possible and to provide a better shared common understanding of the meaning and processes which are required to design and build the building without error.

INNOVATION: THE TECHNOLOGICAL SUPPORT

It is not possible to do without management of some sort but where it resides is critical. If it is within one organisation or entity which can act without formal boundaries then it may well be possible to move away from adversarial positions, hence the increase in design-and-build and multi-disciplinary consultancy practices.

However, it is one thing to say we will aim to get rid of the interfaces but it is another to find a way of achieving it. The past forty years have seen giant steps taken towards connectivity between people and organisations through technology which facilitates the breaking down of the interface barriers. Emerging over this period has been the concept of the building information model (BIM) whereby there is a common model available to all approved participants which can be updated and with internal integrity as decisions are made by designers and other consultants. The process needs managing but can be done in real time providing certain protocols are agreed. Work in this area includes Martin Fischer at CIFE, Stanford University (Fischer 2008), Ghassan Aouad and others at Salford University (Aouad et al. 2005) and Martin Reise (Riese 2008). A major European Project, Divercity, engaging several organisations across the EU also experimented with a number of partners in different organisations cooperating across geographical boundaries. One of the most impressive uses of such a model occurred in the Stata building engaging Frank Gehry Associates and Gehry Technologies together with Skanska and much of the major supply chain (Joyce 2004). The model became the reference for all activity and design evaluation. It also took a big step forward towards paperless design. In addition, it also engaged the steel fabricators in manufacturing the steel members direct from the engineers' drawings and the site erection team used laser technology for setting out in order to ensure compliance with the model. These sophisticated models are not yet in general use but the trend is towards adoption. Interestingly, the regulatory authorities have in some instances not kept pace with the technology (e.g. requiring 2D drawings for projects where this is inappropriate) and it is easier to adopt these new practices where the construction industry is not so heavily regulated.

These changes are not only assisting the process as it stands but also challenging the way we think about the project, its design and the engagement of people within it. Do we need the design team we have traditionally required? Who is in charge of coordination and is it the person driving the model? How should the regulatory authorities act if they are not to be the people who stop innovation? What is the limit to design now that the algorithms have been developed for complex shapes and new materials have extraordinary performance characteristics which allow them to be built?

Although this is happening through those architects who have to have these tools in order that their designs can be built, they are paving the way for the rest of the industry. Often it is the clients who are demanding these new methods to avoid the massive extra costs and overruns which seem to be the province of large projects. One Island East, a large multistorey building in Hong Kong for Swires Development, has a very sophisticated BIM by Gehry Technologies using CATIA software, and its use was requested by a client who recognised that it would significantly reduce cost and time, as well as stress. The savings are self evident. The model found 2000 clashes before tender and over a two-year period, as the design developed, it identified and dealt with a further 150 to 200 clashes a week. It also coped with major changes in design which would have been impossible or very expensive if undertaken manually. It is now thought that savings of up to 25 per cent might be available in post-occupation costs as well.

However, to get this approach into the mainstream requires a radical change of thinking. The technology is beginning to create that change which goes far beyond the concept of just adopting a technology to support design and construction activity. It goes to the very root of why we do things in the way we do and why we behave in the way that we have for centuries. As in the Age of Enlightenment these are issues which will transform our industry and our understanding of the role that each of us will play. In time the change will be even more significant as we hand more and more of the design function to machines with intelligence and more of the assembly process to robots. These moves are already being suggested by many of the software gurus including Grady Booch, Chief Scientist of IBM (Booch Turing Lecture 2007). Booch believes that within thirty years we will see the *rise of the machine* where we will move from dependence upon machines to being driven by them. This, of course, raises all sorts of ethical and moral questions related to our adoption of the technology. This, in turn, will make us ask the questions why we do things in this way and what our behaviour should be. The Age of Enlightenment based on technology is going to be tackled by the wider public in the first instance but it will be a much shorter period than the four or more centuries seen previously. The speed of change may be so fast that in itself it will create problems which are not yet identified and may even exaggerate the two-speed world between the developed and the underdeveloped peoples which has been forecast in both science and fiction resulting in social stresses which are severely destructive.

In the meantime we are developing new technologies which allow people to meet in a more natural way across traditional geographical boundaries. Tele-collaboration is a research topic which could be of great interest to construction. The industry exists by creating virtual teams which are increasingly global. Although building modelling is a big step forward, the human–computer interface still requires significant research to make it natural. In real life we pick up body language, and especially eye gaze, which allows us to interpret the words and actions of others more. The teams at Salford University are investigating ambient technologies and methods of collaboration which will make this technology more accessible. It includes hidden computers with more natural methods of communication, augmented reality where virtual spaces are combined or overlapped with real space to examine or instruct behaviour, e.g. the use of RFID tags together with Personal Data appliances to examine whether the service engineering has been built according to planned design (see Co-Spaces website www.cospaces.org), in the model. Space can be shared in a number of different ways, for example by:

- observation, which is the use of a flat screen and the normal way we videoconference at the present time
- tele-immersion where virtual objects can be shared across a virtual table or a workbench
- collaborative virtual environments where avatars can meet and act, controlled by external persons such as is found in the virtual environment of *Second Life*
- immersive collaborative environments where a person can engage with others, or with other spaces, immersed in a virtual world using a cave.

At Salford University we are creating a reconfigurable cave which has the flexibility to undertake all these approaches. In time, it will allow participants in the design and construction process to have an appropriate method of communicating with each other which is as near real life as we can make it. The barriers of space and time may well begin to disappear and in a global industry this must be significant.

INNOVATION: THE SHIFT TO PUBLIC PARTICIPATION AND DEMOCRATIC RESPONSIBILITY

So how will the technology, which is beginning to remove some of the geographical interface problems, be used? This is a much more difficult issue to anticipate. Predicting the impact of technology on human behaviour is a matter of much speculation and as the introduction of the internet has shown, humans adapt their actions to suit the technology in unforeseen ways.

One further considerable interface is that between the public and the business community in making decisions. Understandably the people wanting to take business decisions and investing their own money in the impact of that decision also want to retain control. This has been easy to maintain until now as it was not a practical proposition to engage the stakeholders in a detailed assessment of the proposed development. Often this was left to representatives of the people such as planning authorities who exercised some control over events within their jurisdiction. In large infrastructure projects within democratic regimes public enquiries have been set up which have allowed the public to make representations for or against a proposal. These often delayed planning consent but at the same time provided endorsement of the project by stakeholders once the project had been authorised. However, the nature of these enquiries, often extremely formal with experts and consultants providing submissions, created barriers which the public found intimidating. More recently, government agencies have provided websites on key issues (sometimes identified by the public themselves in the form of a motion) where people can express their opinion or even provide a petition on line. One such example was a UK government website which asked for opinion on a road-charging scheme to replace road tax (vehicle registration fees) and several hundred thousand people quickly responded with a resounding ‘no’ to the government’s perceived proposal. It was quietly dropped, at least for the time being. Increasingly, technology is being used by planning authorities to demonstrate to residents the impact of a new scheme and some of the virtual reality work at Salford has been used to explain more clearly to planning authorities the impact of a proposed development, e.g. a new prison which could be unsightly, or to engage residents in planning a regeneration scheme encouraging them to explain how crime, for example, can be designed out of the scheme. They know the area best and can make informed suggestions.

Another use of technology was used by media researchers at Salford to develop a game 'Plasticity' which allowed school children to have a say in the development of Bradford (UK) City Centre. The game was based on a game engine which allowed the children to remove buildings and replace them from a fixed menu of buildings which could then be rendered in various ways. The purpose was to engage all the people affected, in this case the children, in the redevelopment so that they felt some ownership of what was eventually proposed.

Public participation is a key feature of Principle 10 of UN Agenda 21 (*United Nations Report* 1992), the agreed blueprint for local authorities to provide sustainable development. The principle states that:

- individuals should have an opportunity to participate in decisions which affect them
- democratic decision-making allows a more sensitive choice to be made related to the needs of the community
- by engaging the general public, values can be shared and an agreed solution can be achieved.

The new technologies allow a better understanding of what is proposed in a way which most people can understand. It breaks down the barriers between the layperson and the expert in certain fields and allows the values of a society to be brought to bear within the process. There have been many examples in the past where authorities have ridden rough shod over the people and the people have risen up to stop the proposal. One example is the introduction of the high-speed train through Turin in Italy which has been delayed for eighteen years because the people affected were not engaged from the start and a 'not in my back yard' syndrome was allowed to develop. Large-scale protests then followed. Engagement through better communication and participation may have avoided such a delay. In long-term issues such as sustainable development it is absolutely critical that the public are involved so that the proposals can take into account their values and engage in dialogue which might influence those values for many years to come.

This may seem a long way from the concept of enlightenment but if increased democratisation takes place, it changes the power structure within society and may well affect everyone's thinking and behaviour. It will start with the models we create in our brain and it will continue to what we propose and what behaviours we adopt. Many will be afraid of the impact, many will welcome it and there is a large debate to be had just on the benefits or otherwise of such a shift. The point is that technology which enables this change has provided a platform for new thinking in a not dissimilar way to the Age of Reason followed by the Age of Enlightenment a few centuries ago.

There is, of course, a very strong potential downside to this adoption of technology. To gain knowledge the technology may be intrusive. To provide information a machine may need to interpret raw data and it may not be evident who provided it or what that interpretation was. Sometimes extensive use of routines are hidden in software which have value judgments within them (Brandon 2005) These may not be known to the user and are, therefore, unchallengeable in the way that normal human debate allows adaptation and evolution of thought. These are serious issues with which society has to grapple. At the moment we appear to be drifting to a society where machines are beginning to rise (Booch Turing Lecture 2007) at the expense of human engagement and modification. This is the opposite of a technology which opens up opportunities for humans to participate in the issues which interest them. In moving in this direction we must be aware of the negative potential of the technology we are adopting.

SUMMARY

This chapter has attempted to explore the concept of a new age of construction based on technology, and it tried to draw a parallel with the 'Age of Reason and Age of Enlightenment' which the Western societies experienced a few centuries ago. It has recognised that in order to gain a change in thinking there needs to be a platform of new knowledge and tools which provide the fertile ground for ideas to develop. Much of the current literature on innovation (Dodgson et al. 2005) seems to take this as a given before innovation can take place. They are right but it is worth exploring in some depth to discover whether we can identify those technologies which may have the major impact on our world, the way we behave and the development of processes and products which might be adopted in the construction industry. If we can focus on these we might speed up the innovation process for the benefit of all concerned or we might be able to avoid the pitfalls that such technologies might bring as a side effect to their major intent.

Earlier in this chapter a number of questions were asked: *Are we at a watershed which is similar to the Age of Enlightenment?* The answer is almost certainly 'yes' but it is important to remember that the Age of Enlightenment took place over a period of 200 years or more and although we are likely to be faster at adopting ideas, a period of 50 years, say, would be a great improvement but is still a long time. It is the cultural aspects which need to adapt before the technologies can be fully harnessed and these are much more difficult to change.

Is there a focus for construction research which might transform our industry? Here we are into the area of speculation but it is possible that a focus on removing many of the interfaces in the construction and manufacturing processes may yield major benefits. This applies to man–machine as well as people–people interfaces and may also be an issue with machine–machine understanding in the future. Construction has spent two hundred years building silos of knowledge as part of an innovation process to build more efficiently – it now needs to unlearn these processes and think in a different way and the integrating technologies will aid this transformation. It is now possible to do what was not possible when the industry had to work within the inadequacies of human thought and limbs.

Is there innovative thinking that we can identify which might provide the transformation? The answer is almost certainly 'yes'. Removing the interfaces is the start but it is not just in new forms of procurement such as alliancing or partnering that this will occur. These do remove the formality of the interfaces but it is technologies such as CAD/CAM in which major advances may occur including the greater development of off-site manufacture yielding efficiencies and better quality control. In this chapter the use of communication technologies which begin to dissolve the geographical barriers has been suggested as ways to improve the interface between people working in the current technologies. Construction will not be immune to the transformations occurring in other aspects of society and the cultural changes that this might bring. It is already clear that new approaches to democratisation are on the horizon and no one quite knows where this will lead even in the short run. Participation will be demanded but at what level and with what authority? It is being encouraged in areas such as sustainable development but will this extend to routine business decision-making?

It is not possible to consider any new technology without addressing its negative impact. As we develop more and more powerful machines and we begin to provide intelligence in these machines which can rival or exceed our own then our perception of ourselves and our ability to solve world problems will change. These are unchartered waters but citizens cannot absolve themselves from the impact this will make. Harnessing technology for good must be the mantra of us all and perhaps the technology can help us identify what is good and what is bad. For construction there is a long way to go before this impact is felt but it is vital that we do not lose sight of our benign objectives for humankind.

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Part 2
Meeting Clients' Needs

CHAPTER 3

Innovation as Proof of Value for Money: The Horizon Alliance

Stephen O'Brien

ALLIANCES AND THE NEED TO DEMONSTRATE VALUE FOR MONEY (VfM)

Why are alliances being used?

The reasons for a project sponsor, or client, to select the alliance model for delivery of a project or program have matured in recent years and are well documented. (Feehely 2007). The reasons include the need to deal with issues such as technical complexity, a challenging schedule, unknown risks, and/or the desire to bring internal capability or add external resources to a project.

Benefits to the client include an enhanced ability to achieve its objectives by aligning the incentives and objectives of the alliance participants, and to flexibly manage the changing project issues and risks (Department of Treasury and Finance 2006). Alliances can extend the reach of participants by 'federating a universe of capabilities' of the alliance participants (Mignot 2006).

One potential drawback which must be managed is the potential lack of transparency of VfM due to the sole-select arrangement of the participants. This applies during development of the project target cost estimate as well as during project execution. Transparency is especially important in public sector procurement. Government agencies need to not only deliver but be seen to be delivering VfM in the projects they implement.

Stages of an alliance

The typical project alliance model includes an initial 'project proposal' phase in which a scope, design, cost estimate and project plan are developed. The main driver for the alliance participants to deliver VfM at this stage is the desire to get the go ahead from the client.

The cost estimate becomes the target out-turn cost (TOC) for the implementation phase. After the client's acceptance of the TOC, the project proceeds on an open-book basis. Incentives are built into the commercial arrangement between the participants to drive VfM and any other client objectives.

A program alliance such as The Horizon Alliance is established to deliver a series of projects. In the case of The Horizon Alliance, the program alliance model offers the client additional benefits in that it:

- locks in the availability of resources even before commitment to any particular project
- allows the alliance to act more as an extension of the client organisation, getting closer to the decision-makers of government and to flexibly respond to its changing needs
- provides the opportunity for lessons learnt to be readily passed on to successive projects.

What does value for money mean to the client?

A common notion of VfM is defined in the following simple formula:

$$\text{Value for money} = \frac{\text{quality, function}}{\text{Cost}}$$

But VfM can mean much more to a client beyond these material benefits. Other aspects that may be of value to a client include community benefits, environment, or rapid completion. A project may deliver legacies such as new understandings, methods, or processes. New standards may be set.

It is important at the outset to identify the areas that are of value to the client and to target innovation to suit. At The Horizon Alliance, specific client objectives include securing resources in a heated construction market and a legacy to attract professionals and build the skills base of the Queensland rail industry into the future.

Demonstrating VfM

The typical project alliance model has a number of features to help ensure VfM in the TOC. Measures directed at getting the budget estimate right include all the contractor's normal commercial tendering processes, such as market testing of subcontract elements of the work and a rigorous risk and opportunity analysis. Additional controls in the alliance environment include:

- benchmarking against similar projects
- setting of corporate overhead and profit by independent audits
- review by independent estimator
- a rigorous system of internal and external reviews
- client participation in the reviews and risk and opportunity analysis process.

Innovation as part of VfM

Whilst the above measures generally aim to prove VfM in the cost component of the TOC, innovation is one of the tools to help prove that VfM has been achieved in the design, methodology and processes that are intrinsic to the TOC.

A common definition of innovation might be 'the successful implementation of a new idea'. In the alliance context, a broader definition can be applied to innovation to include the process of finding the *best* design or the *best* way of doing something to achieve the client's objectives, e.g. best configuration for a road crossing or the best human resources (HR) system.

THE TIMING OF INNOVATION IN AN ALLIANCE

It may appear anomalous that although the greatest opportunities for innovation and hence to deliver VfM are in the interim TOC phase, the direct commercial drivers for innovation and VfM are not established until later in the implementation phase.

In the interim phase the organisations are being planned, the project brief is being developed and the design concepts are being defined. Boundaries and scopes are set. But the commercial arrangements are not mature. The need for simplicity in the commercial arrangements and the need for these arrangements to be developed as a mutual effort between the parties generally preclude the establishment of commercial incentives for innovation.

However, there is consistently a genuine effort to develop a robust TOC at this stage and this typically includes value management workshops to innovate and refine the design. It is common for the TOC submission to include a list of innovations with costings (DTFV 2006). In the absence of direct commercial drivers, innovation and VfM depend on the organisational commitment of the non-owner participants (NOPs) and the desire to see the project proceed through to implementation.

From the HR and administration point of view, this phase includes getting systems and processes set up for the long term. The need to meet this challenge is one of the drivers for innovation and VfM in these areas.

In a program alliance, the opportunity to be presented with subsequent projects is a strong performance driver for the NOPs to deliver VfM at the initial TOC stage of each project. The NOPs see it as worth investing in innovation to build the relationship for the ongoing program of work.

At the implementation phase the commercial rewards are in place to help drive ongoing innovation. These include payments linked to key performance indicators and more importantly the opportunity for the NOPs to share in cost savings achieved against the agreed TOC. Conversely this includes the NOPs aversion to suffering their share of any cost overrun! The alliance is also required to progressively develop a comprehensive VfM report which also includes, *inter alia*, a cost tracking of innovations.

THE HORIZON ALLIANCE

The Horizon Alliance (the Alliance) has been formed as a program alliance to deliver road and rail infrastructure projects for the South East Queensland Infrastructure Plan and Program (SEQIPP). The Horizon Alliance brings together the diverse skills and experience of five organisations: QR, the Department of Main Roads, John Holland Pty Ltd, Kellogg Brown and Root Pty Ltd (KBR) and GHD Pty Ltd. The Alliance's objectives include to:

- meet the demands of the Queensland Government, stakeholders and the public over a range of infrastructure projects
- make available the resources to design, estimate and construct the infrastructure
- deliver a value for money program and projects.

The Darra to Springfield Transport Corridor project (DSTC) is the first project for The Horizon Alliance. The purpose of the DSTC project is to build road, rail and public transport links between Darra and Springfield in Brisbane's south west to service the growing population centres along that corridor and beyond.

Project status

The Horizon Alliance delivered a preliminary design and estimate report (PDER) for the DSTC project to the Queensland Government in October 2007. This report provides outlines and budget costs on a number of options. In January 2008 the Queensland Government announced a decision to proceed with the project in two stages. Stage 1 consists of about 4 km of road and rail from Darra to the Logan Motorway, to be completed by 2011. Stage 1 will include a train station at Richlands. The balance of the transport corridor from the Logan Motorway to Springfield is to be completed by 2015.

The alliance is now proceeding with further development of the design and estimate with a view to submitting a project proposal for Stage 1 in May 2008. The project proposal includes the TOC, the preliminary design and project plans. Subject to acceptance of the TOC by the client, the Alliance will then proceed to project implementation.

INNOVATION TO DEMONSTRATE VfM AT THE HORIZON ALLIANCE

In approaching innovation The Horizon Alliance has adopted the platform of the four-quadrant high-performance model outlined in Wilber (2000). This model recognises that successful innovation comes as much from an individual's frame of mind as from the organisation and systems that they functions within. Team building and team dynamics as well as the role and development of the individual are elements that are considered critical to project success. The Alliance environment allows team members from both owner and non-owner organisations to collectively focus on 'best for project' as a common goal, thus encouraging and enabling innovation.

Examples of the Alliance's initiatives in each of these areas to drive innovation are outlined in Table 3.1.

Table 3.1 The Horizon Alliance Initiatives to Promote Innovation

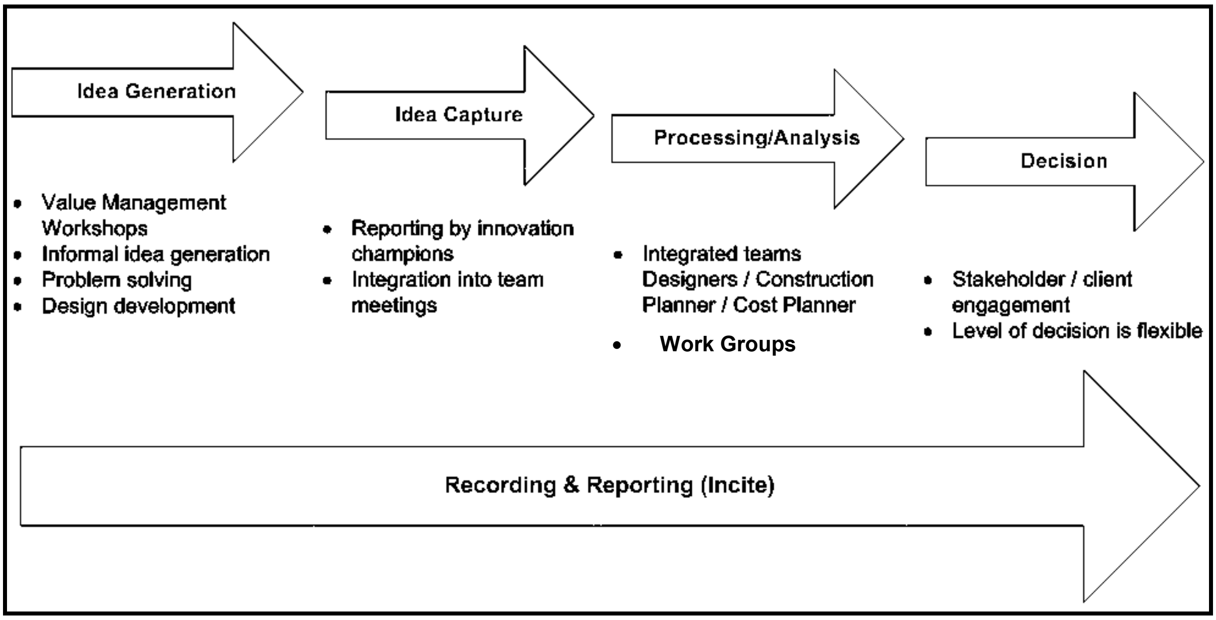
Target area		The Horizon Alliance initiatives
Individual	Values, beliefs and commitment	• Alliance's values defined - one of which is innovation • 'Pulse' committee - to promote the alliance values • Team activities e.g. rowing, art, social
	Behaviour	• Individual reward and recognition e.g. honour board
Group	Culture	• Visibility, communications - 'Innovation Wall' displaying examples of innovation, inspiring quotes, and ideas displayed seeking comments form the broader team • STAR journey (self-awareness, team work, aspiration, relationships). A team education program to promote high performance. The Horizon has committed all staff to this training, based on the Margerison McCann Team Management System • Meeting protocols defined to promote effective and efficient meetings • Alliance history being recorded on video and photos • The weekly team briefing as an 'event', including team-building snapshots.
	Processes and systems, organisation	• Innovation system (Incite) (see below) • Integrate innovation into routine management and team meetings • Innovation champions appointed from within each team. It is the champions' responsibility to administer the innovation system • Organisational - Integrated teams including designers, construction personnel and cost planners, to work on value management and design. Ensures that constructability, hence safety and cost-effectiveness are built in to the design • Challenge team - a panel of external experts to challenge the Alliance's performance at key stages • Open plan office and collaboration spaces, lively decor to foster communication and productivity.

The Horizon innovation system

The innovation system at The Horizon Alliance is designed to record the 'journey' of an idea or innovation in design and other processes. It is intended to help to prove that the Alliance has actively sought and achieved the *best* possible designs and more generally the *best* way to do things.

The typical workflow for innovation was analysed as ideas generation, ideas (or options) processing and then decision (acceptance/rejection). Each stage can be recorded progressively in the innovation system in a form which mimics the defined workflow (refer to Figure 3.1). The innovation system uses an electronic database within the Incite platform (Incite is a web-based information sharing and storage system for the construction industry). The result is the Innovation Register, a recording of the 'journey' of the options and ideas considered along the way.

Figure 3.1 The Horizon Alliance Innovation System Workflow

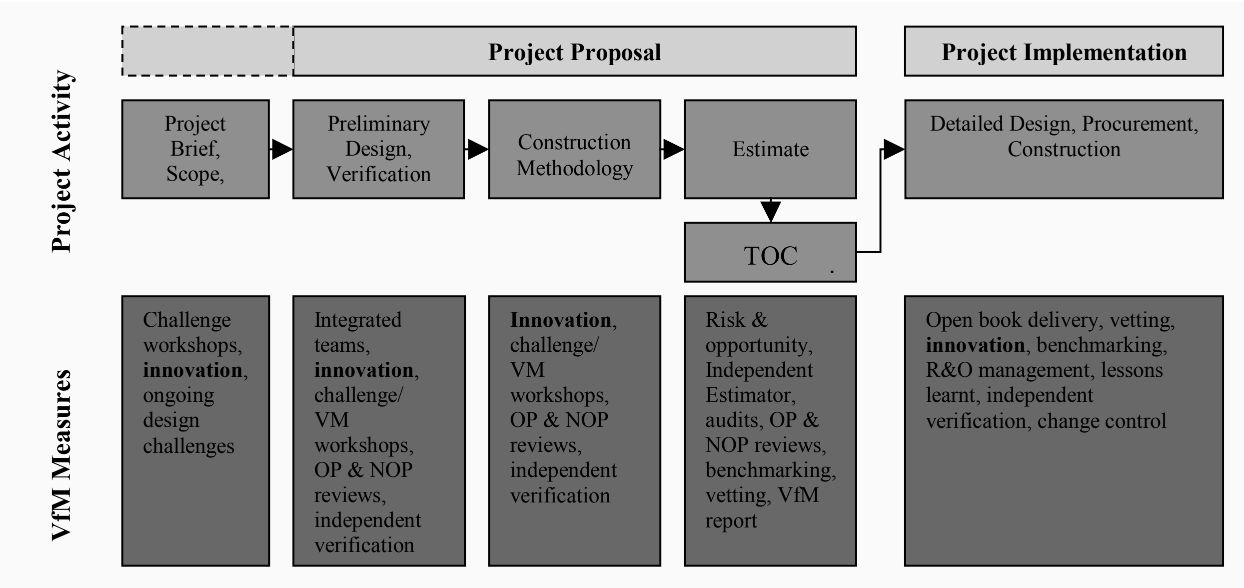


Discipline is required to ensure the thorough recording of ideas. It is easy for a team to consider options, decide and just move on. In the usual pressured work environment there is little time to stop and enter the information into a database, hence the system is integrated into the main design workflow as much as possible to minimise the extra effort in feeding the system. Innovation is discussed as part of regular team meetings across the Alliance and a monthly innovation award is offered as an incentive to participate.

Value for money framework

Figure 3.2 below is a simple representation of the stages of an alliance. The main measures to achieve and demonstrate value are shown. Overall VfM is demonstrated by proving VfM at each stage, and the role of innovation is shown.

Figure 3.2 Value for Money Framework



INNOVATION SUCCESSES AT HORIZON

At the time of writing this paper The Horizon Alliance is in the project proposal phase of its first project. Among the many challenges faced in quickly mobilising this organisation into a high performance team, this section focus must focus on two areas of innovation: project design/construction and planning/estimating, and human resources.

Project design/construction and planning/estimating

From the very early stages of the project, value management and innovation have been applied to the project definition. A rigorous series of value management workshops were held, where all assumptions and rules were open to challenge. This included one full day specifically to challenge the project brief and another three days to focus on the other major design areas. One major outcome of the sessions was that working relationships were established between the team members from the client's and NOPs' organisations, setting up a spirit of open thinking and collaboration.

A hierarchy of reviews was held for the PDER and will be held again at each submission stage. These reviews apply to the design and construction methodology as well as to the cost estimates and risk and opportunity analysis. Reviews are attended by relevant client representatives from NOPs, Alliance management team, Alliance leadership team (akin to the board of directors) and the independent reviewer.

Integrated teams

Ongoing development of ideas and design development are by integrated work teams with designers, constructors and cost planners working side by side. This arrangement was set up to achieve a well thought out, constructible, innovative and value for money project.

The office setup was a determining factor in how well this could be achieved. An open plan office with generous provision of collaboration spaces was arranged and this fosters productivity and open communication.

Challenging the norm

At all times the 'norm' has been challenged throughout the project proposal phase. Areas for challenge include the project brief, the client specification, normal design practice, and normal construction practice.

By having the designer and constructors working together in a less rigid organisation there is the opportunity to challenge the normal practice and develop new and different ideas. By working together in this environment these ideas can be developed further so as to satisfy the client's requirements e.g. specification while at the same providing a project that is innovative and value for money.

Some achievements

Some examples of significant achievements in innovation to date are listed in Table 3.2. Efforts were targeted at the client's specific areas of value, yielding both cost and non-cost benefits.

Table 3.2 Examples of Achievements in Innovation

	Target area	Innovation
Design and Construction Methodology	Logan Motorway Intersection	Rearrangement of this complex interchange has resulted in a major reduction in the total length of elevated structure to be constructed. Result is a reduction in cost and construction impacts. Community benefits. No reduction in the function of the intersection.
	Horizontal and vertical alignment - road and rail	Revision of the alignment to optimize the earthworks cut/fill balance and minimise the volume of imported fill. Reduction in cost and construction impacts and environmental benefits.
	On-ramp at Springfield Boulevard	Originally excluded from scope due to apparent lack of a feasible solution. Innovative arrangement of on-ramp where a conventional design was not possible to fit. Improved functionality yielding community benefits.
	Shared pathway	Inclusion of a shared pathway for cyclists and pedestrians for the full length of the transport corridor, with connections to local roads and paths, to meet community expectations.
	Rail maintenance access road	Arrangement of maintenance access to the rail corridor has yielded significant savings in the number of structures for the rail maintenance access road.
	Rail structures design live load	Savings in rail structures and embankment by matching the design live loadings to the passenger rollingstock.
Other Areas	Approach to scope changes requested by the client	When the client asked the Alliance to undertake a number of optioneering exercises on top of the original ‘base case’, flexibility was taken to a new level. The team’s method of response was itself an innovation. Through careful structuring of the options, the Alliance succeeded in delivering a number of options with only a nominal increase in time and resources. Due to the dynamics of the team and the ability of the parent companies to resource staff as required, the options analysis was efficiently managed and the design output was delivered.
	Community consultation approach	Conducting a targeted consultation approach on specific aspects of the project rather than blanket broadband engagement approach e.g. Richlands station and Springfield Link Bridge.
	Western Corridor Transport Information Centre	Horizon Alliance proposed and was the driver of the Western Corridor Transport Information Centre which is currently being proposed for development. This would be a one-stop-shop for information about all Queensland Government transport projects in the western corridor.
	Community consultation benchmarking	A market research survey was conducted prior to any KPI measurement which enabled us to establish a benchmark and to track future progress.
	Environment and sustainability	Numerous environmental initiatives. Major sustainability audit of the Alliance is proposed, with a view to ongoing reporting of sustainability performance along with conventional measures e.g. budget, program or safety.

How does The Horizon Alliance’s VfM compare to industry so far? The estimate in the PDER (October 07) is on par with the budget of the business case (November 06), yet represents a somewhat increased scope (shared path and on-ramp added). This compares favourably with industry where escalation is estimated to be running at about 15 per cent per year (Evans and Peck 2007). Hence significant value has been added.

PEOPLE CAPABILITY

The human resources challenge

The Horizon Alliance must innovate in the development of its HR processes to meet the immediate challenge of recruiting 400 white-collar and 500 blue-collar workers in six months, whilst simultaneously setting up long-term systems for the program alliance. The Alliance, as a virtual organisation, creates in itself a range of extraordinary people challenges. For example, there are no Alliance employees, as all employees retain their home organisation employment. The challenge is to develop broad Alliance-specific people systems and procedures which integrate each of these people into a workably aligned and functional entity of the Alliance, whilst interfacing with HR systems and processes of the home organisations.

Options considered

Every aspect of HR service provision was analysed and a range of strategies designed to support the Alliance’s long-term people capability. Some of the adopted responses/results include:

- monthly Alliance Management Team meetings dedicated to Alliance team/people development
- consolidation of the different approaches of five parent organisations e.g. integration, collaboration and separations procedures, alliance procedures that meet parent organisation expectations
- electronic personnel filing
- internally designed employment lifecycle portal on the Horizon intranet - to provide ease of access to the full suite of human resource tools, with access control as appropriate.

Examples of the innovative approach adopted in response to the HR challenge are provided in Table 3.3.

Table 3.3 Examples of the Innovative Approach to the HR Challenge

Issue	Innovative response
Attraction and recruitment strategy, branding and marketing	Staff and market research to understand key influences on candidate attraction. Partnering with an expert recruitment strategy and advertising agency to devise a unique Horizon Alliance 'creative', or strategy. This creative covers all aspects of the Alliance's approach to the employment market. Based on a detailed understanding of: • the employment market • staff wants and needs • realities of the employment experience.
KPI reporting	In-house design of tools for tracking performance of key elements of people-based systems and processes
Revamp of HRM engagement plans	Raised to strategic people-capability model
Chris 21 HRIS development	Adoption of information system which provides a one-stop shop for gathering, reporting and forecasting of people - capability matters.
Employee referral program	Rewards employees for referral of other potential employees
STAR Journey • self-awareness • team work • aspirations • relationships	Commitment to provide 4 hours per employee each month for leadership and team development program. Based on Margerison-McCann Team Management System.
Alliance health surveys	Regular on-line staff surveys to gauge staff perceptions
Health by design	Health checks, diet and lifestyle coaching
People transitioning	Clear procedures to manage an individual's transition between phases of the alliance
Onboarding and inducting	Broad-range induction focused on high-level people issues and values. Buddying with an established employee.
Developing supervisor/manager people management capability	Supervisor skill program providing individual programs to fill specific gaps.

OBSTACLES TO VfM

Client needs

Do government agency clients really want innovation? These organisations have standards and systems developed over many years. There are established statewide maintenance processes that favour standardisation, hence conformance to past practices. This considered approach is perfectly valid given the difficulties these organisations typically face under their responsibility to maintain this infrastructure for decades and centuries to come.

Hence changes to the project brief are only achieved after detailed and sometimes lengthy consideration. To encourage the adoption of new ideas, the Alliance has engaged the client in value management workshops and reviews. Proposals for change to the brief are backed up with detailed consideration of all the issues that may affect the future life of the infrastructure, and an indication of the benefit that may be gained.

In the case of The Horizon Alliance it is clear that VfM is expected by the client. Hence innovation is also expected, yet not at the expense of reduced quality, function, maintainability or durability.

Getting on with the job

The main difficulty that The Horizon Alliance faces daily is the gathering of resources to get the job done within the client's desired timeframe. An army of design engineers, drafters, estimators and cost planners have been seconded from the NOP organisations, and supplemented by contract staff where necessary. This has often invoked the high-level commitment of these companies in drawing on their already stretched in-house resources.

The focus on going forward under pressure has often led to the overlooking of the innovation register, resulting in significant gaps in the recording of the 'journey' of innovation.

RESULTS

Has the Horizon Alliance successfully achieved and proven Vfm to the client?

In terms of performance against budget for the Alliance's first project, the answer to this question must be 'yes'. There is no increase in budget in 12 months despite an increase in scope and one year's escalation.

As is typical for an alliance, there has been significant effort to *prove* the price is right. Resources have been mobilised for proving measures such as independent verification and client reviews, on top of all the usual competitive tendering processes, in particular risk and opportunity analysis.

Has the Alliance succeeded in proving the scope and that the design and the process are right? It cannot be said that the innovation register on its own effectively achieves this. Whilst acknowledging that the register has significant gaps, it remains as testament to the focus on searching for VfM in all areas. And the client has been witness to that ongoing effort.

The culture of innovation is visible in the organisation, the work environment and the behaviours of the team members. There is no doubt, however, that this will need constant reinforcement.

As this paper is written, the outcome of all these initiatives and processes still lies ahead. The PDER for the DSTC project has passed the test of acceptance by the series of multiparty reviews, the independent auditor and the other controls listed above.

The Alliance is now proceeding to the project proposal, scheduled for the first quarter of 2008. With focus on the government's preferred option there will be another round of pursuing innovation and VfM, including:

- more value management
- design and construction methodology development and optimisation
- challenge team
- estimating updates and refinement
- risk and opportunity analysis
- internal reviews (NOP and client)
- independent audits and reviews.

The ultimate test of proving VfM in the TOC will be acceptance of the project proposal by the Queensland Government and the green light to move on to the project implementation phase.

Room for improvement

As noted above the innovation register is not a full record of options and ideas because of a general pressure on resources. The 'historian' role of the innovation champion in each team needs to be reinforced and time made available for this function.

The register shows that some ideas have been recorded but not fully explored. These are generally minor and have been considered as opportunities in the risk and opportunity analysis. Follow up on all these ideas should be addressed.

Measures to encourage (individual) innovation can be reinforced. Areas under further consideration are:

- focus on the mindsets of our people, and avoidance of the 'business as usual' way of doing things
- better integration of innovation recording into the design workflow
- better integration of innovation issues into the design team meetings
- environmental initiatives
- coaching, mentoring
- leadership initiatives.

Benefits and Implications for the industry

The need to prove VfM in the Alliance Model for infrastructure delivery is still a hot issue.

The view so far from The Horizon Alliance is presented here to share the alliance's experiences as part of the industry's learnings on this fast-developing area, for the benefit of others on the alliance journey.

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Combined Evaluation of Workplace Performance using Occupants' Subjective Assessment and Objective Measurement of Environmental Conditions: A case study

Brian Purdey
Mark Luther

BUILDING AND WORKPLACE EVALUATION

We have built environments to provide safe and functional workspaces for occupants and employees, not simply to have a building as a low-cost space to operate, or an energy-efficient asset. The functional performance as experienced and assessed by the users determines the effectiveness of the building 'in-use', the extent of operation effort required and energy consumed. Occupant feedback should therefore be used to guide technical evaluation in order to deliver the most cost-effective approach to improving occupant and building performance outcomes.

This paper presents a case study on the combined evaluation of workplace performance using occupants' subjective assessment and objective measurement of environmental conditions.

The term 'functional performance' subsumes comfort, health, satisfaction and productivity of those using the built environment. The first three measures are qualitative, whereas productivity is considered, or at least has been considered, a quantitative measure. The general perception in the property and facility management community is that office productivity and the productivity of knowledge-based workers cannot be quantified and therefore cannot be measured. The authors of this paper regard this as a myth.

The Productivity Commission of Australia defines aggregate productivity, as: 'output per unit of input.' Inputs are either labour (generally measured in hours or numbers of people), capital, and the combined or multi-factor effects of labour and capital working together.

Capital can be hard(ware), like building facilities and workplaces/workspaces, or software and systems. Outputs can be tangible, like products or in our increasingly service-oriented economy, or intangible like value. Implicit in these descriptions is recognition by the Productivity Commission that productivity is now an efficiency-plus-effectiveness concept.

In any workplace there are three major factors contributing to productivity:

- labour intensification - basically this means that people are working longer hours
- capital deepening - essentially the result of investment in capital plant and equipment which over time may replace labour
- multi-factor effects - the combined effects of investment in capital and labour.

In office environments, the interaction between capital investment and labour are complex and it may be difficult to link inputs at the micro level to output at the macro level (and vice versa) due to the nature of the organisational system. The problem of measurement is further complicated by the variable timeframes between inputs and outputs.

However, modern office work is such that many employees have a narrow task focus, and not all employees are engaged in highly innovative, creative or knowledge-intensive work. All jobs do have some knowledge component but for the vast majority of employees this knowledge is codified to systems and routines, policies and procedures (e.g. for accounts payable staff).

Behavioural research indicates around 9 per cent of the total task workload is directed towards delivering 'innovation performance outcomes' while approximately 72 per cent of effort is related to 'efficiency and effectiveness' outcomes.

However, despite the availability of these outcome-based measures for work performance, actual measurement may still be cumbersome, time consuming and need to be task-specific. Assessment of office work performance while possible, still remains difficult in practice.

How can workplace performance be more simply but reliably measured? In the field of workplace productivity measurement, a range of indicators can be used, but the most reliable is occupants' self-assessment. Self-assessment measures are strongly correlated with actual measured productivity (Mabe and West 1982; Oseland 1999; Oseland and Bartlett 1999), and if the self-assessment questions are framed appropriate to the work context, then this approach is the most cost effective. The KODO probe survey method has adopted self-assessed productivity as one measure for functional performance.

Another question relates to the reliability of employees or occupants. Can they make sound evaluations of their workplace? Should one leave the assessment of buildings to the experts?

Our experience is that if occupants are given the opportunity to express their experience in their environment, they are equally likely to say something positive as they are to say something negative. If a sufficient sample size is used then extreme responses get sorted out. In practice a sample size of 50 responses can be enough to get a good picture of the building.

A representative sample of all of the building occupants is also better than a 'sample size' of one, being the building, property or facility manager, who may not live in the building anyway.

Table 4.1 compares the actual results from performance evaluations of nine Sydney buildings by the property manager and the employees in terms of the impact of the building on their productivity. The first column indicates the property manager's off-the-top-of-the-head rating of the buildings from the best to the worst. The second column shows responses from around 1000 occupants in all of the nine buildings. The comparison shows rankings are the same.

Table 4.1 Property Manager and Occupant Assessment of Building Performance

Property manager assessment	Occupant assessment of building impact on productivity
Building 1 (best)	+ 7.5%
Building 2	+ 1.1%
Building 3	- 1.7%
Building 4	- 1.6%
Building 5	- 4.2%
Building 6	- 3.9%
Building 7	- 6.5%
Building 8	- 6.7%
Building 9 (worst)	- 10.1%

However, the occupant survey provides further feedback as the occupants actually indicate the nature and extent of the building-related issues impacting performance and their relative significance. These additional pieces of information are important when developing strategies for occupant performance improvement.

Although occupants' surveys are useful to obtain a general rating of the space and to pin-point specific aspects of performance shortcomings in the built environment, they are often not sufficient to base design development for improvement measures on. Here environmental performance measurement can be used to identify and investigate the objective reason for inadequate performance, highlighted by the qualitative survey.

KODO probe© occupant survey

KODO Pacific is an Australian consulting firm specialising in workplace strategic planning and performance evaluation. The KODO probe[1] survey method was developed locally and in the past four years has been used to successfully evaluate the performance of more than 60 buildings and capture the experiences from more than 5500 building users. In doing so KODO has gained a reputation for leadership in occupant assessment of building performance.

Mobile Architecture Built Environment Laboratory (MABEL)

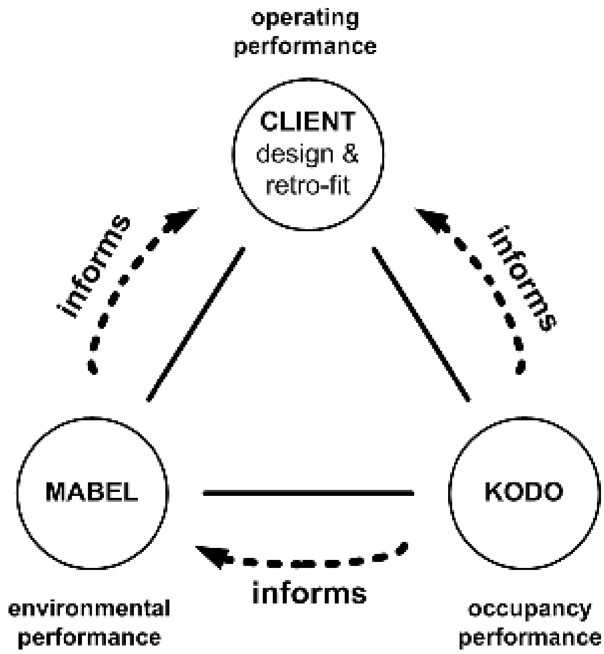
The Mobile Architecture and Built Environment Laboratory (MABEL) is a facility of the Built Environment Research Group at Deakin University providing environmental measurement services in research and consulting projects and is specialised in holistic diagnostics of physical comfort conditions in the built environment (Luther and Schwede 2006). A MABEL study involves the collection of environmental parameters to assess the performance in the thermal, visual and aural comfort domains and indoor air quality. It is usually conducted in a number of representative building zones. The various room climatic parameters are captured, either continuously or in detailed survey measurements at specific times of the day. Additionally the outdoor conditions are measured continuously.

Combined investigation using KODO probe and MABEL

The KODO probe survey and the MABEL environmental measurement scheme generate two complementary sets of building performance information (see Figure 4.1). Subjective performance measures as provided by KODO probe are useful to diagnose building performance across a wide range of environmental domains, using an inexpensive but sensitive instrument. KODO probe results are able to identify the problems, but may not be specific enough to fully inform the design of improvement to the built environment.

[1] probe = productivity occupancy in the built environment

Figure 4.1 Occupancy–environment–operation Performance Framework for Building Performance Evaluation



MABEL measures environmental variables (light, noise, thermal comfort, air quality, etc.) of the building performance as related to international standards and best practices. This objective information is used here to assist the subjective results as provided by KODO.

In the presented case study KODO results are used to inform the client and the design of targeted MABEL measurements. MABEL results are used to help improve the design of specific building improvement measures based on objective physical measurement in response to performance shortcomings perceived and reported by occupants in the KODO survey. Together KODO and MABEL further the development of most cost-effective performance improvement solutions that require little or no additional capital investment.

The methodology of the combined investigation in the presented case study is described in more detail later in this chapter.

NSW Government Workplace Performance Evaluation Program

In early 2005 the Department of Commerce and State Property in New South Wales realised an opportunity in a rolling program of evaluation of its owned and leased properties. It commissioned KODO to:

- demonstrate the processes used by the department to deliver base buildings with above average performance
- ensure the accommodation solutions provided in the tenancies support agency business needs with productivity outcomes for occupants and other key indicators at or above Australian benchmarks
- provide feedback to improve current design and management processes.

CASE STUDY

Government office building, Lithgow

The NSW Government office building at Lithgow is located at 61 Railway Parade, and comprises three office floors and a basement carpark. The building forms part of the NSW Crown Property Portfolio and is owned by NSW Treasury. State Property manages the building (area 2900m^2). The base building has been designed to be very energy efficient and to achieve a 4.5 Stars Australian Building Greenhouse Rating (ABGR).

Methodology

The KODO probe method is a robust building performance evaluation system used to measure occupant responses to built environment factors known to have the strongest association with human comfort, health, satisfaction and performance. It evaluates 90 factors grouped into 15 key result areas covering the base building, tenancy, workspace design and management issues. The data was collected using a paper-based survey in this instance because not all employees had access to the internet (online survey) and the survey was complemented by workplace observation, management interviews and employee focus groups.

KODO conducted its first post-occupancy evaluation of the building between late November and early December 2005 and identified issues that were having a detrimental impact on occupant performance. These issues enabled the MABEL team to focus their technical evaluation of the building and a joint survey of occupants and actual building performance was carried out between late June and early July 2006. MABEL provided the following services to the project:

- thermal comfort assessment (ISO-7730) with PMV (predicted mean vote) result
- air temperature stratification (0.1m, 0.6m, 1.1m, 1.7m)
- facade temperatures (internal and external) and a heat-transfer assessment of the facade (calculated or measured) through thermal imaging
- acoustic testing of the office background noise (in an octave-band frequency analysis), as well as the reverberation time of the space
- CO_2 levels, VOC indicators and an air-change rate (ventilation rate of the building)
- lighting assessment, including glare and luminance measurements
- weather, solar radiation and lighting data collection (outside).

Internal measurements were taken on two floor levels at locations with identified performance shortcomings. Measurements were conducted continuously and at selected time intervals (10:00, 13:00 and 16:00).

The final report allowed the qualitative and quantitative data to be overlayed to determine the most cost-effective approach to performance improvement.

Productivity topographical maps

To date, conventional performance evaluations of built environments have tended to provide aggregated results from all occupant responses, with perhaps some basic graphical representation of the distribution of responses around the sample mean or appropriate benchmark. While this is useful feedback, what designers and managers are really interested in is *where* exactly in the building are there performance ‘hot spots’, and *what* should the improvement initiatives be focused on – the physical aspects of building or the tenant and the organisation of its occupancy?

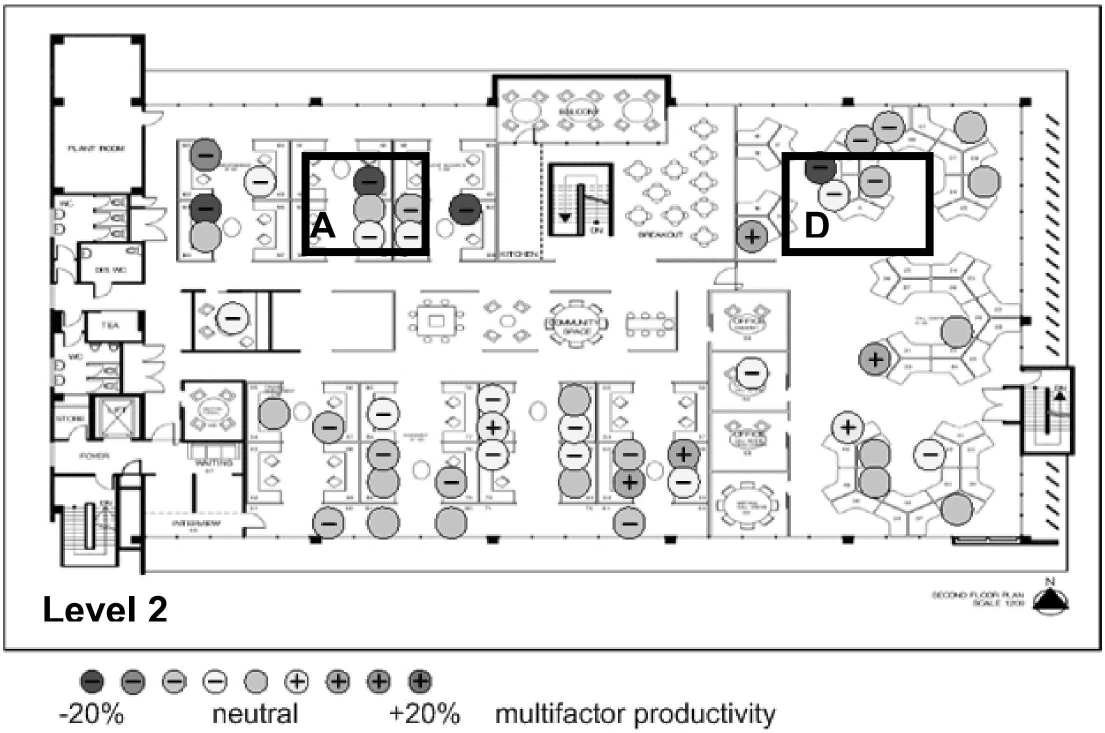
In the case of the Lithgow building, the **productivity topographic maps©** were developed to understand how productivity impacts on occupants were distributed across the floor plate.

The distribution depicted in Figure 4.2 shows quite clearly that all occupants on the north side of the building rated the productivity impact of the built environment as either neutral or negative. The fact that the occupants in this area rated the impact of their environment on their own performance uniformly indicates that a building-related problem is prevalent and building-related solutions are required.

However, in the other parts of the floor plate the results were quite mixed, pointing more to tenant-based solutions not necessarily requiring capital investment. For example, would it be possible to move people whilst maintaining the integrity of the work group?

With these results the MABEL investigation is informed to understand the physical environmental characteristics on the north side of the building where building-related problems are prevalent.

Figure 4.2 Productivity Topographical Map and MABEL Investigation Locations (A and D)



Key performance indicators

Figure 4.3 provides a visual snapshot of the overall performance in terms of key performance indicators. The 50 per cent score represents the Australian Benchmark in the KODO probe database. Scores above this figure indicate better than benchmark performance in this building/workplace. The single-issue indicators (building design, building facilities, office facilities and noise) of the overall performance of the workplace point to a slightly above-average base building. There are significant concerns related to lighting in the workspace itself. The five indices (occupant satisfaction, masterbranding, building usability, user control and building comfort) similarly provide a single performance score, based on a composite of contributing factors. The indices are key performance indicators derived from the occupant responses, and reflect a combination of responses to individual performance measures appropriate to the index itself. Clearly these measures point to a below-average assessment of building comfort conditions which, when combined with the lighting scores, results in a just-average satisfaction score and a negative impact on occupant productivity.

In relation to thermal comfort conditions particularly, the evaluation was particularly concerned with the extent to which any occupant discomfort might be translated into adverse work performance outcomes. Figure 4.5 shows the results from the occupant assessment of the impact on their performance when they were bothered by thermal comfort conditions. In the case of the Lithgow building, 60 per cent of respondents to the survey (about half of the total population) indicated that on average they considered they were 'as productive as usual' for only 76 per cent of the time when affected by the thermal comfort conditions.

With these results it would be unwise to automatically assume that adverse comfort conditions causes productivity to fall off by around one quarter, but it does indicate a high degree of occupant sensitivity to variations in thermal comfort condition and a positive link to lower human performance outcomes as a consequence.

This finding was an issue of concern to both the building owner and the tenant in this instance.

Figure 4.3 Lithgow: Key Performance Indicators Compared to the Australian Benchmark (July 2006)

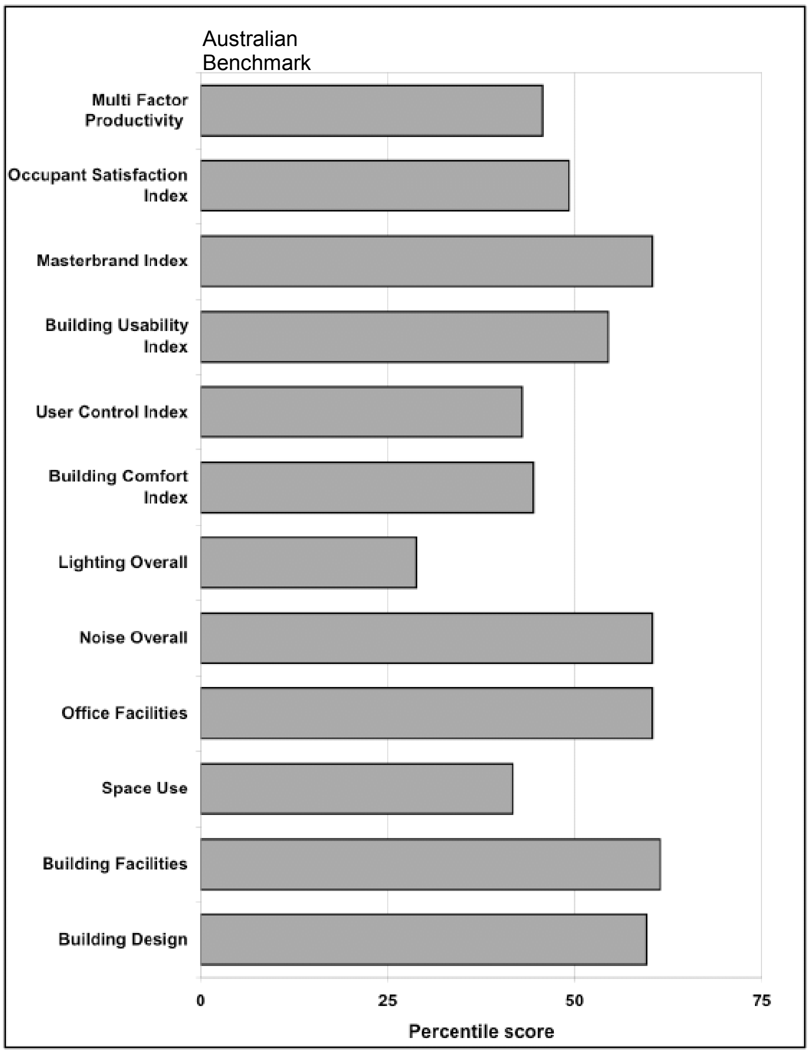
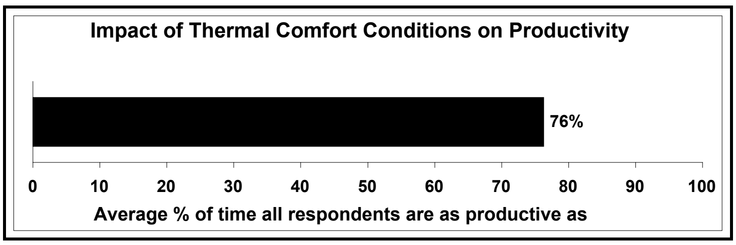


Figure 4.4 The Impact of Thermal Comfort Conditions on Productivity



Discussion of findings: KODO and MABEL results

Lighting at location A

The KODO study has found that the overall lighting conditions are not satisfactory and the multifactor productivity at location A (refer to Figure 4.2) is rated as poor (-20%). The KODO study suggests that a building-related problem is prevalent in this area.

MABEL confirms the lighting conditions found through the KODO survey. The results for one location are shown on the right side of Figures 4.5 and 4.6 in form of luminance maps (brightness) showing the luminance range from 1 to 5000 cd/m^2 for a workplace at location A. Values exceeding this range are shown as white spots in the picture. The left picture shows the same location in real colour for location reference only (not for assessment of the lighting conditions).

The pictures are indicative of the surface brightness levels at the workstation facing the north facade of the building. Figure 4.5 indicates a workplace location (somewhat removed from the perimeter) where a direct solar source is in the field of view. Although Figure 4.6 indicates the same time period moments later with the blinds drawn, bright sources from the overhead lighting continue to exist.

This perimeter location is an example of where occupants require greater control over the daylight level penetration onto the workstation. Contrast levels between the electric lighting fixture and the surrounding surfaces are high with respect to the immediate task area. There is some control capability via the blinds, but it is a concern that the building design itself does little to incorporate the diffusion of direct lighting.

Figure 4.5 Area A – Luminance Measurement at 15:30 (Blind Up)

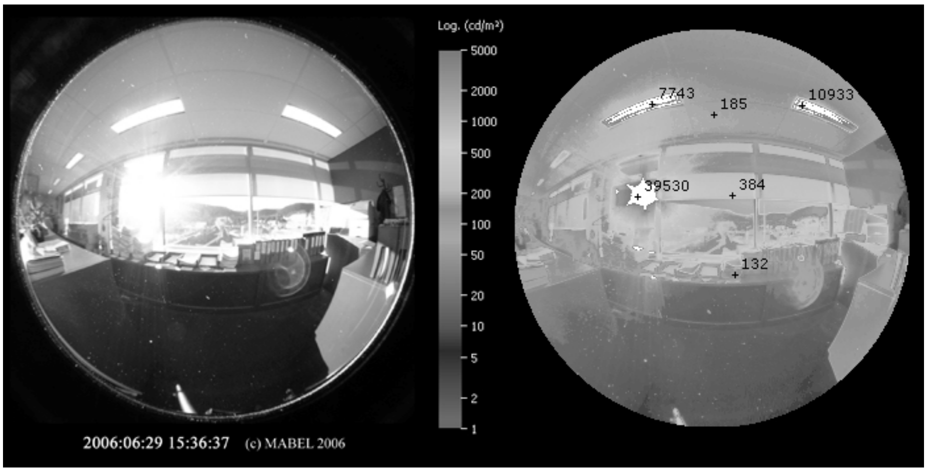
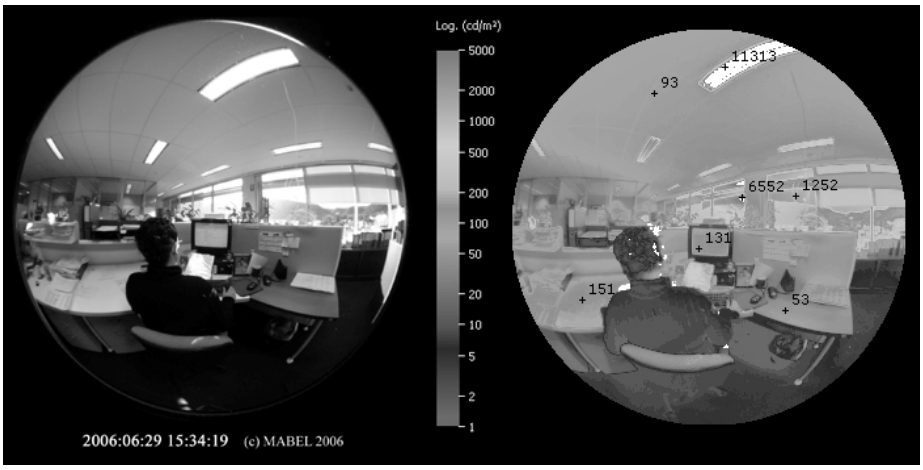


Figure 4.6 Area A – Luminance Measurement at 15:30 (Blind Down)



Noise at location D

Background noise is measured in the ‘survey mode’ at all locations. The background noise measurements for all investigated locations at 13:00, with occupants, and at 20:00, after hours, are shown in Figures 4.7 and 4.8. Figure 4.7 shows that the average sound pressure level at occupied location D is in the range between 55 and 65 dBA, the range of normal conversation. Note that the maxima exceed this range by about 10 dBA and the total variation is about 25 dBA. The results for the after-hour measurement in the same area show that the sound pressure without occupants is within the recommended range of 40 to 45 dBA with only a small variation of 5 dBA. The space can be over four times louder than when unoccupied.

The direct comparison between the measurement with occupants at 13:00 and without occupants at 20:00 show also that the measured sound-pressure ranges do not overlap. This indicates that a permanent ‘manmade’ sound environment is prevalent during occupied hours. As location D is located in a call centre, it can be assumed that this noise is information-rich (speech) and therefore intrusive and disturbing.

This analysis suggests that better speech privacy between the call centre workplaces should be investigated.

Figure 4.7 A-weighted Sound Levels and L_{90} and L_5 Values at 13:00

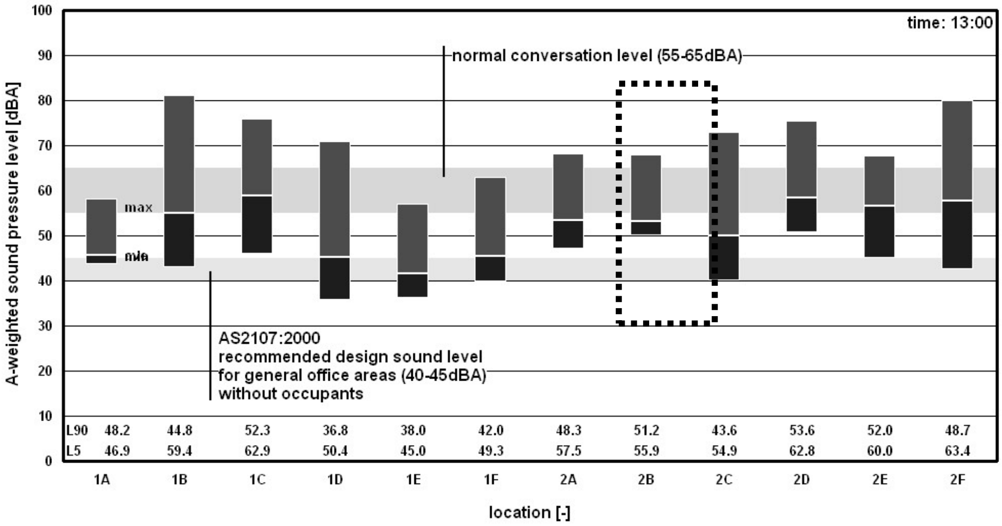
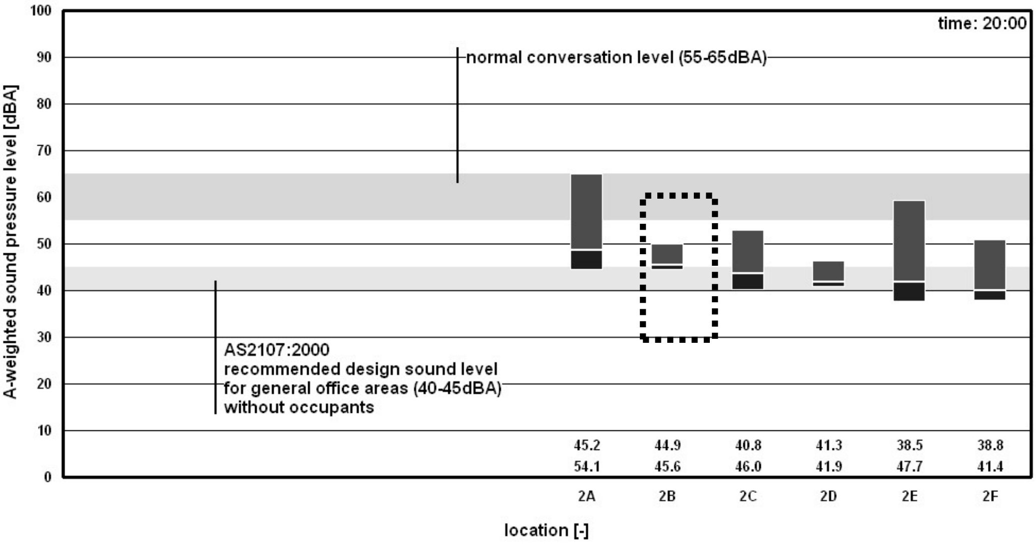


Figure 4.8 A-weighted Sound Levels and L_{90} and L_5 Values After Hours at 20:00



CONCLUSION

The value of a combined subjective (KODO) and objective (MABEL) measurement is demonstrated for the ABGR 4.5-Star Lithgow NSW Government Office building in the identification and 'shortcomings' of productivity-effective environmental conditions, namely office background noise and light conditions.

Through analysis of occupant survey results in **productivity topographic maps©** the KODO study separates capital investment building solutions from non-capital soft solutions. Thereby it guides the more expensive and extensive technical evaluations with MABEL to investigate the productivity-effective environmental conditions.

The KODO study identifies the building and occupancy problems. It informs the client as well as being further validated by the MABEL study, while the MABEL measurement informs the design and retrofit of specific improvement measures. The combination of both ensures that the building owner and occupants get the best and most cost-effective results in performance improvements.

This case study demonstrates the benefit of leading-edge practice in evidence-based performance evaluation and the continuing development of commercial benefit of innovative and effectively combined performance evaluation tools like the KODO probe survey, the **productivity topographic maps©** and the MABEL measurement scheme.

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Streamlining Local Government: Evaluating an eGovernment initiative in South-East Queensland

Craig Furneaux
Nik Vassilev
John Burgess
Kerry Brown
Michael Ward

INTRODUCTION

Recent initiatives around the world have highlighted the potential for information and communications technology (ICT) to foster better service delivery for businesses. Likewise, ICT has also been applied to government services and is seen to result in improved service delivery, improved citizen participation in government, and enhanced cooperation across government departments and between government departments.

The Council of Australian Governments (COAG) (2006) identified local government development assessment (DA) arrangements as a ‘hot spot’ needing specific attention, as the inconsistent policies and regulations between councils impeded economic activity. COAG (2006) specifically suggested that trials of various ICT mechanisms be initiated which may well be able to improve DA processes for local government. While the authors have explored various regulatory mechanisms to improve harmonisation elsewhere (Brown and Furneaux 2007), the possibility of ICT being able to enhance consistency across governments is a novel notion from a public policy perspective. Consequently, this paper will explore the utility of ICT initiatives to improve harmonisation of DA in local governments.

Specifically, this paper examined as a case study the recent attempt to streamline DA in local governments in South-East Queensland. This initiative was funded by the Regulation Reduction Incentive Fund (RRIF) Program, and championed by the South-East Queensland (SEQ) Council of Mayors. This paper examines the ways in which increased harmonisation was achieved through the project.

LITERATURE REVIEW

This literature review outlines the concepts of eGovernment and eGovernance as these relate to enhanced service delivery through the use of modern ICT. The espoused benefits of eGovernment over traditional service delivery are examined and will be used as a framework for evaluating the recent attempt to improve DA processes in South-East Queensland.

Definitions

Central key concepts to understand this initiative are those of eGovernment and eGovernance, which are defined and explained below.

eGovernment

eGovernment (sometimes rendered as e-government or E-Government) refers to the development and application of ICT towards the improvement of activities in the public sector. The Audit Office of New South Wales argues that eGovernment is about improving the efficiency and effectiveness of government by using the Internet and related technologies (Audit Office of New South Wales 2001).

In turn ICT allows for the development of new ways for delivering services, and provides for opportunities for new partnerships within the public sector and between the public sector and other sectors. According to Becker et al. (2006), eGovernment entails the simplification and implementation of information, communication and transaction processes, in order to achieve, by means of ICT, an administrative service, within and between authorities and, likewise, between authorities and private individuals or companies (Becker et al. 2006).

An important, if not central, point about eGovernment is that ICT is the platform or facilitator for systems and institutional change. By moving service delivery online, organisations are forced to examine their own structure, examine their own policies and operating procedures, and examine how they relate to customers and other stakeholders. eGovernment is not simply about developing and implementing a technology, it is about building organisation and governance structures to support the organisational implementation of the technology (Saxena 2005).

eGovernment has fiscal and social dimensions. The fiscal dimensions are about the quality and cost of service delivery. The social dimensions are about improving citizen access to government and developing more effective and interactive mechanisms between the government and all community stakeholders. Hence the OECD (2003) argues that eGovernment is more about government and less about 'e'. In particular, 'IT should not be considered in isolation, as it has become an essential instrument to transform the structures, cultures and operations of government' (OECD 2003, 2). Thus for government ICT processes do more than just enhance efficiency, they enhance or enable the engagement of citizens in the process of government. This then, leads to the concept of eGovernance, which is central to the development and implementation of eGovernment.

eGovernance

While eGovernment provides the opportunity to rethink how the government provides services and how it links them in a way that is tailored to the users' needs, eGovernance is far more about people and politics than it is about technology and rationality (Heeks 2001). In essence governance is about the system of organisation and management that supports the IT systems. Governance requires public sector organisations to re evaluate their organisation, their rationale, their operations and their relationships with stakeholders. If governments can achieve this radical new conception of their role, then there is the potential for eGovernment to transform 'not only the way in which most public services are delivered, but also the fundamental relationship between government and citizen' (Symonds 2000, S3). eGovernance contributes to the functioning of democracy by online provision of government information which would otherwise be difficult to obtain or unavailable, and through online debates and plebiscites (Teicher et al. 2002, 14).

An eGovernance focus needs to be differentiated in the literature from techno-centric views of eBusiness. Unfortunately, most interpretations of eGovernance have been techno-centric to date. Bringing a governance-centric focus, though very much desirable, is often difficult as it requires addressing a number of critical issues. Saxena (2005) argues that these are:

- *Defining a citizen-centric or governance-centric vision for the eGovernance projects.*
- *Developing a process-oriented view of government work* – which enhances collaboration within and between government agencies.
- *Developing a performance management system* for efficient and effective service delivery.
- *Defining a flexible technology architecture* that is secure, provides easy access to users, and is scalable for high-volume operations as well as being cost-effective for the government.

Organisational support is required at a number of levels to support the ICT platform. Few incentives have been built to encourage adoption of eGovernance initiatives within government. For example, governments have seldom incorporated marketing into their eGovernment activities, nor have they targeted specific segments of their user base to encourage taking advantage of those services.

Benefits of eGovernment and eGovernance

The benefits of eGovernment and eGovernance initiatives are examined below. Benefits are not interpreted here in purely monetary terms, but in a broader sense of costs and benefits to business, consumers, government and society at large.

Direct benefits of eGovernment and eGovernance

The potential advantages of eGovernment are significant in terms of financial and efficiency gains but also in terms of in the effectiveness of delivering core services and in more effectively accessing stakeholders and developing new relationships within and outside of the public sector. eGovernment may help break down government agencies' boundaries and jurisdictional barriers to allow more integrated whole-of-government services across the three tiers of government in Australia (Huang et al. 2002). This breaking down of silos also applies within the same tier of government in terms of more effectively linking departments and agencies within the one tier of government. Reaching out to citizens and communities to not only deliver better quality services, but provide more service access, is an important purpose of eGovernment. Beyond these frontline objectives eGovernment provides opportunities for improved citizenship and partnerships developing within and outside of the public sector.

Various authors (Huang et al. 2002; OECD 2003) argue that the benefits of eGovernment are:

- *Efficiency gains* – savings in data collection, information provision, communications with clients and transaction costs
- *Service improvements* – improved customer focus for service delivery and increased accessibility to services
- *Improved policy outcomes* – through information sharing, interaction with citizens and explaining policies and programs
- *Improved governance* – through openness and ongoing communication, and greater communication with stakeholders
- *Building trust* between government and citizens – through opening up policy development, explaining policies and ongoing communication.

Indirect benefits of eGovernment/eGovernance

The development and application of eGovernment processes in itself can generate indirect benefits that may not have initially been foreseen, but are important byproducts of eGovernment.

Often the processes of developing and delivering eGovernment requires organisations to examine how they deliver services and how they relate to other divisions within the same organisation and to other organisations in the public sector. Harris and Cornelius (2003) conclude that the development of eGovernment systems leads to new organisational architecture and new ways of doing business and delivering services. Inter-agency collaboration over the delivery of one service can lead to ongoing collaboration over the delivery of additional services. Inter-agency information sharing results in offering fewer contact points for end-users of public services, thereby leading to more efficiencies in the delivery of these services to the end-users (Bajaj and Ram 2003). In addition there is an educative and knowledge-sharing process that enables separate departments and agencies to better understand what is happening elsewhere within the one organisation or in other organisations. Information sharing can result in more effective policy design but also result in agencies and their employees developing a holistic view of service delivery. eGovernment allows for empowerment of citizens in their being able to seek out the information they require on their own accord (Tan et al. 2005).

By reviewing the available literature on eGovernment and eGovernance, there are a number of consistent themes which emerge from the literature, which could be expected from such initiatives. Those themes which occur numerous time in the literature are detailed in Table 5.1.

Table 5.1 Summary of Benefits of eGovernment Projects Identified in the Literature

Benefits
Inter/Intra government collaboration
Improved engagement of citizens
Improved service delivery
Improved access to services
Reduced cost to the consumer
Transparency of government processes

METHODOLOGY

Public policy case studies have been called for as a way of advancing public policy practice (Osborne and Brown 2005). A case study is 'a method for learning about a complex instance, based on a comprehensive understanding of that instance obtained by extensive descriptions and analysis of that instance taken as a whole and in its context' (US General Accounting Office 1990, cited in Mertens 2005, 237). Case studies provide for in-depth analysis of a particular issue or technology as it impacts an organisation or industry, and can provide strong recommendations for improvements in theory, technology or policy.

Two main methodologies were used in this case study to examine the RRIF Program: semi-structured interviews and content analysis of policy documents

Semi-structured interviews

Semi-structured face-to-face interviews were conducted with individuals responsible for the implementation of the RRIF Program in South-East Queensland. Semi-structured interviewing was selected as the main methodology as it ensures cross-case comparability (Bryman and Bell 2001, 346), and is an important methodological tool when conducting exploratory and explanatory studies, particularly in order to find out what is actually happening in practice (Saunders, Lewis and Thornhill 2000, 245).

The interviewees were selected via purposive sampling (Zikmund 2003, 383) as respondents required particular expertise concerning the implementation of the RRIF Program in their local jurisdiction in order to be able to respond meaningfully to questions.

A snowball sample of six councils out of the 21 involved in the project, was undertaken – two small, two medium, and two large councils. By interviewing councils which were of different sizes, it was hoped that resource issues and other variables which could affect implementation of the initiative could be identified.

The interviews were then analysed using content analysis in order to code the issues raised by interviewees.

Content analysis

Content analysis is a technique for gathering and analysing the content of text (Neuman 2000, 292), and is an approach that has wide applicability in policy- related research studies (Marinetto 1999, 68). Content analysis in this project is descriptive rather than interpretive (Bauer 2000, 135), particularly as the 'concreteness of materials studied in content analysis strengthens the likelihood of reliability' (Babbie 2004, 324). A key element of content analysis is the use of a coding system to quantify the data into an analysable format. Coding systems in content analysis can identify numerous characteristics of online text content (Neuman 2000).

Individual informants have been de-identified and any commercial-in-confidence information has not been divulged. All interviews were conducted in confidentiality, and the names of interviewees have been withheld. When citing interviewees, the generic term 'Interview X' is used as a means of preserving anonymity. The names of government departments, government reports, and most government policies have not been obscured as most of this information is already freely available, either on the Internet or in public libraries. The names of individual councils interviewed were also obscured.

FINDINGS: RRIF PROGRAM OVERVIEW

The Regulation Reduction Incentive Fund (RRIF) Program was created by the Australian Government with the aim to provide incentives to local councils to reduce red tape for small and home-based businesses. The funding for the program was facilitated through a competitive merit-based grants process targeted at local government authorities. Grants were awarded to projects which targeted specific areas identified for reform. In South-East Queensland, this focused around improving DA processes and creating transparency in environmental health policies, regulation and compliance.

An important key factor to note with this case study is that it is unusual for an eGovernment initiative. Typically individual government departments undertake eGovernment projects in order to improve their internal performance. The RRIF case study examines the implementation of an eGovernment initiative across 21 autonomous local councils in South-East Queensland. In order to move ahead, agreement needed to be reached between councils at the highest level. The RIFF Program consisted of two projects:

1. Planning and Development Online
2. Local Government Toolbox.

These projects were designed to reduce red tape in the areas of development assessment, environmental health, and regulation and compliance, with an overall vision to enable customers to interact more transparently with councils through standardising the way councils operated through the various initiatives within the projects. The two projects each incorporated three initiatives, as outlined in Table 5.2.

Table 5.2 Summary of RRIF Program Initiatives

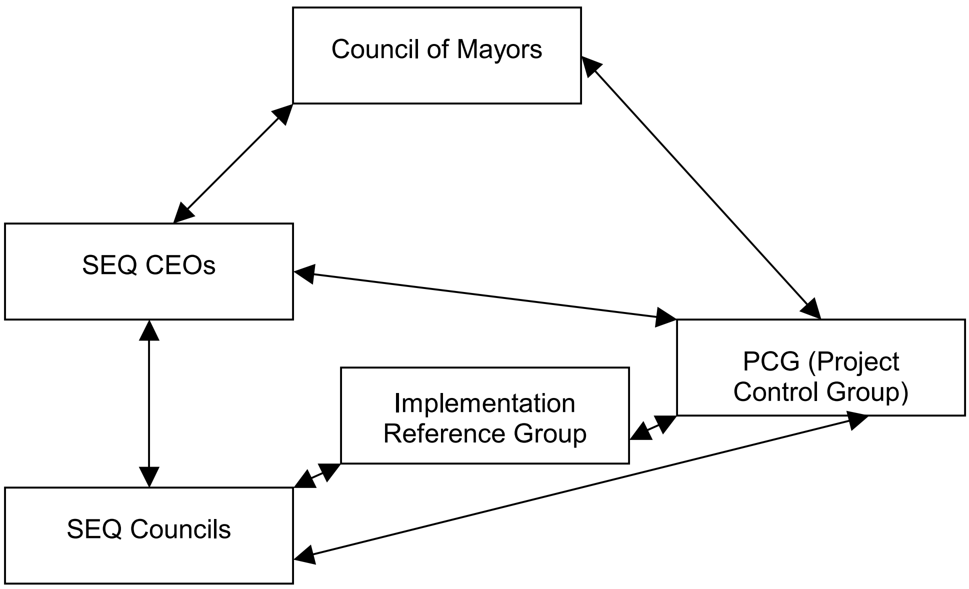
Planning and Development Online	Local Government Toolbox
DA tracking	Customer facing information
Planning scheme online	Customer service scripting
RiskSmart	Local law review and standardisation

Key elements of the project which are related to harmonisation are discussed below. Firstly, the governance arrangements of the project are examined as these enabled the project, but were also strengthened by the project. Secondly, the Local Government Toolbox is examined. Thirdly, the Planning and Development Online is examined.

RRIF PROGRAM GOVERNANCE

The application process for RIFF was originally initiated and endorsed by the Council of Mayors following their vision of 'speaking with one voice for South-East Queensland'. The RIFF Program in SEQ acted as a catalyst aimed at harmonising processes across 21 councils. The Council of Mayors (CoM), as the top tier of governance within the program, was unique as it provided a unified body which had agreed to implement a set of initiatives for the SEQ region. Underneath the CoM, control groups were also formed to steer and provide focus to each of the initiatives that made up the RIFF Program. These governance bodies were designed to bridge the gap between the CoM, project team, project implementers and the eventual users of the system. This structure is outlined in Figure 5.1.

Figure 5.1 Governance Model



The importance of the governance structure for the RRIF Program, and the consequences of the governance structure, are discussed further below.

Importance of the governance structure

One of the unusual features of this project was that it was conducted across a number of local councils, which are technically autonomous from each other. As was noted in Figure 5.1, the RRIF Program engaged the peak agency for the project which was the Council of Mayors for South-East Queensland (SEQ CoM) and the CEOs of South-East Queensland (SEQ CEOs), who endorsed the project at the highest level, and gave impetus and legitimacy to the RRIF Program.

> *Having the support of the CEOs and the mayors was beneficial. Without their support I don't know whether we would have been able to achieve the requirements as a region.*
>
> *[Interview 8]*

I think one of the things that really helped us was the Council of Mayors group and the CEOs, they really cleared the path for us to make this essentially happen … How that played out was that there were a couple of times that we needed to go back to the Council of Mayors and CEOs with when we need regional agreements for certain aspects of the project.

[Interview 11]

From a public policy perspective the SEQ CoM does not have statutory or legislative authority. It is simply a group of councils collaborating to achieve regional outcomes and share information between councils. The RRIF Program is possibly the first major activity conducted by this council.

Consequences of the governance structure

While the governance structure enabled the RRIF Program to be undertaken, the RRIF Program also resulted in improved information sharing and relationships between local governments in South-East Queensland.

Improved relationships

Huang et al. (2002) argue that improved relationships within and between government agencies can be a consequence of eGovernment initiatives. This is supported in the interviews:

SEQ Councils – we were able to deliver. We have established and built very good relationships with each other, and that is implemented very much through the regular meetings we have with DA managers in the region. We are very strong, we are like a support group, obviously there is a lot of pressure in local government and dealing with the development industry so having the support of all of your peers in the region is very good.

[Interview 8]

In actual fact that was one of the positive outcomes of the whole RIFF process, [was that] other councils have reported that the relationship building internally between their assessment services people and their IT people was a major positive outcome of the project … We talk more now with the other councils … because of the project.

[Interview 10]

Information sharing between councils

Bajaj and Ram (2003) argue that improved information sharing, which can lead to increased efficiencies, is also a consequence of eGovernment initiatives. This view was supported in the interviews:

That's right, you don't necessarily have to go to a meeting to share information. You can get online and have a look at it at your own convenience basically.

[Interview 5]

Toolbox is almost like an online chat line, it has got those capabilities as well, you can chat with people, and saying I think this means this, what do you think it means? … so if [other councils] have had the same sort of problem, that sharing of information, there would be no way of knowing that data before, so [now] you can ring the guy up. You can get onto somebody and say this is the problem I am having, how did you guys handle that?

[Interview 3]

Thus the RRIF Program built on and extended existing collaborations between councils. The various ICT tools have enabled information sharing across councils, which has enabled increased standardisation of certain approval processes in councils.

PROJECTS CONDUCTED UNDER RRIF

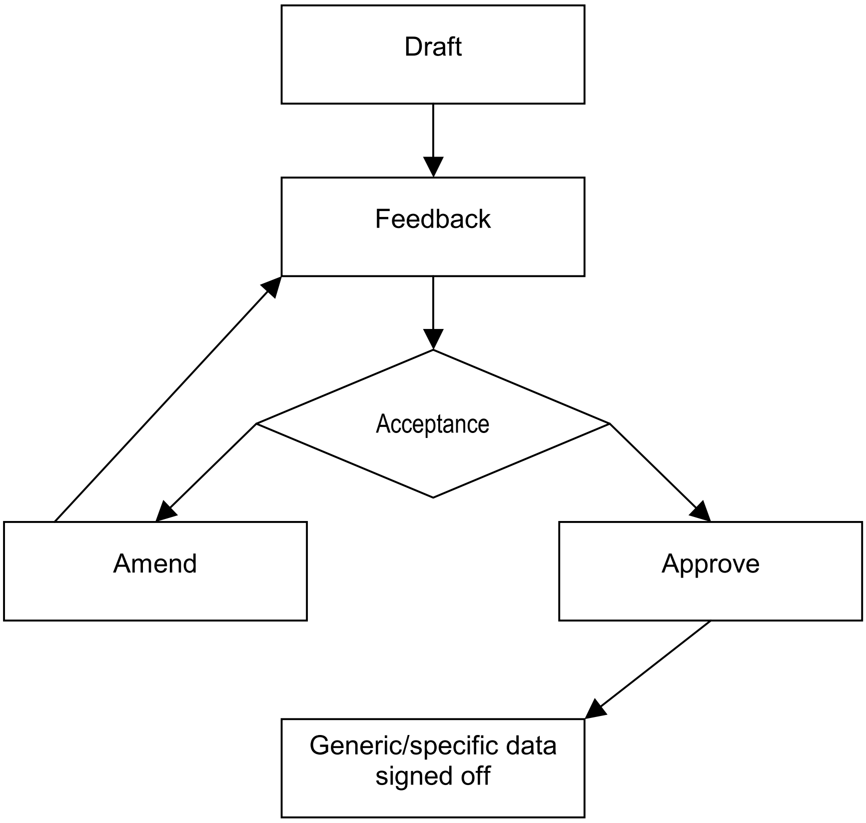
The two projects carried out under the RIFF Program were delivered through two different approaches: each approach aimed to facilitate a model where the needed expert knowledge could be sourced to meet the project needs. Local Government Toolbox was developed as a custom-made solution built in-house while an outsourced product was developed for the planning and development project (Regulation Reduction Incentive Fund SEQ Program (A) 2007).

LOCAL GOVERNMENT TOOLBOX

The objective of Local Government Toolbox was to act as a knowledge base for councils with its primary aim to provide the same environmental health information and local law policies across the whole region. As part of the initiative it focused around standardising local laws regionally. The system enables customers to access one set of council requirements online, no matter under which council jurisdiction they belong.

Prior to making the information public and standardized, the project team was involved in setting a process under which laws would be distributed to councils, agreed upon and signed off, only then being loaded onto the system (refer to Figure 5.2). The team was required to script and standardise the laws yet still ensure that variance in laws across councils were met. This process of standardisation was an efficient way in which to harmonise local laws across the region and it was only made possible through the project team consisting of council workers with expert knowledge in this field.

Figure 5.2 The Standardisation Acceptance Process



The way the application was built enabled enough flexibility to have both generic and council-specific sections to accommodate for variances in local council fees and requirements.

As a web-based knowledge management system, Toolbox gives council staff, individuals from the public and businesses access to regionally consistent information and standardised local law policies. Through information consistency and transparency the intent is to reduce the need for interactions with councils (Regulation Reduction Incentive Fund SEQ Program (A) 2007).

PLANNING DEVELOPMENT ONLINE

The initiatives within the second project, Planning and Development Online, focused on improving DA processes through standardisation, a clearer application process and information transparency and consistency. As part of this initiative property information that had previously been paper-based was made available electronically.

DA tracking (DAT): property and application enquiry

The Property and Application Enquiry initiative has been designed to provide customers with the ability to firstly view property information and secondly track the progress of development applications online. Its objective is to provide basic property and mapping information to planners, developers and members of the community to aid in their preparation of a development application based on property information made available. As part of this module it provides a facility to view other development applications.

The second component in the application tracks the progress of development applications from lodgement through to determination, identifying the current status of an application, tasks undertaken as part of the assessment process and estimated assessment timeframes. In addition as part of this process it provides any associated documents that may be required. Transparency in the application process was aimed at increasing accountability in council staff and intended to speed up the application approval process through the ability to track this process.

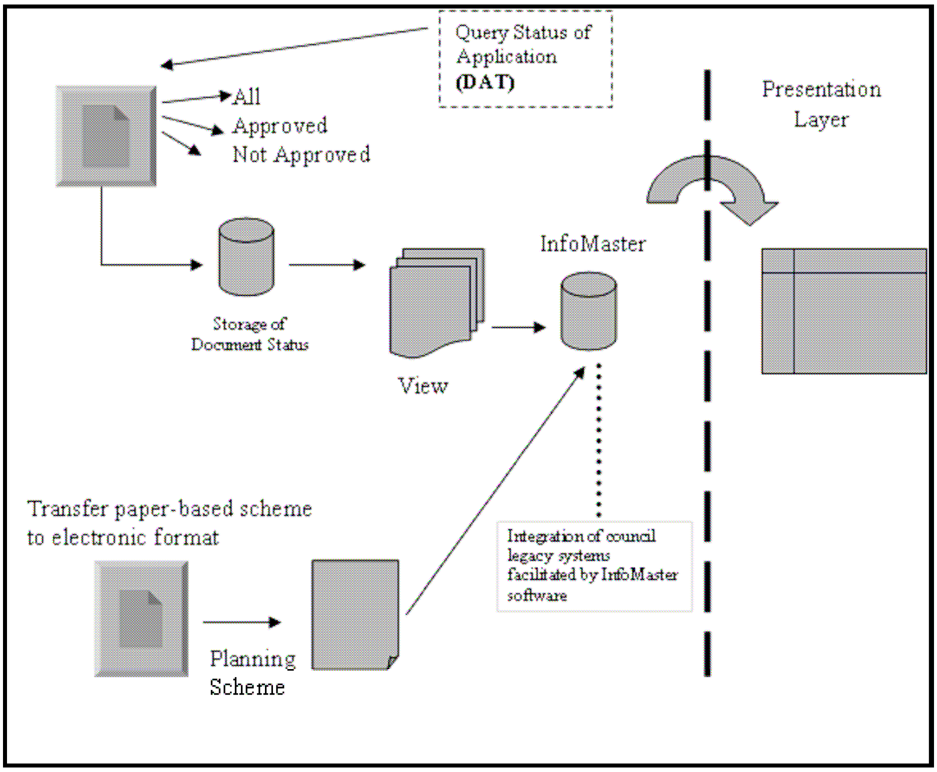
Planning Scheme Online initiative

The Planning Scheme Online (PSOL) initiative was developed to provide more accessible, accurate and timely planning information to planners, developers and members of the community about what levels of assessment and development controls are applicable to specific properties.

PSO was made possible through the transfer of each council's paper-based planning scheme to an electronic format, integrating relevant information into the scheme online and providing tools to be used by the public to query the information presented. With all this information accessible via the web, it emphasises a shift in making the overall development application process more streamlined and seamless. Overall, the process enacted a significant shift from having to access hard copies or searching for PDF versions.

Planning Scheme Online allows relevant planning scheme information, regulatory planning information and basic property and mapping information to be accessed with relative ease. The manner in which the application works ensures it only displays only relevant information for a development application. In turn this ensures the council's application process is more transparent and council customers can lodge their application with greater ease as they are aware of the necessary documentation required to complete the application. Through this process it is intended that the overall application process will become more efficient (refer to Figure 5.3).

Figure 5.3 PSOL and DAT



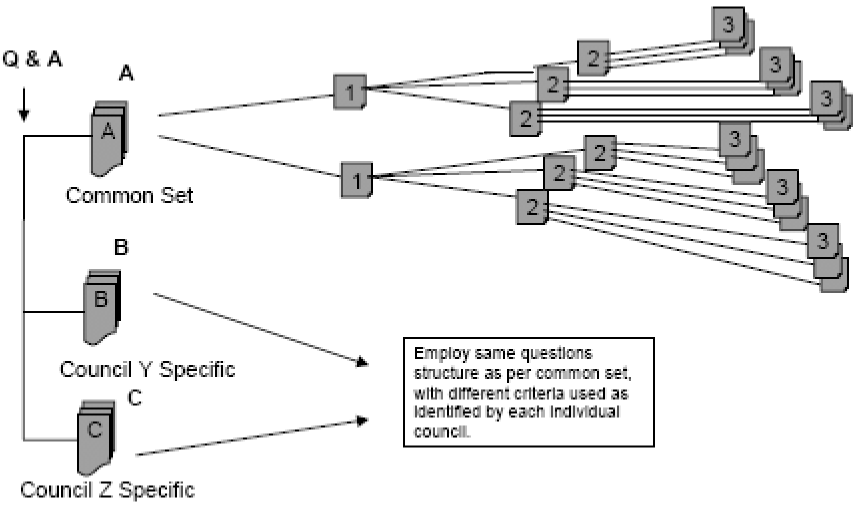
RiskSmart

The RiskSmart application intends to introduce a streamlined process for assessing 'low risk' development applications through the use of a series of questions relating to a selected 'use type' (e.g. building a warehouse in an industrial area). As part of this process it qualifies the level of risk associated with a development and if it is considered low risk, provides a turn-around of five working days. Formal applications still need to be submitted but the outcome is a faster assessment turnaround for customers if the application is identified as low risk, with business benefiting from time and resource savings across the region. Industry associations such as the Property Council of Australia (2007) are particularly interested in the RiskSmart initiative as it has the potential to dramatically cut down the approval times for specific types of applications. RiskSmart aims to deliver the following benefits to planners, developers and the community (RIFF SEQ Program (E) 2007)

- Efficient identification of the level of risk associated with applications.
- Transparency of planning scheme provisions and decisions.
- A front-end system which alerts applicants to risks prior to the lodgement of their application.
- Fast assessment/approval of low-risk applications.
- Provides transparency as to what requirements are needed for the submission of a quality application
- Reduction in councils' assessment timeframes and duplication of effort in the assessment process.

With RiskSmart each council was required to develop their own risk frameworks and criteria for the public to use. Given the complexity of applications most councils implemented only one scenario under which the RiskSmart application process would be applicable with the intent to increase this in the future. RiskSmart is summarised in Figure 5.4.

Figure 5.4 RiskSmart Framework



BENEFITS OF THE RRIF PROGRAM

Improved access to services and or information

OECD (2003) and Huang at al. (2002) argue that increased access to services and information is one of the likely consequences of eGovernment initiatives. This is supported in the interviews:

> *Beforehand, we had applicants screaming to have that information accessible … and the benefit for us was that instead of the applicants coming in and hassling the counter staff or ringing up my planners, they could jump online and essentially download the information themselves. We have had anecdotal feedback, it is fantastic, it is easy to use, real estate agents love it, valuers love it … instead of them having to come into council and ask a series of questions they can now search for that information themselves online. The online tool provides a lot of information in relation to property.*
>
> *[Interview 8]*

Improved access to information has had a number of consequences. Notably these include increased transparency, pressure to keep information up to date, and a reduction in counter enquiries, and improved service delivery.

Improved transparency

Tan et al. (2005) argue that increased information provision is empowering for citizens and is an important element in eGovernment initiatives. One particular element of the Planning and Development Online project was that it enabled increased participation in the scrutiny and comment of DA. Whereas before, individuals had to travel to their councils in order to view and comment on DAs, now they are able to view and comment on these applications from home. Additionally, whereas the names of people providing comment were typically kept anonymous, now the names are displayed, with a view that this may discourage vexatious submissions.

> *For other councils that was new for them, and this notion that people could see submissions, but it would seem from an outsider that this would improve your transparency, this was seen as a big win out of the whole thing.*
>
> *[Interview 1]*

> *I think it has certainly made the process that councils go through a bit more transparent, because you can actually get on and see where an application is up to, what information has been submitted with the application. If it is an impact accessible application, this council has made submissions available online, including the names and addresses of the submitters … So I think that in terms of impact of accessibility of applications, making people aware that their submission is available to the general public, they are probably less likely to make a vexatious submission.*
>
> *[Interview 5]*

Improved service delivery and information provision

OECD (2003) also argued that eGovernment initiatives could result in improved service delivery to citizens. For many councils, this increased provision of information has also enabled faster turnaround times on applications, and therefore improved service delivery:

If we can have a five day turnaround for say 40 per cent of our applications, because they are so easy to process, because there are no significant outstanding issues, they have all been addressed prior to lodgement, it is great for the industry, great for mums and dads, and great for the council.

[Interview 8]

The spin off to the council should be better-made applications, faster turnaround because of the quality of the applications has improved.

[Interview 2]

Reduced costs to the consumer (time or money)

Often the logic behind implementing an eGovernment project is to reduce costs. This is true for the RRIF Program, with interviewees noting savings in reduced approval times, reduced reliance on consultants, reduced adaptation costs, and reduced fees.

The first saving is in the reduced processing times. There are huge cost savings there to streamline the DA process in particular.

[Interview 1]

We have seen the flow-on results of all of that, by delivering information on how to apply to the customer we are getting better quality applications come into council which equals faster processing times because we don't have to go back out and ask for more information and which leads to faster final approval times which makes the applicant happy

[Interview 6]

Increased consistency across councils

As noted in the introduction, COAG (2006) had argued that pilot projects needed to be implemented in local government agencies to demonstrate the potential for ICT to deliver improved harmonisation across councils.

The two main projects within RIFF achieved consistency in different ways. Tool Box was able to achieve considerable improvements in standardisation:

Every council had their own food fit out guide, and they were all excellent guides, but it is state and national legislation so it is no reason why every council had to have a different one. So we picked the best bits out of every one, and everyone agreed to that one version and now for the future if there is ever a change in food legislation, that one version gets changed and 22 councils have got that updated version, so from that point of view it is brilliant.

[Interview 6]

While the Planning and Development Online did not increase the harmonisation of the actual content of local legislation, it certainly provided a similar look and feel across South-East Queensland. The project itself is the first major collaboration between many of the councils, as is noted by interviewees:

Again, I think it was just a major initiative that affected the whole region so we recognised the need to work together and collaborate on how we could as a collective unit achieve the project outcome. We really did look at the needs of the region, rather than an individual focus, and we were very supportive.

[Interview 8]

To see 18 councils in SE Qld, plus the Burnett ones, actually implement a major software system and achieve that in nine months with the level of standardisation that there is, is a major achievement.

[Interview 10]

So there are a number of findings which confirm those found by other researchers. In particular, the research found that RRIF provided opportunities for the improved engagement of citizens, information sharing and collaboration between councils, improved access to services and improved service delivery, and transparency of government. Further work is needed, however.

Further work required

While seen as a good first step, more work is required to achieve the outcomes that industry desires particularly at a regulatory level:

Down the track, ultimately, between the 19 councils there will be one set of standards, rules and regulations and all that sort of business we will all work off them, but at this point of time, if we talk local laws, there could be 19 different sets of local laws.

[Interview 3]

While many interviewees felt that the RRIF Program made gains in the area of increased harmonisation, within the constraints of existing regulatory frameworks, many noted that much work was needed in order to achieve harmonisation.

Personally, I can't see how we are going to get uniformity unless there is a uniform [planning] scheme … [there's] different terminology, like what we call a detached dwelling [another council] might call a house, or like it is just minor things. What you might consider would be allowable in one council is not in another, like set-backs and building materials and all sorts of things. There's squillions of things that are just different in different councils, so until there is uniformity at that level, I don't see how having the same look and feel on the website is going to help that much.

[Interview 7]

Thus, while the RRIF Program achieved consistency in certain areas, there were limitations due to differences between the current local planning schemes. The *Integrated Planning Act* was being reviewed at the time of the interviews and the results were not known on what the changes would be. Most people interviewed were also aware of a Queensland government initiative called 'Smart eDA' currently under way in Queensland, which unfortunately was beyond the scope of this project to investigate. Additionally future research would need to consult with users of the services to determine if the views from within local councils align with those accessing and using those services.

CONCLUSION

It is important that to recognise that the initiatives undertaken formulate a platform from which business can perform transactions with councils in a simplified manner. Increased transparency, accessibility, accountability and consistency all contribute to reduce red tape in the areas identified for reform which included development assessment, environmental health and regulation, and compliance.

The governance of the project enabled the project to be undertaken in a collaborative manner. However, a byproduct of the project itself was increased information sharing and improved relationships between separate local councils.

Increased information provision to the public, a core element of both projects, was seen to result in improved transparency of process and quality of applications. In turn, these resulted in improved service delivery, due to the improved quality of applications, and therefore reduced costs to consumers. Increased consistency in the Toolbox project was also achieved. Thus the RRIF Program has demonstrated that local councils can work collaboratively to achieve an outcome which has positive outcomes for industry and society. As a case study, there are valuable lessons which could be learnt to use in other initiatives.

Future research would need to examine potential impact of impending changes to the IPA, local council amalgamations, and the views of a wider range of stakeholders.

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CHAPTER 6

Designing a Workplace that Embodies Client Values

Robert Backhouse
Steve Coster

INTRODUCTION

This case study paper presents the premise, process, outcome and measured results associated with the creation of Maddocks Lawyers new workplace in Melbourne. The outcome is an innovative legal workplace, directly resulting from strategic engagement with Maddocks' people to align the design solution with Maddocks' organisational values.

Maddocks Lawyers

Maddocks is a leading, medium-sized legal firm in Melbourne and Sydney. The firm takes a specialist in select areas of practice. With a reputation for innovative and quality service, Maddocks has carefully developed a strongly embedded set of organisational values, resulting in a clear sense of identity.

The project

For Maddocks, this project was about refreshing and reinvigorating the firm for another period of growth and success. Maddocks has traditionally considered the creation of a new workplace every ten years or so as a regular marker in the evolution of their organisation.

In 2004, approaching their lease expiry, Maddocks assessed the available alternatives and decided to remain in the historic modernist building at 140 William St, refurbishing and extending rather than relocating. As such, the refurbishment needed to be dramatic in order to create a refreshing, reinvigorating experience for the firm, despite retaining existing space.

Maddocks commissioned workplace strategy consultants DEGW and Hassell interiors to design a new workspace of approximately 5500m^2 across five levels of the building, demolishing and replacing the existing fitout on four levels.

DEGW and HASSELL in collaboration: Roles during the Maddocks Project

DEGW are an international consultancy focused on the changing nature of work and its affect upon the design of built environments. HASSELL is a leading multi-disciplinary design firm with studios throughout Australia and Asia.

DEGW and HASSELL have worked collaboratively on a range of innovative workplace projects over the last decade. The relationship consists of an integrated briefing and design process, where DEGW lead the consultation/briefing and strategic workplace concept stages, and HASSELL progressively takes the lead during concept design and design development stages.

Together, DEGW and HASSELL have applied this collaborative approach for clients such as ANZ Bank, SA Water, VicUrban, and Westpac Bank. Collectively, their legal experience includes work with Allens Arthur Robinsons, Freehills, Deacons, Gadens, and Minter Ellison.

The history of the Maddocks workplace

The Property Group pilot project

Maddocks has a history of strategic and innovative use of the workplace. The Maddocks' Property Law group, with DEGW and Carr Design, had previously created a test-case 'free-plan' work environment designed to maximise communication, collaboration, and flexibility.

The lessons learnt

A limited, anecdotal post-occupancy review reported improved levels of communication and awareness amongst the group, particularly improved awareness achieved through visual connection to colleagues. Communication was reported to be more efficient and the open environment offered valuable learning opportunities for less experienced staff.

The degree of openness caused problems for some staff. In particular, staff responsible for large and complex matters found the level of surrounding activity distracting. As a result, they used the shared 'quiet rooms' for extended periods, making them unavailable to others. Storage generally was also an issue, requiring regular archiving to avoid clutter.

These issues were all manageable, whether by adaptation of the space or the development or refinement of work processes and protocols. Over time, a small number of highly transparent areas with large sliding doors or retractable walls were introduced to the space for certain senior staff, although not the group's most senior partners who found the improved communication to be of significant business benefit as it assisted their ability to lead the group effectively.

Applying the lessons

The Property Group's pilot project proved to be both an advantage and a disadvantage when approaching the new workplace in 2004. Rather than being more open to less traditional models of space and less definite in their perceived need for individual enclosed offices, in reality two attitudes to the open plan experiment emerged. The experience had polarised the 'office vs open plan' debate.

ALIGNING THE WORKPLACE WITH VALUES

The opportunities of workplace change

A holistic concept of workplace: People, process, place

The workplace is more than a physical built environment. In conceiving places of work, the design process must also take into account the psychology of people using them and the processes undertaken by those people. For Maddocks this meant involving the interests of a cross-section of its people in the design process, building upon both its operational effectiveness and its cultural advantages over other organisations.

Flexibility over time: Design for change

Organisations grow, change and rearrange at an ever increasing rate. For Maddocks this required the development of more adaptable physical spaces, allowing simpler and easier rearrangement of people over time, while retaining the ability to tailor spaces to suit their needs.

A tool for organisational change: New workplace and new mindsets

Finally, a change of physical workplace represents an opportunity to change mindsets in its occupants. For Maddocks this opportunity was primarily to refresh people's attitudes, focusing their efforts on another phase of growth and evolution of the firm. For this initiative to resonate with the firm's people, the design outcome was drawn directly from an alignment with the firm's fundamental organisational values.

Productivity or alignment with values?

Productivity and the knowledge economy

We live and work in an economy based upon the creation, sharing and application of knowledge. Among the areas of genuine potential competitive advantage are the ability to effectively share knowledge, the engagement of staff, and the commitment to improving the organisation's collective position.

Staff engagement, motivation and loyalty

The link between performance and the concept of staff engagement is the basis of 'staff engagement' survey tools such as the Hewitt survey. Under this paradigm 'human resources' become 'people capital', and the critical measure becomes the degree to which people are motivated by their work. Staff engagement also establishes employee loyalty in the increasingly competitive employment market.

Alignment between personal and organisational values

Organisations exhibiting high levels of employee engagement often also display correlation between the organisation's value system and individual employees' values. People often choose their employer on this basis, with alignment overriding other factors such as industry preference and remuneration.

The role of the workplace: Designing for alignment with values

An organisation's physical environment is a powerful expression of that organisation's beliefs. In the best cases, the design process and physical outcome translate organisational culture into an environment which sends clear messages to staff and visitors. Not always overt, these messages are the means by which successful workplaces achieve that 'buzz' or a 'feeling', making them enjoyable and energising places in which to work. This expression of identity goes beyond a limited concept of 'branding' to become a manifestation of the organisation's values, implicitly and powerfully reinforcing 'who we are and what we do' as an organisation.

ENGAGING THE ORGANISATION IN THE DESIGN PROCESS

The engagement process

The Project Steering Group

Maddocks' Project Steering Group was crucial to effectively engaging with the organisation. The configuration of the group gave the project leadership and ownership at the highest level, and also a strong view towards the future. This group formed the interface between Maddocks and the consultant team for the duration of the project.

Executive interviews and workshops

DEGW and HASSELL undertook interviews with Maddocks Partners, and then brought them together to collectively identify and debate workplace attributes that they associated with each of Maddocks key values: integrity, stewardship, collaboration, excellence and innovation, and diversity. These links were developed to become the driving concepts behind the design of the workplace.

Staff workshops and surveys

All staff were invited to contribute to the process through a series of 'envisioning' and 'workstyle' workshops and a web-based 'workplace performance survey'.

'Envisioning workshops' use image cards and other exercises to establish cultural strengths and aspirations. These exercises focus on what people want the firm to be in the future. Across a series of sessions, key themes emerge, to which the workplace design can then respond, helping to enable the achievement of these aspirations.

'Workstyle workshops' focused on the operational tasks and requirements associated with the nature of people's work. The sessions identify what people do, rather than what they want, and highlight the opportunity to embrace new ways of working and associated models of workspace.

The 'workplace performance survey' asks respondents to rank the importance and performance of various aspects of the existing workplace. This information identifies staff priorities and provides opportunity for all staff to express their views in ways that can be analysed and applied to the briefing and design process.

The strategic brief

The strategic brief is the way in which the consultation information is gathered, synthesised, debated, ratified and communicated to the design team. It takes organisational concepts and translates them to corresponding spatial concepts for the design team.

Organisational values and design principles

Maddocks' strategic brief linked potential design attributes to Maddocks' values as an organisation. In collaborative workshops with the firm's leaders, the firm's values were translated to a set of agreed design principles, proposed as a means for guiding all subsequent design decisions. The design principles for the project were:

1. Focus on fostering quality client relationships
   - Cater for a diverse client base and a range of relationships
   - Bring clients closer to more Maddocks people
2. Encourage increased interaction
   - Connect the whole firm
   - Connect individuals and teams
   - Idea of knowledge and learning in a social context being better retained.
3. Accommodate varied workstyles
   - Accommodate more diverse workstyles within a consistent framework
   - Adopt a more task-based approach to workpoint allocation
4. Balance the needs of the individual with the needs of the collective
   - Support a more collaborative way of working
   - Trade-off between larger offices being given to collaborative spaces.

Desired benefits

Maddocks also identified a number of benefits for inclusion in the new workplace: improved efficiency, improved effectiveness, and improved expression.

Improved efficiency:

- Less downtime and faster turnaround through more immediate, efficient interactions
- Direct access to support staff
- Flexibility to quickly and cost-effectively accommodate future change

Improved effectiveness:

- Better quality space through access to natural light
- Adequate team storage spaces and work surfaces for paper
- Greater team awareness through visual connection with others
- Effective learning and mentoring and increased collegial interaction
- Attraction and retention of the best people by giving them access to partners
- Better spaces for training, development and marketing seminars
- A variety of meeting and conference room experiences

Improved expression:

- Enhancement of the 'Maddocks experience' for clients
- Matching of workplace to Maddocks' image of 'understated quality'
- Refreshment of public spaces and reinvigoration of the firm
- Convey ambitions for the next ten years: keep innovating and evolving

THE DESIGN PROCESS

Having developed the strategic brief as the clearly defined ‘design problem’ in close consultation with Maddocks, the design team commenced concept design with confidence that they were focused on the right issues.

Exploring key design opportunities

The challenge for workplace architecture is to personify a group of people’s values, sense of identity, and community. Design is an imaginative leap to a future that client or architect alone cannot see. The measurement of design success is unavoidably subjective, but if strategic and functional aspirations are met without a personality or spirit, the sense of ownership and belonging by its occupants will fail.

The Maddocks design process was defined by a relationship involving trust, respect and preparedness for conflict and debate by both the client and design. A holistic design approach is not scientific.

Client involvement, review, feedback (and debate)

The project design stages consisted of an interactive process whereby various schemes we tabled with Maddocks’ Steering Group for open debate and feedback. These design sessions involved the entire group and were deliberately separated from pragmatic project management meetings. Close involvement in the evolution of the design was beneficial to all parties.

The HASSELL team’s approach involved multiple studies in a collaborative and iterative dialogue with the client group. The ever-changing issues and pressure of a delivery program and budget made for an exhausting experience for both, but the freedom for both to ask ‘can it be better?’ led to an outcome where perhaps the client and the design team could not remember where the idea originated.

THE DESIGN OUTCOME

Breaking-down the traditional client floor

The Maddocks workplace represents a move away from the conventional approach of keeping client interactions to a designated, highly finished series of formal meeting rooms with little or no relationship to the majority of the firm’s workings. In contrast, Maddocks sought to bring its clients closer to its people, creating more intimate working relationships. Major client facilities are distributed over two levels, linked by an open staircase and voids, with a series of less formal client meeting spaces provided to allow for more relaxed or intimate meeting with clients when appropriate. Spaces were also created in which certain clients could be brought much closer to the workspace, thereby exposing them to more of Maddocks’ people and the Maddocks way of working.

Creating a central, informal ‘hub’ for staff and encouraging vertical movement

In the interests of fostering a sense of collegiality amongst Maddocks people, the design creates places where people can come together across all areas of the firm. The extension of an existing open stair to connect all levels of the tenancy, making vertical movement through the tenancy more visible, was critical to this strategy. Also critical was the location of the central knowledge-library, staff café and training hub, acting as an attractive, multi-use destination for staff and therefore driving increased movement through the tenancy. Finally, multi-use or ‘cross-over’ spaces were located adjacent to the stairs and lifts on each level, providing readily accessible working space suitable for both project/team and client use.

Keeping entirely open workspaces in the corners of the floorplate

To improve the quality of workspace for all staff and more evenly distribute access to natural light and views, the design of the typical working levels include open plan workspaces in corners of the floorplate for the benefit of the ‘collective’ rather than a limited number of individuals. This design feature also serves to establish high levels of visual connection between all staff, enabling more efficient communication, the maximising opportunities for *ad hoc* interactions, impromptu problem solving, awareness by ‘overhearing’ and learning by observation. For some people this entailed the provision of an enclosed office. These offices were located away from the open team spaces in the corners of each floorplate to protect the light and views in these areas, and retain as much visual connection with colleagues as possible. The zones in which offices are located are designed to easily expand or contract so that any changes to the number of offices over time, or any differences in the number of offices between different practice groups, can be accommodated within a spatial framework that will retain its integrity and spatial qualities with varying degrees of enclosure.

Create a range of different levels of enclosure for personal workspaces

The Maddocks workplace also accommodates diverse workstyles through a more task-based approach to workpoint allocation and the creation of varying degrees of enclosure. The conventional extreme of *either* completely open *or* completely enclosed offices, does not reflect or adequately support the full range of tasks being undertaken in a legal workplace. A hybrid model is more appropriate, providing a spectrum of *both* openness *and* enclosure, and even various states between, allowing people to choose between a diverse range of settings depending on the task at hand. In addition, the design allows for the addition and removal of elements to tailor the level of enclosure within a group or team. This achieves a balance of screening and personal space with ‘connectedness’, using glazed partitions and large sliding doors to create maximum visibility and physical connection. Other elements such as whiteboards, display boards and storage units are also used as an alternative to glazed walls.

MEASURING WORKPLACE PERFORMANCE

Twelve months into occupation, evaluation of the project's success has been limited, although initial findings reflect a positive response from Maddocks' people. The common hurdles to meaningfully reviewing such projects have again resulted in a missed opportunity to learn important lessons.

The high performance workplace

In some cases workplace performance will be considered in terms of cost efficiency alone. In other cases facilitating more meaningful communication may be the dominant objective. Sometimes visual impact, branding, or 'wow' factor may be the only critical objective. Usually, however, the performance sought is a complex and delicately balanced mixture of these dimensions, leaving a difficult measurement challenge.

Measuring environment quality, staff satisfaction and productivity

Most approaches to measuring workplace performance are too narrow in scope. Most measurement relates to scientific measurement of environmental conditions related to temperature, lighting levels and air quality. Other approaches look to the perceptions of building users to understand the effects of the environment upon them and their performance. Finally, measures of increased productivity or 'staff engagement' are often sought as the definitive proof of workplace performance, although both are business performance measures, not workplace performance measures.

The question is whether workplace performance (in combination with other factors) leads to business performance. And if so, how can we know that the workplace is making its maximum possible contribution?

Workplace performance measurement: alignment with values

The critical measure of workplace success is the degree to which pre-defined workplace objectives are being met. Projects with a strategic brief clearly outlining the objectives will have a ready-made performance measurement framework.

One approach is to combine the various types of measurement to reflect alignment with organisational values. A survey can measure relative staff perceptions (perhaps before and after a project) of particular aspects of their workplace. If these aspects of the workplace are grouped according to which project objective or organisational value they support, then the cumulative results will show the degree to which people perceive their physical workplace to align with the organisation's objectives.

Linking workplace performance measures to business performance measures

Once the broad and holistic nature of the relationship between workplace alignment and workplace performance is accepted, a similar relationship might be drawn between workplace performance and overall business performance. To demonstrate the link we might plot staff perceptions of workplace alignment with values over time and then plot traditional measures of business performance over the same period. The complex and holistic nature of both workplaces and organisational performance requires us to look for coinciding patterns, rather than direct and absolute triggers.

MEASURING THE SUCCESS OF THE MADDOCKS WORKPLACE

Maddocks staff survey results

Following occupation of the new workplace, Maddock included a short series of workplace-related questions in their regular staff survey. According to the results:

- 'most' enjoyed working in the new environment
- 'more than half' believed the new environment has helped them become more efficient
- 'more than half' believed the new environment has helped them become more effective
- 'a resounding number' believed the new environment creates a favourable impression of the firm.

These results reflect a favourable response from Maddocks' people, and also imply a favourable impact upon the effective and efficient operation of the business.

Measuring success against the Maddocks strategic brief

While succinct, the questions offer some insight into how we might initially judge the success of the project against the objectives set out in the strategic brief. Although the overarching objective of creating a workplace aligned with organisational values is not specifically addressed, if we can assume that it is the firm's underlying values that give Maddocks its unique identity, and we can also assume that staff choose to continue to work at Maddocks because they *enjoy* doing so, then we can deduce that an enjoyment of the workplace environment indicates a degree of alignment between the workplace and the firm's values.

Furthermore, since the strategic brief outlined Maddocks' desired benefits of a new workplace under the broad headings of improved efficiency, improved effectiveness, and improved expression, the staff responses above reveal a clear success in achieving these benefits, at least in as far as staff perceive these benefits to have been achieved.

More detailed measurement

A re-deployment of the workplace performance survey undertaken during the briefing stage could provide a greater level of detail in analysing which aspects of the workplace staff perceive to have contributed to the reported improvements in efficiency, effectiveness and expression, or to the alignment with each of Maddocks' values.

Barrier to post-occupancy evaluation

Even organisations that have invested in the strategic opportunities of workplace briefing and design rarely gather a body of post-occupancy data by which to meaningfully measure workplace performance. Ongoing measurement of workplace performance, against a regularly reviewed set of workplace objectives, has the potential to extract new levels of business value from workplaces over time.

Assisting client organisations to embrace this ongoing measurement, and establishing approaches and methodologies to enable meaningful analysis, is the critical task confronting the design industry's ability to unlock new levels of value by establishing a culture of evidence-based innovation in workplace design.

CONCLUSIONS

Maddocks set out to utilise the design of its new workplace as a strategic business tool for reinvigorating the business. To achieve this, in addition to courageously testing new models in pilot projects, they engaged their people in a strategically minded briefing and design process. This process set their objective to create a workplace environment that is aligned with their organisational values. A collaborative design process allowed both client and design team to fully explore the opportunities inherent in this strategic approach. The outcome featured innovative concepts that could be pursued with confidence due to the clearly established brief. The results have been favourably received by Maddocks staff, and there are great opportunities to further analyse the contribution various aspects of the workplace are making to the performance of Maddocks' business.

Leading organisations such as Maddocks, by commissioning and managing such projects, continue to demonstrate that the ultimate source of innovation in our industry is innovative clients. The challenge is to provide these clients with the right tools, processes and information to continue to drive this innovation.

Satisfying Client Expectations in a Project Through Innovative Procurement Routes

Adekunle Sabitu Oyegoke
Malik Khalfan
Peter McDermott
Michael Dickinson

INTRODUCTION

Recent studies in the UK (Egan 1998; and Latham 1994) and the US (Kashiwagi 2004) support the fact that construction clients are dissatisfied with project outcomes due to their expectations not being met. The client's main expectations are on-time project delivery, completion within budget, satisfying the client's needs, and achievement of the correct quality of work (Munns 1995; and Chua et al. 1999). In addition, Hatush and Skitmore (1997) lay emphasis on the need for reasonable security.

The project performance is influenced by many environmental factors due to the interactions and interrelationships of the stakeholders. According to Yng et al. (2002), project owners', contractors', and consultants' characteristics, procurement systems and other factors affect project performance. Yng et al. (2002) refer to the findings of Kumaraswamy and Chan (1995) on the effect of the size of the project in comparison with unit costs, delivery, and construction speeds.

According to Yng et al. (2002), issues relating to procurement such as pre-contract activities, tendering procedures, tender evaluation, contractual arrangement, and award of contracts may affect the success of a project. Therefore, there is a need to define a project management strategy that will be used for managing both the design and construction delivery processes, and facility management. Such a management strategy requires effective project management systems that will enable a proper definition of scope, cost and schedule estimates and control, and quality specification, adherence, control and management both in preconstruction and construction stages.

In this paper, an STO procurement approach is suggested as a means of achieving clients' project expectations. Procurement strategy is chosen because it is an important management tool as it deals with the attributes of supply chain, it defines inter-firm responsibilities, it allocates risks and distributes responsibilities, and it sets out the overall project organisation i.e. relationship management. The aim of this paper is to examine key management areas where project performance can be improved in order to effectively manage clients' project objectives and meet their expectations in the 21st century. The study is carried out through literature reviews and a case study (example) of a recently completed office complex. The scope of this paper deals with the management of client expectations by satisfying client's project objectives, and focuses on projects of new and old buildings.

PROJECT MANAGEMENT AREA IN RELATION TO CLIENT'S MAIN PROJECT EXPECTATION

This paper adopts four client project objectives (scope, cost, time, and quality) as the key management areas. These management areas are thoroughly integrated and interact with each other and with other management areas of knowledge throughout the duration of the project, namely in the design, construction, and facility management phases.

Scope management is the foundation on which the other project elements are built. It sets out the work that must be done to meet a client's project requirements in terms of program, space requirement, function, features, and level of quality, and it defines the boundaries within which the delivery team and the external stakeholders interact. It is a platform on which the client's requirements are defined in the planning stage and form the basis of a systematic process of monitoring and managing adherence to the requirements in the construction phase. According to the Project Management Institute (PMI) document (2000), there are five key steps in scope management: initiation, scope planning, scope definition, scope verification, and scope change control.

Cost management includes the process required to ensure that the project is completed within the approved budget. It consists of four integral parts according to the PMI documents: resources planning, cost estimating, cost budgeting, cost control. In the design phase, costs are planned, estimated, evaluated and analysed as design progresses in order to determine the most cost-effective solution. In the construction phase, costs are controlled in order to deliver the project within budgeted costs. An effective project cost from the owner's perspective must align with the scope, the quality requirements and the milestone (schedule) estimate for verification and control purposes.

Schedule management establishes a timeline with schedule milestones to be followed in delivering the project in order to avoid schedule slippage. Milestones (dates) are set as a control tool in the construction phase to keep track of the work progress. Schedule management interfaces directly with scope, cost, and quality management when team members' roles and activities are defined, coordinated, and continually monitored. The PMI document (2000) highlights five areas in project time management: activity definition, activity sequencing, activity duration estimating, schedule development, and schedule control.

Quality management includes the process required to ensure that the project will satisfy the needs for which it was undertaken. The design phase begins with an initial specification of the quality level, matching it with both the project budget and scope for a realistic plan. In construction phase, the planned qualities are controlled and managed through adherence through a program of inspections, tests, and certifications. It requires coordinated performance among the entire project team for a completed building program to fully satisfy a client's expectations. The PMI (2000) highlights three major quality requirements:

1. Quality planning: identifying which quality standards are relevant to the project and determining how to satisfy them
2. Quality assurance: regularly evaluating overall project performance
3. Quality control: monitoring specific project results to determine if they comply with the relevant quality standards.

PROCUREMENT TYPES/DELIVERY SYSTEMS

The performance of a procurement route depends on many organisation variables as the procurement route defines the project organisation setup. Love et al. (1998) define procurement as an organisational system that assigns specific responsibilities and authorities to the people and the organisations, and defines the relationships of the various elements in the construction of a project. In other words, project procurement establishes the contractual framework that determines the nature of the relationship between the project team within the duration of their interaction. Oyegoke (2001) emphasises that the most important issues in the procurement route are dependant on how risks are distributed, responsibilities are allocated, works are divided, schedules are planned, and compensation and payments are structured, as there is no single procurement route considered best in all circumstances.

Cox and Ireland (2002) argue that construction supply chains remain fragmented and highly adversarial due to the conflicting nature of demand and supply. The fragmentation of a supply chain is also due to the effects of a technologically driven notion that has caused significant changes to conditions of standardisation, innovation, mechanisation, and prefabrication of materials, plants and labour (Cox and Ireland 2002).

The evolution of project delivery systems shows that in the early 1900s, most projects were completed under lump sum contracts, which is now viewed as the 'traditional system'. Exceptions were developed in the private sector to improve costs, and in both the public and private sectors they were developed to improve schedules. Construction management emerges in the 1960s, consultative design and build in the 1970s, and program management in the 1980s as owners sought more efficient ways to complete complex projects (Dorsey 1997). In this paper, procurement is categorised in terms of being integrated and fragmented in accordance with project performance responsibilities. Therefore, design-build is integrated, while traditional, ACM, at-risk CM, and MC are fragmented approaches.

Integrated approach

Design-build (D-B) places design and construction responsibilities on a single firm, resulting in single performance responsibility for complete project execution. Some of the inherent qualities of D-B include the certainty of the price and single point of performance responsibility regarding the risk, time, and quality of the project and the elimination of conflicts. One could conclusively deduce that the design and build approach does not solve all the problems associated with the prevalent procurement systems.

In a typical D-B contract, the owner initiates the project and produces a written scope statement in terms of performance parameters. The D-B contractor defines the scope definition by subdividing the major project into smaller deliverables. The client (representatives) carries out the scope verification and the scope change control exercises. There is a reservation concerning the contractor's proposal matching with client's requirements potentially leading to an unclear or ill-defined scope. The dual responsibility of the D-B contractor regarding the scope definition, the partial scope change control, project execution, cost of interface variables (payment clauses), quality (inspection of work), and time (reasonable duration/milestone), prevent adequate checks and balances.

In the D-B arrangement, the certainty of price is ascertained due to the fact that the D-B contractor carries out resources planning, cost estimating, cost budgeting, and cost control. The owner does not have the same degree of control over the construction phase as is the case in some other delivery systems (Dorsey 2004).

It is difficult to make use of competitive (packages) bidding thus, making it difficult for the client to negotiate a realistic and most cost-effective project. The D-B contractor carries out the quality planning exercise by identifying relevant quality standards for the project. The responsibility for evaluating quality assurance and monitoring control lies with the client (representatives). Although quality might have been agreed upon at the planning stage, the client must ensure that this is properly documented and clients must monitor the situation to prevent an unnecessary trade-off of quality for the sake of either a shortened implementation time or cost saving.

The problem related to checks and balances is evident as the D-B contractor is solely responsible for both schedule development and control in his carrying out of the activity definition, the activity sequencing, the activity duration estimating. Chritamara and Ogunlana (2001) present some of the problems in a design and build construction project: an unclear scope, design changes, communication and coordination lapses among parties, and project interface problems with the environment are commonplace. The D-B contractor's responsibility does not cover facility management/maintenance.

Fragmented approach

The traditional approach is a form of contract where the client appoints independent consultants to act on his behalf to produce the design and to supervise the construction work. In a typical traditional approach, the client initiates the project and produces a written scope statement, identifying the project's objectives and verifying the scope definition by the architect. The architect is responsible for defining the project scope in order to facilitate a clear assignment of responsibilities and to monitor the scope change control with the project team. The design team produces complete design documents before engaging the contractor, often affecting the quality by not taking into consideration buildability, constructability and lifecycle costing. The architect provides a leadership role in quality planning, assurance, and control by identifying and monitoring the quality standards that are relevant to the project.

The project cost will rise because of long project duration and additional layers of profit from subcontractor's works. The client's agents usually solicit fixed price bids from the contractors, and they develop a cost estimate in the form of an approximation (estimate) of the cost of the resources needed to complete the project activities. The contractors carry out the same activities in cost planning, estimating, and budgeting. The cost consultant influences the factors that create changes to the cost baseline, determining when such changes have occurred and managing them. A single contractor is selected and enters into an agreement with the client to construct the facility in accordance with the plans and specifications. The project schedule is long because it precludes fast-track or concurrent design and construction as it requires a complete design before bidding, after which construction work commences. The detailed activity definition, the activity sequencing, the activity duration estimating, and the resources requirements (schedule development) are carried out by the general contractor. The cost consultants provide a schedule control mechanism to ensure that changes are beneficial and thoroughly integrated with the other control processes. The main contractor's responsibilities end at the construction stage and do not cover facility/maintenance management.

Agency CM is a fee-based arrangement in which the construction manager is responsible exclusively to the owner and acts in the owner's interest at every stage of the project. He offers advice on the optimum use of the available funds, control of the scope of work, project scheduling, avoidance of delays, changes and disputes, enhancing project design and construction qualities, and optimum flexibilities in contracting and procurement.

In agency CM format the client initiates the project and involves a construction manager at the onset. The construction manager is involved in comprehensive management in every stage of the project, beginning with the scope planning in the form of a written scope statement, which outlines the project objectives, the agreement between the client and the project team, and the major project deliverables. The construction manager also is involved in the project scope definition by subdividing the major projects into smaller deliverables by trades. The construction manager coordinates and monitors the various trade contractors, who become direct (prime) contractors to the owner.

The contract duration (schedule) is shorter than the traditional approach because agency CM is a flexible concept and can be used for fast-tracked or phased construction work because of the involvement of different trade contractors. The construction manager evaluates the work schedules provided by the trade contractors and coordinates and updates the overall project schedule. There is an opportunity to obtain a trade contractor's proposal without bid shopping by the main contractor or second layer of profit added in. The cost implication of this contracting system is that it eliminates one complete contracting tier, thus, eliminating a layer of profit and overhead. Non-involvement of the trade contractors in the design phase prevents gaining additional knowledge on the project's constructability and buildability that affects the quality level. Although quality control and management is safeguarded by a series of checks and balances, there is a negative impact on project quality assurance owing to the fact that the project risks lie with the client while the client holds the contracts. The services of the construction manger (agency) do not extend to facility/maintenance management.

At-risk CM is more predominant in the private sector as the construction manager is not precluded from self-performing the work that is customarily performed on a project. In a typical at-risk CM contract, the CM contractor performs preconstruction ACM duties (input on scope, budget, schedule and quality) and is involved in the actual construction works. The major problem in this approach is the dual responsibilities held by the CM contractor in both the preconstruction and the construction phases, which abrogates the principle of checks and balances. However, the client is not bound to involve the at-risk CM contractor in actual construction as preconstruction and construction contracts are separated. The major advantage of this approach is the ability to schedule fast-tracking in the construction phase even when the drawings are not completed. At the end of the design development stage, the at-risk CM contractor guarantees the costs by providing a guaranteed maximum price (GMP) and the schedule. The guarantees remain as long as there is no material or significant changes in project scope, drawings, assumptions, etc. According to Dorsey (2004), the constructor's fee is generally a negotiated fee for services, with the project contingency being the focus of undefined risk instead of the constructor's fee. The early inclusion of the at-risk CM contractor can bring additional information to the design team on constructability, buildability, and value analysis, which have quality implications.

Combination of integration and fragmentation

New combined solutions contradict the work of those proponents who rely solely on either extensive fragmentation or full integration. Combinations can be innovative and fragmented/differentiated under the integrated management system. This new specialist task organisation (STO) route is aimed at improving the current contracting systems, the procurement routes, and the processes in construction projects. Under the robust integrated management (system), the STO route applies the principles of specialisation and innovation to carrying out the core tasks/activities through product/project development, implementation, and possibly finished product maintenance. The STO route utilises semi-autonomous integration in product/project development processes and full fragmentation in implementation processes. The total scope of the product/project in question is procured from among organisations that are specialised in the various development/design, manufacturing, supply, installation, construction and maintenance tasks.

The STO management team carries out demand and need analyses to initiate a project in conjunction with the users. This involves strategic planning, project selection criteria, benefit measurement methods, expert knowledge, and business and historic information. A preliminary report is prepared for the sponsors and the users, which includes project identification, with constraints and assumptions. Scope change control is applied at this point to look at change requests by the user and their implications. Next, is the preparation of the scope statement that assists in making future project decisions and help to foster a common understanding of the project scope among stakeholders. The scope statement also includes a list of the major deliverables, which form a component of the project. The STO management team carries out a project scope definition exercise that involves subdividing the major project deliverables into smaller, more manageable tasks. The aim is to improve cost accuracy, concept clarity, and assignment responsibility, and to define a baseline for performance measurement and control. The users and the sponsors, after reviewing all facts, verify the scope definition report thereby allowing the project to proceed.

The STO management team procures the total project/product development plan with the overall design documents from among the specialist designers. The STO management team is involved in identification of the site requirements as well as in the development of the project scope from concept through preliminary planning, which requires a thoughtful definition of the goals and needs.

The changes in the nature of clients nowadays prompt the STO management team to prepare project viability studies, design economies studies, and project funding requirements in other to woo sponsors/investors and financiers to support the project. The project costs are reduced to the barest minimum due to the involvement of specialist task organisations in both design and construction of their tasks based on their expertise, i.e. evaluation of project alternatives through STO bid shopping, and several STOs bidding for the same task. These types of projects survive on a revenue stream from the rents or lease, with master planning done by the STO management team to accommodate anticipated future needs and a realistic construction schedule via concurrent design and construction to shorten project duration.

Further, the STO team procures the work packages from among specialist contractors and suppliers with detailed technical engineering design documents. Finally, the lifecycle costing, usability, alternative materials, and maintenance services form part of the competitive criteria for tender evaluation, thus improving the project quality. The users of the facility are involved from the design phase through to the construction and maintenance stages. This is so owing to the longevity of leases and rents from the intended users.

Thus, the project is tailored to their needs. Each of these STOs enters into an agreement with the client (owner) and holds their own contract, which positively impacts the quality level. The early selection of the specialty contractor team members allows them to provide their services. This helps in achieving the most economical design and cost control systems, and it increases the predictability of significant events and their impact on cost, schedule, and quality.

Value-adding capability of STO route

Along the STO route, the STO management team is responsible for the storage, retrieval and dissemination of information during all project phases. For example, short feedback loops allow the utilisation of knowledge concerning the status of the preceding contracted STO packages for managing the remaining STO packages.

In the prevailing procurement routes (e.g. design-and-build), the maximum value to be attained for each phase is fixed before proceeding to the next phase because each phase must be completed before proceeding to another phase. In principle, the completeness of the design documents before the construction phase is adhered to in order to safeguard project parties against any uncertainties in cost, schedule and quality. In practice, several uncertainties emerge as risks that are encountered through claims, additional works, variations, disputes etc. Naturally, as progress is made in the project value chain (phase milestones are reached), value is added to the process, resulting in a phase higher than the previous phase. If the process is then fast-tracked as in a construction management contract, the resultant effect of a short feedback loop shows the minimum value loss in the traditional approach and the value added in a fast-tracked approach.

However, the STO route exploits progressive tasks though bid packages, commences the first construction works very early, monitors costs, and sorts out the most viable solutions from among competing bid packages. The concurrent design and construction in the STO adds more value, as the task organisations are all involved in the same phase at the same time and they also control the input and output of design and construction of their task. The additional added value along the STO route in comparison with the prevailing procurement routes is the combined outcome of:

- early availability of information from the preceding tasks, i.e. short feedback loops
- improvements based on expert knowledge
- immediate feedback on the performance of tasks under execution
- short feedback loops
- improvements in product quality through healthy competition based on (besides prices) different designs, lifecycle costs, materials, construction means, techniques and technologies
- immediate monitoring of actual costs, schedule and quality
- a high certainty of the scope of a given task under consideration being ensured during the detailed engineering phase, which reduces claims, disputes, variations, extra works etc. in later phases.

STO CASE STUDY (EXAMPLE): THREE OFFICE BLOCKS

This case study consisted initially of two office blocks (with an option for a third one). The owner is an insurance company that developed the office blocks under a separate limited liability company (subsidiary). The owner's team comprised the risk-carrying CM contractor and the designers. The CM contractor was selected early to allow his participation in the preconstruction project management. He acted as the owner's main representative and negotiated the direct contracts between the owner and the specialty contractors. The leaseholder and user is a multinational IT service company. The latter was involved already in the conceptual overall design.

The project was divided into eleven main tasks: substructural works, a structural frame, a glass facade, cladding, roofing, in-fill, HVAC systems, electricity, plumbing, external works, and minor specialist works (e.g. art, security, and surveillance). The procurement procedure involved the design team that produced the overall detailed design upon which the estimate was requested. In addition, the design team provided the general information for the bidders to provide both the alternative designs and the estimates.

Building design and bidding procedure

When the user's requirements were first fully established, the design team was commissioned to produce the overall project design. Within the invitation-to-bid documents, the owner provided the general information about the blocks, e.g. the floor areas and the building volumes. The documents included a concept design followed by a detailed design (after three weeks) in order to enable two-way bidding: a bid based on the detailed design and another one based on the specialty contractor's own solution. The specialty contractors could use their expertise by adding, subtracting, and/or adjusting the original detailed design or by offering a new concept. The additional information was submitted for such individual solutions. For instance, the owner provided the items in the preliminaries (site services) that might have cost consequences if unmentioned (e.g. a main crane and water and electricity for works). Each specialty contractor submitted their own technical designs/working drawings to the design team, which were pre-checked and the winner's documents were sent to the town planning authority for approval. All grey areas were sorted out at the joint meeting with the bidders.

Structural frame

The owner's invitation-to-bid documents included the structural specifications including those for beams, columns, floors, the spacing of trusses and the load-bearing structure of each frame. The minimum requirements concerned the heights of the ground floor (4.5 m), the basement and other floors (3.6 m), the heating and ventilation room with the free space (4.6 m), and the special spaces in the basement, especially the maintenance route (5.0 m). The annexes consisted of the architectural and structural drawings plus the responsibility distribution chart. Five structural frame contractors submitted bids that followed the original invitation with some changes only. Many other contractors bid on both the original steel frame and on the alternative concrete-based frame. During the evaluation process, the submitted drawings were thoroughly checked with their full implications on cost, schedule, quality and lifecycle costing examined. The schedule of the winner was incorporated into the overall design to ensure program compatibility and the master schedule. The selection criteria of the owner were based on a fixed price bid, the general quality level, the compatibility with the other project tasks (design and construction), and the lifecycle management. Three major negotiations on prices took place before the contract was signed. The winner also submitted an alternative scheme.

Glass facade

The owner's invitation-to-bid documents included the scope of the glass facade, including the wall, the doors, the windows, the complete aluminium frame, and the accessories, as well as the sun and rain screens. The extra features like the glass wall for the main entrance and hall were included in Block 2. Contractors were asked to bid for each of the elements on a functional block-by-block basis. During the procedure, the design team twice made some changes that were communicated to the contractors. The costs of the bid included the design (optional), manufacturing, materials, delivery and installation as well as the site machinery for the installation (except the major crane). No overhead was allowed for the specific items of material or labour. The winner submitted the bid based only on the owner's detailed design. The advantage of this approach was that competition was based on the design, the materials, and the lifecycle management. One of the winner's merits involved the alternative glass type that best suited the environmental requirements. The sound, solar, and light penetration qualities of the glass took into account the location near the highway. The fixed price contract was agreed upon. The winner's work schedule was adjusted and incorporated into the master schedule.

CONCLUSIONS

The study shows weaknesses of the prevalent routes in key management areas that affect a client's expectations with regard to project delivery. In most cases the client provides the needed requirements, while the architect provides the project scope, which is often not realisable in terms of cost, schedule and quality and often results in claims and disputes. There are not enough mechanisms to improve quality and to adhere to specified quality standards, as in the case of design-and-build, both in design and construction stages respectively. The nature of clients is changing as well as that of the construction environment. Previous clients in property development, such as Nokia, may now be concentrating on their main business (core competence) and want to lease properties to carry out their business. Competition in the consulting practice is also driving the construction stakeholders to look for alternatives in property ownership, financing, and procurement approaches. For instance, in most of the medium-sized cost expert (quantity surveying) practices, there is at least one financial market expert who works with the cost planning team to weigh the financial implications of different development schemes. For instance, before a speculative investor becomes convinced to invest in a project, project financial studies and design economies of the building in question should be made. The suggested STO has been used in practice in Finland where scope is clearly defined so as to suit a user's requirements, costs are minimal due to bid shopping, quality is improved due to STO expertise and involvement starting from the design stage, and project time is shorter due to the possibility of carrying out design and construction concurrently.

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Part 3
Procurement and Risk Management

Can Project Alliance Contracts Truly Provide Value-for-Money Outcomes?

Charles MacDonald

INTRODUCTION

In recent years the engineering and construction industries have been attracted to 'relationship contracting', a term that describes new procurement models which attempt to avoid the adversarial nature of traditional procurement models and achieve project outcomes that are more acceptable to all parties, using a cooperative or collaborative approach.

There is a relatively broad spectrum of relationship contracting models including various forms of partnering and different styles of alliances. The terms 'partnering' and 'alliancing are', however, often used interchangeably when they really describe procurement approaches which are quite different, particularly in the manner in which they address the distribution of risk and reward.

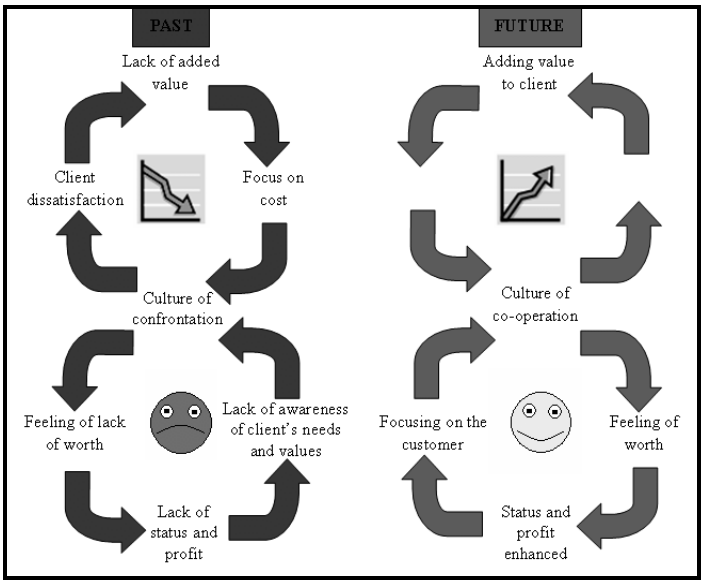
At the outset of this paper, it is considered to be important to highlight the fundamental differences between relationship contracting, and the form called project alliancing in particular, to the so termed 'traditional' contracting model. Whilst this distinction will be explained further in this paper the following summary definitions (Mallesons 2003) seek to clarify the key differences between the two approaches.

Alliancing is often described as a 'risk embrace' culture under which the parties seek to better manage risks by embracing them (rather than trying to transfer them) and then work together to manage them within a flexible project delivery environment. It is an agreement between two or more entities who undertake to work cooperatively, on the basis of a sharing of project risk and reward, for the purpose of achieving agreed outcomes based on principles of good faith and trust and an open-book approach towards costs. By contrast, traditional contracting is often described as a 'risk transfer' culture where the parties seek to transfer as much risk as possible to others under a range of separate contracts. Under a traditional contracting arrangement, the owner and the main contractor would enter into a master–servant style contract for the performance of the works and the main contractor would then pass down as many risks as possible by using a series of master–servant-style subcontracts.

The author takes the view that the traditional contacting culture, which often results in a confrontation and an adversarial atmosphere, is often unsuited to the successful delivery of value for money (VfM) in the present-day construction industry. This position is supported by a number of sources, including significant reports relating to the construction industry both in Australia and the UK which include 'Constructing the Team' (Latham 1994), 'Rethinking Construction' (DETR 1998), 'Building for Growth' (DISR 1999), '*Construction 2020*' (CRC 2004) and 'Scope for Improvement' (ACA/BDW 2006).

A schematic diagram contrasting the potential differences between a confrontational and cooperative approach is provided in Figure 8.1. This diagram is based on a model developed by Blockley and Godfrey (Blockley and Godfrey 2000) to illustrate the potential impact of systems thinking but serves to contrast what can potentially be achieved in moving from a 'culture of confrontation' to a 'culture of cooperation'.

Figure 8.1 Opportunities Available in Moving from a 'Culture of Confrontation' to a 'Culture of Cooperation'



Adapted from Blockley and Godfrey (2000)

VALUE FOR MONEY

> *It is unwise to pay too much, but is worse to pay too little. When you pay too much you lose a little money – that is all. When you pay too little, you sometimes lose everything, because the thing you bought was incapable of doing the thing it was bought to do. The common law of business balance prohibits paying a little and getting a lot – it can't be done. If you deal with the lowest bidder, it is well to add something for the risk you run. And if you do that, you will have enough to pay for something better.*
>
> *John Ruskin 1819–1900*

It is fundamental to any discussion as to whether a particular procurement method provides VfM to define what is meant or understood by the term 'value for money'. For a term which is so widely used it is difficult to find a commonly accepted definition. At a superficial level, VfM is generally seen as obtaining goods or services for the cheapest possible price. This rather short-sighted approach has been commented upon extensively in the literature but is elegantly addressed by the UK National Audit Office in their publication *Modernising Construction* (NAO 2001). In the executive summary to this report the following comment is made:

> *A succession of major studies … have highlighted the inefficiencies of traditional methods of procuring and managing major projects – in particular the fallacy of awarding contracts solely on the basis of the lowest price bid only to see the final price of the work increasing significantly through variations with buildings often completed late. Experience has shown that acceptance of the lowest price bid does not provide value for money in both the final cost of construction or through life and operational costs. Relations between the construction industry and government departments has also often been typically characterised by conflict and distrust which have contributed to poor performance.*

The definition of VfM is directly defined in the HM Treasury publication, *Value for Money Assessment Guidance* (UK Treasury 2006) which provides particular guidance in appraising the VfM of investment proposals to be procured under private finance initiatives (PFIs). The definition used here is:

> *Value for money is the optimum combination of whole-of-life cost and quality (or fitness for purpose) to meet the user's requirements and does not mean the choosing of the lowest cost bid.*

Whilst PFIs have different commercial drivers to project alliances, it is felt that this definition is universally applicable to any procurement method.

The fact that these sources all come from the UK is not simply a matter of coincidence. The UK construction industry has taken what might be described in colloquial terms 'a good long hard look at itself' in recent years having come to the realisation that it needed to understand why its performance was so poor, particularly in comparison with mainstream manufacturing industries. Whilst there had been a series of government-sponsored reports on the performance of the industry between 1944 and 1998 (Murray and Langford 2003), each suggesting some degree of reform, most of these documents had resulted in little or no action. However, the Latham Report (Latham 1994) and the Egan Report (DETR 1998) appear to have genuinely galvanised the industry into action. Both of these reports made specific reference to the issue of VfM.

There have also been a number of recent reports concerning the status of the Australian construction industry. *Building for Growth* (DISR 1999) specifically referred to VfM being a key 'action agenda' item for the local industry.

RELATIONSHIP-BASED CONTRACTING

Relationship-based contracting involves the development of mutual trust, open and honest communication and free sharing of information. Such conduct is quite contrary to the pattern of behaviour that is associated with and normally determined by the 'traditional' models of construction procurement. It should not be a surprise, therefore, that it is not easy for some people who have been involved in the industry in the past to suddenly change their mindset and embrace the brave new world of relationship contracting.

As is often the case with emerging fields there are several definitions in use which often lead to misunderstandings and this problem seems to particularly plague the area of relationship contracting. Consequently it is important to precisely establish what is being described by the terms used to describe the various forms of relationship-based contracting.

PARTNERING

Partnering is generally understood to mean *'a commitment by those involved in a project or outsourcing to work closely or cooperatively, rather than competitively and adversarially'* (Gunn 2002).

It is important to understand that partnering is in fact a code of conduct. There is no partnering contract, as such; rather an agreed partnering 'charter' forms the basis of a working agreement that is intended to shape a non-adversarial culture to promote a 'win-win' relationship between the parties.

Partnering on a one-off project-specific basis starts at the concept stage or more often after the contract has been awarded. Project-based partnering was initially championed by Colonel Charles Cowan, then of the US Army Corps of Engineers, with significant success. Partnering is now used by the Corps of Engineers in all construction contracts and has been widely embraced in the US in public sector procurement.

Partnering, particularly project-specific partnering has also been widely embraced in the UK following the Latham Report, (Latham 1994), which advocated the development of a team approach to construction. This movement was then given even further impetus by the Egan Report (DETR 1998) which identified integrated processes and teams as being amongst the key drivers needed to set an agenda of change for the construction industry as a whole.

Whilst partnering has been used in Australia it has enjoyed limited success. The alliance model as discussed below has been more readily accepted by the local industry.

ALLIANCING

Alliance contracting is the term used to describe an arrangement where parties enter into an agreement to work cooperatively and to share risk and reward, measured against an agreed set of performance indicators. The owner and service providers work as a single integrated team to deliver a specific project under a contractual framework where their commercial interests are aligned with actual project objectives.

Alliancing involves a formal contractual agreement in which the parties formally undertake to act in the best interests of the project and this is a key difference from partnering where the undertaking to act in such a manner is purely a 'gentlemen's agreement'.

It is generally understood, although perhaps not universally recognised, that a contactor must a make a profit from an agreement in order to survive commercially. It also needs to be recognised that the client has a direct influence on the way in which the contractor makes a profit, through the selection of the procurement strategy. The key philosophical principle in the selection of an alliance approach is the recognition that the contractor's profit should be earned through performance and not on the contractor's ability to make and win claims (Bowyer 2003).

ESSENTIAL DIFFERENCES BETWEEN PARTNERING AND ALLIANCING

In alliances there is a joint rather than a shared agreement to the acceptance of risk. The non-owner participants declare and agree with the client all their costs above direct costs (typically head office overhead and profit) beforehand and then place these at risk. Because risk is then jointly assumed, should any one party fail to perform, all parties are at risk of losing their rewards and, importantly, even jointly distribute losses according to the agreed painshare/gainshare model.

The joint assumption of all risks is the key factor that ensures that the commercial terms of the arrangement are aligned with the project objectives. This cannot be achieved in an agreement where it is possible for a party to 'lose' at the same time that another 'wins'. The 'win-win' or 'lose-lose' outcome enjoyed by all alliance parties is the most fundamental characteristic of the alliance and drives the behaviour of all parties.

The total sharing of risk and the placing of overhead and profit at risk (by the non-owner participants) based on agreed performance criteria is a very powerful driver of behaviours that result in very close working relationships and the development of an innovative culture that seeks to drive down costs and reduce contract durations. If these pressures are responsibly managed it is possible to achieve substantial VfM for the client. This value is, it is suggested, regularly achieved and takes the form of improved project outcomes in many areas including cost savings.

THE SKEPTICAL VIEW OF VfM IN PROJECT ALLIANCES

Despite all the processes, procedures and protocols described above it is natural and appropriate for owners and/or their financial advisors to ask how they can be satisfied that they are getting VfM and, importantly, how they can demonstrate to themselves and the community, or their shareholders, that VfM is being achieved.

An unusual feature of the use of the project alliance model, compared to most other procurement models, is that there have been very few, if indeed any, examples of significant failures of this procurement method. The Hot Briquetted Iron (HBI) project undertaken by BHP in Western Australia is sometimes quoted as an example of such a failure but it is questionable whether this project truly fulfilled the definition of a project alliance and was rather an amalgam of three separate fabrication/construction contracts termed alliances (Ross 2000).

Nevertheless, there remains a degree of scepticism, particularly in some public sector treasury agencies, regarding the apparent achievement by alliances of successful outcomes represented by completing projects for less than the target out-turn cost (TOC), agreed between the alliance participants, and meeting or exceeding the non-cost performance targets. The sceptics have questioned the veracity and robustness of the development of the TOCs and performance targets and suggested that the commercial arrangements of the single TOC approach, in particular, encourage the non-owner participants to seek a higher TOC and more achievable performance targets (VicDTF 2006).

Consequently, it could be argued that the need to demonstrate that project alliances truly deliver VfM is not a consequence of the failure of the model in the past but is the result of the apparently very high rate of success of the model. This success causes some observers to be concerned that it is being predetermined by the inherent nature of the commercial arrangements in the model which may be presenting 'soft' targets to the participants.

In the ten years since the Wandoo and the East Spar alliances in the private sector and the first bold step by the public sector in the Northside Storage Tunnel alliance, the use of project alliances has become very widespread in Australia. Recent years have seen a rapid increase in project alliances in Australia as a means to effectively deliver infrastructure in the public sector, with well over $10 billion of projects being delivered or planned under an alliance model (Leighton 2007). Most of this increase has been in the public sector even though it is generally considered that there is greater pressure on public sector than private bodies to demonstrate VfM in procurement.

Some of the large public sector works procurement authorities such as the RTA in New South Wales, who were reportedly initially sceptical about the benefits of the single TOC project alliance model, have initially selected a 'competitive' TOC approach and have later proceeded to adopt a 'single' TOC model. This is illustrated by the history of the RTA experience with project alliances. Initially, for the Windsor Road Alliance, they chose to pursue a 'price competition' form, seemingly as a consequence of their reservation about securing VfM with a form that did not involve competitive pricing. However, subsequently they chose to adopt the single TOC model for projects such as the Lawrence Hargrave Drive Alliance and now appear to prefer this model for all their subsequent project alliance projects. By comparison, the Victorian Government has been prepared to move directly to the single TOC model as demonstrated by the recently completed Tullamarine–Calder Interchange Alliance and the Middleborough Road–Rail Grade Separation Alliance. This could suggest that the popularity of single TOC project alliances in the public sector is being driven by a dynamic which is stronger than the initial conservatism of public sector financial officers, and this is considered further below.

THE ROLE OF COMPETITION

In any procurement process, comparison needs to be made between suppliers and there should be competition between the parties seeking to undertake the work. Without competition, efficiencies and innovation will not be driven and this will conspire against VfM. However, competition does not automatically mean a process that drives suppliers to offer the lowest price. If it is possible to fully quantify the required attributes of a good or service and it becomes, in effect, a commodity, then price competition alone may be a reasonable and legitimate basis on which to base the procurement decision. However, in the case of complex infrastructure delivered through construction contracts, selection based solely on price grossly oversimplifies the procurement decision: indeed the adoption of such a simplistic attitude on the part of the body undertaking such procurement could be characterised as lazy and or even negligent.

As suggested above, the use of project alliancing in Australia, by public sector clients in particular, has grown significantly in recent years. It would appear to be self-evident that such bodies would be unlikely to enthusiastically embrace such a procurement model if they believed that the outcomes were unsatisfactory and that VfM was not being achieved. However, the continued growth of the model is possibly being stimulated by both the perceived success of the previous uses of the method and a sense, within some public sector clients, that in the currently extremely buoyant market in Australia, alternative approaches (i.e. traditional procurement models including document/tender/build, and design and construct (DandC)) are losing their attractiveness due to a shortage of resources and general lack of capacity to deliver projects within the construction industry. It has recently been remarked by some government agencies that there is little interest by contractors to bid for D andC contracts which allocate all significant risks to the contractor, when there is an abundant supply of work available as project alliances or other forms of relationship contracting, with risk-sharing regimes which they view as much more equitable (Skinner 2006). The shortage of resources also means that the contractors are reluctant to commit large teams of personnel to preparing long and detailed tenders for D andC contracts when alliance selection procedures are much shorter and more direct even though they may involve the time of more senior members of the respective organisations.

This situation has now reached the point that some requests for D andC tenders are reportedly attracting a very limited number of responses, or even none. Clearly this impacts on the opportunity to develop competition between bidders and as a consequence the cost of undertaking work under a price-based procurement strategy such as D andC has risen substantially in recent times (Skinner 2006). These increases are thought to have arisen for several reasons including increasing costs of labour in a buoyant market and high material costs for commodities such as steel and cement which result from world demand. This situation provides an interesting illustration of the ultimate consequences of trying to follow a ‘price based’ procurement process in circumstances where a ‘cost based’ procurement approach such as project alliancing would provide a much more transparent process that would enable clients to better understand, and then better justify, whether the investment involved offered best value.

Whilst the project alliance approach originated in the private sector, the public sector has embraced the procurement model more extensively in recent times. There is evidence to suggest, however, that the private sector is renewing its interest in the model primarily due the competition issues described above. It is also worthy of note that, to date, project alliances have not been extensively adopted for building contracts, although when the method was selected for the Acton Peninsula Alliance which constructed the new National Museum in Canberra, it was generally hailed as a success.

Experience of project alliances has developed and the procurement method has matured to the point where most of the initial ‘problem’ issues associated with this new procurement methodology have now been largely overcome. However, one issue that remains a relatively controversial matter is the demonstration that alliances truly offer VfM outcomes. Concern that this matter is yet to be successfully demonstrated is a view held broadly by both individuals and organisations associated with project alliancing. This is confirmed by this issue being a particular focus of the Alliancing Association of Australasia (AAA), an industry group formally constituted in 2006 to represent the interests of owners, contractors, designers, lawyers and other professionals involved in both strategic and project alliancing.

EARLY CONTRACTOR INVOLVEMENT (ECI)

A further form of relationship contract that has emerged in recent times but not described earlier in the discussion, is a form called early contractor involvement (ECI). This approach, developed initially in the United Kingdom as an extension to the partnering model, has recently been adopted in Australia, notably by public sector clients in South Australia and Queensland.

ECI is, in fact, a hybrid form which consists of a project alliance front end (up to the development of the target TOC, and then a D andC delivery phase in which the contractor takes all delivery and cost risk. At first glance, this may be seen as an odd combination of approaches and could be seen as placing at risk all the goodwill that should have been built up during the initial phases of the project, by adopting an adversarial mode during delivery. Experience with this model, particularly in Australia, is limited to date and consequently it is too early to suggest whether there is any evidence to support these concerns. However, the mere existence of this model and certainly the nature of its adoption in Australia appears to act as a metaphor for the fact that VfM concerns remain, particularly within some pubic sector treasuries. Such bodies can seemingly be persuaded that early consultation with a constructor can drive better solutions for construction-related projects and that this should make a contribution to improved VfM up to the development of the TOC. An apparently difficulty occurs, however, when the parties come to jointly accept risk for the final cost of the works. If such a joint ownership of risk is embraced, the price for the project is not fully determined and the owner carries price risk, albeit that this risk can result in either downside or upside exposure i.e. the final cost of the project could be less than the TOC and the owner would then benefit from these circumstances.

Anecdotal evidence, supported by the adoption of ECI, suggests that treasury agencies would actually prefer to commit to a fixed price at the time that the TOC is developed rather than endure any exposure to price risk even though experience to date with project alliances suggests that a shared risk regime is more likely to increase VfM as a consequence of the whole project team working together to deliver further cost savings and enhanced non-cost-based benefits during the delivery phase.

If this is the case, then concerns often expressed about VfM in alliancing are perhaps not genuinely about best value at all but are really concerns about certainty of price. Given that most project alliances in Australia complete the project for a sum less than the TOC it could be claimed that such an approach actually sacrifices a likely increase in VfM in order to purchase certainty of price. This position might be seen as even more illogical is one considers that the adversarial D andC delivery mode often leads to the development of a 'claims mentality' that almost invariably results in the final price for the works being higher than the original contract value (in this case the TOC) and occasionally, substantially higher.

CONCLUSION

Whilst there appears to be an abundance of logical arguments which support the proposition that project alliances should offer better VfM than more conventional adversarial delivery methods, there remains a degree of unease that such a conclusion has not been demonstrated to the satisfaction of those who remain sceptical about this new procurement model. A systematic methodology for demonstrating VfM on any given project, which would be strongly welcomed by all those involved with project alliances, has yet to be established and this represents a gap in the current body of knowledge.

The *Project Alliance Practitioners Guide* (VicDTF), issued in 2006 by the Victorian Department of Treasury and Finance lists some nineteen measures that could be adopted to demonstrate VfM, spanning the establishment, project development, implementation and post-completion phases of the project. However, it is believed that whilst this list represents a good start, further development of a model that will identify the key measures that need to be implemented at each stage of an alliance and describes the 'vital signs' that need to be monitored in order to both ensure and demonstrate that VfM is being achieved, requires further development.

The author is of the view that a model based on a similar rationale to the Gateway process developed by the UK, Office of Government Commerce, has the potential to provide guidance to practitioners on the steps and measures that should be taken at each stage of delivering a project, procured as a project alliance, to best ensure that VfM is delivered. It is also believed that some of the work undertaken in recent years to demonstrate that public private partnerships can deliver VfM may have a number of lessons to offer in the development of a model suited to project alliances.

The author is currently preparing a doctoral thesis on this topic and will be seeking to gather suitable data both through the existing literature and from the broader industry through a survey instrument that is intended to be circulated in the second quarter of 2008. It is expected that the model will be available in early 2009.

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The KOSMOS Programme: Stimulation of innovations with the right procurement strategy

Pascal Mousset
Carlita Vis

WHAT IS THE INNOVATION IN KOSMOS?

- Consider a government agency that specialises in public works, that has to reduce its number of employees.
- Allow it to try to solve the problem of the diminishment of the backlog of maintenance work of its dense infrastructural network within two years, with a budget of half a billion euros on a national scale.
- Change the traditional way of practice within the public client. Focus on converting public responsibility for the design and construction of infrastructure projects to private responsibility for the design and construction.
- Realise this within the limits of minimal disutility of the infrastructure and with minimal effects (hindrance) to its users.

Taking the above demands into account, you will conclude that this is a 'mission impossible.' Rijkswaterstaat, the Centre for Public Works of the Ministry of Transport, Public Works and Water Management in the Netherlands, thought differently and picked up the challenge with the KOSMOS programme. By designing a new procurement procedure, a new approach to consumer satisfaction and a strong focus on quality (for instance minimising traffic hindrance) instead of choosing the lowest price, a more effective programme was born.

PURPOSE OF THE KOSMOS PROGRAMME

The backlog of maintenance work on highway and waterway infrastructure, sometimes a result of been neglected for 30 years, became a strong political issue in 2004. Parliament decided in 2005 that within a two-year period most of the currently occurring, and expected short-term maintenance problems should be solved, in order to keep the infrastructure up and running.

At the same time the disutility of the infrastructure and expanding traffic jams became alarming for several reasons, not in the least because several of the executive public works divisions did not synchronise any of their maintenance programs, and took no initiative in merging different works. Strong demands for a more corporate approach made the ministry decide upon a national KOSMOS Programme to merge all existing technical problems concerning flyovers, overpasses, bridges and other related objects built on or in the Dutch highway and waterway infrastructure network.

In addition to this, this new approach of maintenance had to be organised with fewer civil servants. The underlying effect was the need to cut costs by way of searching for more efficient solutions.

PROCUREMENT AND REALISATION APPROACH

To achieve both end-user and market satisfaction, the following approach was decided upon:

- Market consultation by means of new public–private discussions.
- Establishing a corporate (= national) procurement strategy, considering new sizes of contracts and integrating all necessary disciplines in one individual contract.
- Providing maximum transparency in information for all interested parties.
- Expanding the necessary market by designing standards, and standardised processes and procedures resulting in acceptance by smaller contractors.
- Pre-selection of private parties required to fulfil principal requirements of the contracts.
- Making the pre-selected participants responsible for determining the actual problems of the infrastructure during the procurement procedure.
- Competitive dialogue with all participants (the consortia) to finalise contracts and the procedural and technical gaps.
- Making the individual risk distributions possible per pre-selected private party.
- Awarding the contract to the consortium having best met the principal requirements both qualitatively and financially (economically most advantageous bid).
- Coaching on the job of system-based quality control during the realisation phase, since both parties are in a learning phase.
- Evaluation with all the involved private parties and Rijkswaterstaat to measure the opinions and results of the innovative process.

INNOVATION BY A PROCUREMENT APPROACH

Corporate tender strategy and extent of contracts

Where individual objects were subject to individual maintenance in the past, current public opinion asks for a more user-friendly approach taking the whole infrastructural network into account. At the commencement of the KOSMOS programme the following strategy was developed:

- Maximise contract volume by combining objects.
- Determine rough time slots according to actual traffic compulsion (and influence of disutility of the infrastructure) to offer strict maintenance timeslots to the participants in the tender phase.
- Create financial incentives for minimising traffic hindrance.
- Ascertain the volume of maintenance to be carried out on one object to achieve a basic maintenance level.
- Determine the type of maintenance works to be executed (several disciplines).
- Determine the maintenance in terms of problems to be solved with functional requirements instead of damages to be repaired.
- Predict or forecast the extent/amount of the maintenance expected in the future as a function of time.
- Determine regional diversion of the network.
- Determine interfaces with other projects.
- Digitalise all information and digitalise the whole tender process.

Although the regional offices of Rijkswaterstaat had to decide upon which objects were to be included in the KOSMOS programme, the central procurement and engineering department decided upon the actual size of the contracts to be tendered after having consulted the private sector. This resulted in nine contracts nationwide:

- Six contracts with an interdisciplinary content (road and water infrastructure, interdisciplinary), regionally diverted, containing between 100–200 objects and 300–500 problems.
- One contract with a technical interdisciplinary content (water infrastructure) and one similar contract for road infrastructure, both combined to reach optimum in the particular (water)way traffic and the optimal expertise of the selected party.
- One contract including seven bridges over the Amsterdam-Rhine canal, combined to reach an optimum in the (dis)utility of both the waterway and crossing bridge traffic.

All the contracts have been uniformly designed to facilitate all participants in the tender:[2]

- A small overall contract with an underlying uniform document structure and hierarchy.
- A uniform set of general terms.
- Uniform technical specifications on functional level.
- Engineering, eventual design and construction responsibility by the contracted party.
- Technical and procedural gaps to be discussed with parties in the tender phase, resulting in concrete content by parties.
- Auditing and quality control by an independent technical inspection service.

FIRST TENDER PHASE: PRE-SELECTION OF PARTICIPANTS

Selection criteria for participants to the following competitive dialogue phase have been kept relatively simple and abstract. Besides ISO-certification, participants had to prove:

- experience/expertise in maintenance and/or reconstruction of earlier mentioned objects
- experience/expertise in maintenance and/or reconstruction of highways and/or waterways
- experience/expertise in managing a design-and-construct contract including a proven lifecycle approach
- interdisciplinary management expertise
- proven experience in the field of realisation of a constructional contract combined with traffic management (work in progress while traffic in progress).

A specific demand from the industry was to keep these requirements rather abstract in order to invite the smaller contractors as well (or a combination of smaller companies) to tender. For Rijkswaterstaat this proved to be advantageous in providing competition, support and success by increasing the number of entries able to participate in the several tenders. Secondly, the process of learning the KOSMOS Programme would not be restricted to the ‘Big six’ contractors.

For eight of the nine contracts, the selection phase led to four selected bidders per contract to participate in the tender.

[2] All tender documents have been published (in Dutch) on www.aanbestedingskalender.nl (keyword ‘kosmos’) and on the European procurement sites.

SECOND TENDER-PHASE: COMPETITIVE DIALOGUE

For six out of nine contracts Rijkswaterstaat decided to arrange a competitive dialogue, for the following reasons:

- Rijkswaterstaat intends to be less of a highly technically oriented organisation that develops technical solutions by itself. It has transformed into a public service organisation responsible for services relating to consumer demands: traffic management, road safety, traffic-related information and communication.
- With a deficiency of highly technical expertise and with a focus on procurement, both Rijkswaterstaat and the construction industry are in a transitional period where the private parties have to provide solutions to problems defined by the public client.
- Due to the backlog of maintenance, asset management is starting to develop. A continuous gap in the assets information has prevented some problems from being solved. Rijkswaterstaat wanted to fill the information and technical gap by means of dialogue with the bidders.
- Although Rijkswaterstaat arranged a contract with principal requirements for its realisation, it wanted to receive full innovative cooperation in order to improve methods of realisation related to the infrastructure's users.

RESULTS OF THIS METHOD

In general, the approach by Rijkswaterstaat and the innovations of the bidders have proven to be advantageous for its end-users. Expected major problems in traffic and road utility were therefore avoided. It may be noted that the abovementioned procedure has resulted in successes and failures, as outlined below.

Successes

Time, preparation and market benefits

As an example, preparation for maintenance work on a single viaduct usually takes six months to prepare. Now 1200 structures will be renovated within two years. It will not only generate more work for the private sector, but also gets the private parties involved at an early stage in deciding how the work will be done in spite of limited time and resources.[3] **Result: less time, less investment for the whole process.**

Buying timeslots

In the tender phase Rijkswaterstaat offered timeslots on highways for maintenance works (e.g. from Friday 20.00h to Monday 06.00h). Parties were able to 'buy' extra hours to extend these periods. The calculation of their offer included the extra hours and would increase the actual fee compared with the virtual offers of other parties. Less extra hours resulted in more quality in the light of traffic flow.

Where buying extra time beforehand was actually done to a relative good price, delays in the execution phase would cost the party substantially more. In practice, several parties tried to be very competitive in this way and were innovative, as illustrated in the examples below.

Road closures and speed limitations avoided by innovative design

Rijkswaterstaat traditionally decides upon road closures, limitations and deviations in its contracts. It does so to balance both maintenance works and traffic flow with regard to in-house traffic management and incident management.

In one specific contract Rijkswaterstaat decided on a partial closure in the timeslots of Highway A9 (Amsterdam), where 46 000 cars pass (one-way) in 24 hours. It was expected that, besides the normal timeslots, many extra hours would have to be bought to have the maintenance executed within the fixed period and detours to other highways seemed necessary. During the tender phase, three of the four parties came up with traffic management plans and engineering solutions that confirmed the expectation of Rijkswaterstaat. However, one party came up with a totally new concept. This party proved that a total closure of the left-lane (traffic from Amsterdam to the north) and two-way traffic on the right-lane was not necessary for its solution. This party made clear that (partial) road closures could be avoided by detours. The expected limitation of 46 000 cars per 24h (in one contract) could totally be avoided, while speed limitations could be kept to an affordable level[4]. **Result: less traffic congestion, cheaper, more public satisfaction**

In all contracts speed limitations were subjected to the same timeslot/extra hour-construction as above. Most parties came with ideas matching the traditional view of Rijkswaterstaat as above (maintenance means low speed means congestion). For instance, repairing joints in a highway construction normally needs closure of the highway and speed limitations accordingly. However, expected speed limitations and closures on highways could gradually be avoided by innovative engineering constructions by participants 'bypassing' bridges for traffic over these joints, where the maintenance work could continue without hindrance. The party concerned therefore was not bound to buy extra time to have the work done. **Result: no traffic congestion, cheaper, more public satisfaction.**

Closure timeslots and lane-rental constructions proved highly efficient for public and private parties in planning activities.

Object-related and corridor-related activities proved to be efficient, resulting in avoidance of traffic limitations and fewer complaints and dissatisfaction by its end-users. When the end users see that quick, though more intense, multidisciplinary work is done in a short period of time versus different types of maintenance with less limitations, though in a longer period, they prefer the 'quick and dirty' method. **Result: cheaper, more public satisfaction.**

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[3] http://www.rijkswaterstaat.nl/pim/uk/nieuws/conferences/kosmos_pim.jsp
[4] KOSMOS contract Noord-Holland, subject to competitive dialogue (not published)

The new method proved to be effective between the client and contractors. Respect for each other's expertise and experience produced optimal results.

Failures

New methods developed by one party can result in distrust by the others. 'Did this party actually fulfil the actual requirements?' was an argument sometimes heard, and one almost resulted in a lawsuit to try to prove that Rijkswaterstaat and one party did not work honestly.

Speed is not everything. Where Rijkswaterstaat wanted to include all parties in the shared responsibility of the inspections and reach a sound technical specification by ways of the competitive dialogue[5], not all parties accepted the complete responsibility which they confirmed when signing the contract, according to Rijkswaterstaat. Also same have stated that Rijkswaterstaat does not have enough asset knowledge to advance this manner of contracting to the market at this stage. Missed backlogs of maintenance, extended problems and extra damages are at the time of writing subject to a discussion on the philosophy of the program, and this may end up in arbitration between the Rijkswaterstaat and contractors.

Although Rijkswaterstaat offered a complete maintenance program in a certain timeframe, spin-offs of the program seem likely to have their loose ends tied up by 2008 or 2009.

PRELIMINARY CONCLUSIONS

Can the procurement strategy of the KOSMOS Programme be called a success? Many best practices and innovations have been developed. Unfortunately mistakes have also been made. Rijkswaterstaat and the contractors involved are in a learning process where parties allow each other to make mistakes and learn accordingly. In that respect this pragmatic approach can be classified as successful and directly fruitful for the users of the infrastructure.

Realisation phase

Overall, the tender phase was successful enough to allow for the realisation phase, which is now in full progress. The works 'outside' have been executed, and the digital paperwork is in progress. Technical and procedural suggestions and innovations have helped Rijkswaterstaat and end users in time, reduced hindrance, and money.

Some of the contracts have been tendered with delays, and will end later than December 2007. Overall, the programme has been delayed by one year. Delayed maintenance in 2008 means more 'sense of hindrance' to the end user than expected[6] and also means extra costs for supporting personnel in the public and the private parties.

The dialogue and transitional processes continue, stop, and then resume. They are, however, regarded as fruitful and important, and there is faith that all parties will bring the program to a successful end. Most important is that all parties are unanimous in their opinion that this is the way it should be. The private contractors should be driven by the functional demands of the Rijkswaterstaat. The next logical step is a process filled with technical innovations brought on by the contractors. The KOSMOS Programme will have its successor.

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[5] http://www.rijkswaterstaat.nl/pim/uk/nieuws/conferences/kosmos_pim.jsp

[6] http://www.vananaarbeter.nl/English/

CHAPTER 10

The Competitive Impacts of Leveraged Training Outcomes

Siobhan Austen
Richard Seymour

INTRODUCTION

The broad focus of this paper is the competitive effect of government policies aimed at securing training outcomes from public construction contracts. Its context is the trend towards the contracting-out of public construction works and the attempts that have been made to use construction contracts to 'leverage' a wide range of social outcomes. In federal and state jurisdictions it is now common for governments to impose a range of additional requirements on public works contractors that relate to broad social/community objectives. These requirements include commitments to train apprentices and trainees, to provide local and/or indigenous employment opportunities, to buy local materials, and to include art works.

The cost and benefits of using public construction contracts to achieve social/community goals have, to our knowledge, not been thoroughly researched in an Australian context. This is likely to reflect in large part the relatively short history of contracting-out public works. As Jensen and Stonecash (2004) explain, most previous empirical studies of contracting-out have attempted to measure the cost savings achieved through privatisation, as this was the focus of policy debate in the 1980s and 1990s. Relatively few studies have addressed the ability of contracting arrangements to ensure the delivery of desired 'quality' outcomes[7], or the costs of achieving these outcomes through contracting arrangements.

One of the potential costs of attempting to leverage social/community outcomes on public construction projects is a reduction in the amount of competition for these projects, with obvious consequences for average bid prices and choice. In jurisdictions, such as Western Australia currently, where construction market conditions are already causing a shortfall of tenderers and rising costs, this potential competitive effect is of particular concern.

This paper aims to contribute knowledge on the nature and extent of the competitive effects of the leveraging of social/community outcomes on public construction projects. It does so by examining the effects on the level of bid activity for public construction projects of two policies of the Western Australian Government: the Priority Access Policy and the Building Skills Policy. Both of these policies aimed at ensuring an adequate supply of skilled labour in the construction industry[8]. The Priority Access Policy, first implemented in August 1999, required contractors to meet a range of minimum training requirements[9] before being eligible to tender on public building and construction contracts. The Building Skills Policy, which was first implemented in October 2002, specified that 10 per cent of deemed labour hours be allocated to the employment of apprentices and/or trainees. On 1 January 2007 both policies were integrated into the Priority Start–Building Policy.

The paper's analysis of the competitive effects of these policies is based on data drawn from the WA Department of Housing and Work's (DHW) Tender Registration System between 1997 and 2006. The Tender Registration System (TRS) was implemented in 1996 as a way of recording the tender details of all WA government construction projects. The TRS database contains records on the details of each project: a description of the works to be undertaken, the location of the planned work, and the estimated pre-tender value of the project. The database also contains information on the number of tender documents requested for each project, together with details on each of the tenders received and the winning bid. As such, the TRS is a unique and comprehensive resource for examining changes and variations in bid activity in an important segment of the construction 'market'.

In this study use is made of the TRS project and tender details on 2519 government non-residential construction contracts awarded between 1997[10] and 2006. For these contracts 11 525 tender bids were submitted. This represents close to all the contracts and bids included in the TRS over the ten-year period. Only a very small number of contracts were excluded from the analysis due to incomplete recording of their details[11].

The analysis presented in this paper is important for a number of reasons. First, it comprises a detailed quantitative analysis of a large set of data on public construction contracts. To our knowledge, little use has been made by academics of the data that now exists on tender bids and outcomes in most Australian jurisdictions. This paper hopefully highlights the potential to draw on these sources to gain greater insights into the trends and issues affecting the construction market in Australia. Second, it is a novel

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[7] A notable exception is Domberger and Jensen (1997) which explored the ability of a public authority to ensure adequate investments in vehicle maintenance in its contractual arrangements for the provision of refuse collection services.
[8] *Priority Access n.d.* retrieved 20 October 2006, from http://policies.det.wa.edu.au/; *Building Skills n.d.* retrieved 20 October 2006, from http://policies.det.wa.edu.au/.
[9] Contractors need to meet a minimum of 100 points in order for them to be able to tender. Points are allocated based on the contractor's involvement in specified employment and training activities, such as employing apprentices and/or trainees, staff with recognised VET qualifications, staff with tertiary qualifications, or having staff participating in work-related training programs.
[10] Although the TRS was initiated in 1996, records in this year were incomplete and, thus, excluded from our investigation.
[11] The omission of records on location and tender value appeared to be due to record-keeping errors and is, thus, unlikely to be a source of systematic bias in the results of our analysis.

attempt to examine the efficiency of using the contracting arrangements of public works authorities to achieve training goals. Specifically, the analysis generates unique information on the effects on competition for public construction contracts that may stem from different types of 'leveraged' training policies. The rising trend towards the contracting-out of public sector activity, together with concerns about the availability of skilled labour makes this type of information of great policy relevance.

The paper is organised in a straightforward manner. Section 2 gives an overview of activity in the public non-residential construction 'market' in WA generated from the TRS and other data sources. The third section provides an overview of the methodology used to analyse the relationship between the implementation/application of the Priority Access and Building Skills policies and bid activity in the public construction 'market'. Section 4 presents the results of this empirical analysis, whilst the final section provides a discussion and summary.

OVERVIEW OF THE NON-RESIDENTIAL CONSTRUCTION SECTOR IN WA, 1997–2006

The total value of non-residential construction activity completed in Western Australia in 2006 was $2280m. As Table 10.1 shows, private sector work dominates this total, comprising close to 75 per cent of all non-residential construction work in 2006. Public sector activity in 2006 was valued at $592m.

There is a strong upward trend in non-residential construction work in the state from the beginning of 2002, with this increase being dominated by private sector activity (ABS 2007). Between December 2001 and December 2006 the total nominal value of private sector work increased by 120.6 per cent. This compared to a 3.1 per cent increase between December 1996 and December 2001.

It is not particularly surprising that the 1996–2007 period was also characterised by a sharp fall in the average number of tender bids for WA government non-residential construction contracts. Between 1997 and 2006 the average number of bids on these contracts fell from 5.1 to 3.3 bids, or by 35.3 per cent. A large part of this change was concentrated in the years from 2001.

Western Australia is a large and geographically diverse state and, as such, any analysis of construction activity needs to take into account sizeable regional differences in costs of production. In the study period, the large majority (70%) of public construction contracts related to work undertaken in the Perth region[12]. A further nine per cent of contracts were located in the South West and Peel regions, both of which are relatively close to Perth. The remaining contracts were spread across a range of remote regions.

The decrease in bid numbers observed in the state as a whole also occurred in the two groups of regions identified here. In the regions located relatively close to Perth – that is, the Perth, Peel, and South-West regional development regions – the average number of tender bids declined by 42 per cent between 2001 and 2006. In the remaining, more remote regions, this decline was 35 per cent.

Another source of diversity in public non-residential construction work in WA is the size of the work undertaken. Projects range from small additions to local schools to large infrastructure projects. This diversity is especially important in the context of the current investigation because the training policies being studied only apply to relatively large projects. The Priority Access Policy applies only to contracts with a pre-tender value of $150 000 or more; the Building Skills Policy to contracts with a pre-tender value of more than $2 million. 1019 contracts (or 54.2% of all awarded contracts) have been subject to the Priority Access Policy since its introduction in August 1999. The Building Skills Policy has applied to 160 contracts (or 11.8% of all awarded contracts) since its introduction in October 2002. The downward trend in tender bid numbers was common to each of the prequalification levels associated with the contracts, but it was largest in magnitude in the Level 2–4 (mid-range) categories. This pattern is summarised in Table 10.1.

Table 10.1 Percentage Decline in the Average Number of Tender Bids by Prequalification Financial Level between 2001 and 2006

Prequalification financial level	Percentage decline in the average number of tender bids
(Level 0) $1 to $149 000	22.9%
(Level 1) $150 000 to $750 000	50.2%
(Level 2) $750 001 to $1 500 000	56.4%
(Level 3) $1 500 001 to $3 000 000	60.4%
(Level 4) $3 000 001 to $7 500 000	56.4%
(Level 5) $7 500 001 and above	26.2%

The observed trends in bid numbers are likely to have been strongly influenced by changes in factors affecting the availability of other construction work and the cost/availability of resources. The years since 2002 have been associated with substantial growth in WA's resource and construction industries and this has produced large pressures on available labour and materials.

A number of related statistical measures convey information on these pressures. For example, in the DHW's building cost index[13] there was only a slight rise in building costs (by around 8%) from the beginning of 1997 up to mid 2002 but these then increased rapidly (by around 55%) to the end of 2006 (West Australian Department of Housing and Works 2007).

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[12] This study matched the postcode information contained in the TRS with the WA Department of Land Information's [0]regional development regions to identify the regional distribution of contracts.
[13] For the Perth region this includes both labour and material costs[0].

The building cost index is derived from measures of labour and materials costs and reflects the costs of accomplishing standard types of public and private sector construction projects[14]. The influence of labour costs on the index is apparent in the similar pattern of change in construction industry wages over the study period. These remained relatively stable between February 1996 and August 2002 (increasing by only 1.6%). However, they rose rapidly from August 2002 onwards, increasing by 40.8 per cent by November 2006 (ABS 2006a). Materials costs rose by only 6.1 per cent between December 1996 and September 2002 but rose by 23.6 per cent between September 2002 and December 2006 (ABS 2006b).

Labour shortages emerged in the state after 2002 and were an important contributor to the rising wage costs. Illustrating this, the Department of Employment and Workplace Relations skills vacancy index (DEWR n.d.), which provides a monthly indicator of the degree of difficulty that employers have in filling vacancies in occupations or specialised skill needs, recorded a 129.5 per cent increase between the start of 2002 and the end of 2006.

MULTI-FACTOR ANALYSIS OF BID ACTIVITY

The central research question addressed in this paper is whether the additional training requirements imposed as a result of the Priority Access and Building Skills policies had a *measurable and distinct* impact on bid activity for public construction contracts. That is, was there a measurable effect of these policies on bid numbers that was separate from the impacts on bid activity generated by changing economic conditions in the state?

Conducting such an analysis clearly requires a multi-factor approach that is able to ‘control’ the influence of the range of other factors on bid numbers (such as changes in private construction activity and costs, as well as variations in contract region and project size) before focusing on the relationship between the implementation of the policies and bid activity.

The approach adopted for this investigation is to examine variations in the number of tender bids for non-residential government construction contracts around the time of the implementation of each policy[15]. For the Priority Access policy, the analysis period is August 1997 to August 2001, which encompasses the 24 months prior to and the 24 months after the implementation date of the policy. For the Building Skills policy, the 48 month analysis period is October 2000 to October 2004.

The analysis focuses on differences in bid activity between the ‘market’ segments affected and unaffected by the policy. In the case of the Priority Access Policy this involves a comparison of changes in bid activity across the analysis period between (a) projects with a pre-tender value of at least \$150 000 (and thus potentially affected by the policy); and (b) projects with a pre-tender value of less than \$150 000 (not affected by the policy). In the case of the Building Skills Policy the two comparison groups are (a) projects with a pre-tender value of more than \$2m; and (b) projects with a pre-tender value of \$2m or less. In each case we hypothesise that if the policies were affecting bid activity, activity levels would fall in relative terms in the market segment affected by the policy. Furthermore, this fall would be observed in the analysis period.

This data is clearly not supportive of the above hypothesis. In fact an opposite pattern is apparent: the average number of bids declined for contracts *not* subject to the Priority Access Policy over the analysis period, whilst there was negligible change in the average number of bids for tenders subject to the policy.

At face value, the data on changes in the average number of bids for contracts affected/not affected by the Building Skills Policy between 2000 and 2004, is more supportive of a hypothesis that the policy affected bid activity: the average number of bids for contracts subject to the policy fell at a greater rate than those not subject to the policy over the analysis period. There is also an apparent alignment between the introduction of the policy and this relative change. However, given the strength of the other influences on the construction market (as described in the previous section), there is a need for caution before reaching firm conclusions about the effects of the policy. The following section provides more definitive insights.

Econometric strategy

The multi-factor analysis of the relationship between bid activity and policy settings is structured into two parts, each relating to the key policy initiatives: Priority Access and Building Skills. In each part, however, the same approach is taken to the measurement of the effects of the policy. Specifically, linear (OLS) regression techniques are used to estimate the following equation, which relates to the determination of the number of bids for public construction contracts:

$$NB_i = \beta_1 + \beta_2 PD_i + \beta_3 Z_i + \beta_4 PT_i + \beta_5 RN_i + \beta_6 OF_i + \gamma_2 (Z_i \text{ x } PD_i) + \varepsilon_i \quad (1)$$

NB_i, is the number of bids submitted on contract *i*; PD_i is a dummy variable that is based on the date of implementation of the policy (for example, in the case of Priority Access this variable takes on a value of 1 for all contracts dated after August 1999); Z_i is a dummy variable that identifies whether the contract falls within the scope of the policy’s application (in the case of Priority Access this variable is coded as ‘1’ for all contracts with a value of \$150 000 or more); PT_i is a continuous measure that relates to the contract’s pre-tender value; RN_i is a dummy variable that identifies whether the location of the project was in the Perth, South-West or Peel Regions, or in another, more remote region. OF_i is a continuous variable based on the value of the building cost index in the month that the bids were recorded. It is used in this model to proxy the level of competition in the construction market[16]. Finally, the interaction term (Z_i*PD_i) identifies those projects that were affected by the implementation of the policy (for example, in the case of Priority Access this variable will only take on a value of 1 for contracts with a pre-tender value of \$150 000 or more and dated after August 1999). ε_i is a random error term, which is assumed to be normally distributed with $E(\varepsilon_i)=0$ and the var $(\varepsilon_i)= \sigma^2$.

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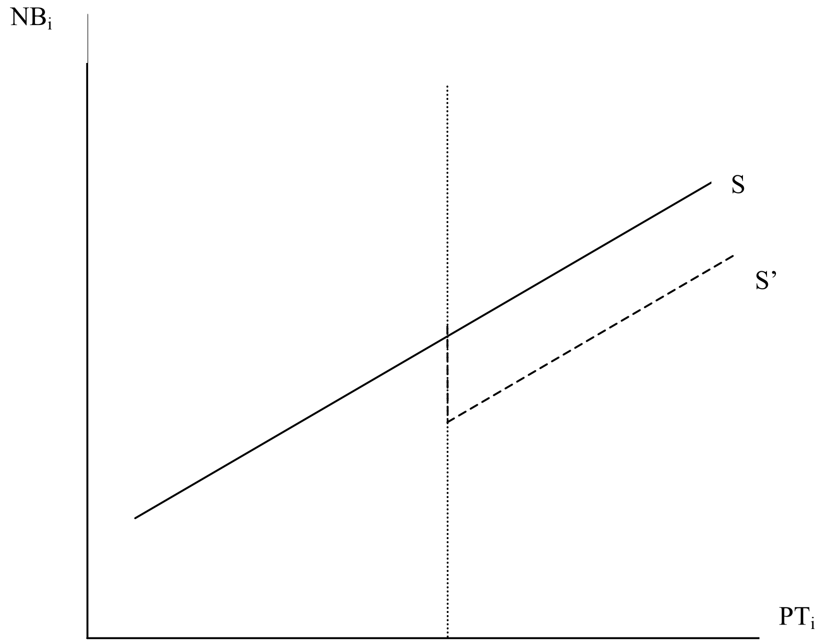
[14] For example, it reports the current cost of a typical school and prison.

[15] This approach to restricting the time period allows us to focus more fully on the effects of the policy whilst allowing for the possibility of anticipatory or delayed effects.

[16] As noted in the previous section, this index reflects current costs of accomplishing the types of construction projects contracted for via the TRS. A variety of measures of market conditions (indexes of labour availability, materials costs, etc.) are available. However, testing indicated that these are strongly correlated with the Building Cost Index.

The modelled relationship can be described in the following simplified terms. First, the function S, shown in Figure 10.1, represents the positive relationship between the pre-tender value of the contract and the number of bids.

Figure 10.1 The Positive Relationship between the Pre-tender Value of the Contract and the Number of Bids



The other factors in the model are hypothesised to be associated with shifts in this function. For example, in more remote regions the function S could be expected to shift downwards (implying a positive coefficient on the variable RN_i in equation 1) due to the greater difficulties in accomplishing construction work in these areas as compared to less remote regions. The background statistics shown in earlier parts of this paper support this hypothesis. Higher building costs are likely to be associated with a downward/rightward shift in the function (implying a negative value on the coefficient on OF_i). If the introduction of a training policy has a negative effect on bid activity, its application only to projects with a $PT_i \geq Z_i$ would cause a discontinuity in S around point Z_i (as represented by the function S'). Evidence in support of this hypothesis would be a significant negative coefficient on the interactive term (Z_i*PD_i). The individual term PD_i controls for the possibility (seemingly remote) that there was a change in bid activity for all contracts around the time of the introduction of the policy. The individual term Z_i controls for the possibility (more likely) that there are underlying differences in the relationship between tender activity and pre-tender prices in the group of contracts 'priced' above and below the trigger value of the policy.

RESULTS

The estimated relationships between tender bid numbers and the various explanatory variables included in the RHS of equation 1 using DHW data are outlined in this section. Reflecting the above discussion, these results are presented separately for the Priority Access and Building Skills policies.

Priority Access Policy

Equation 1 was first estimated with reference to data on bid numbers on DHW contracts for the period August 1997 to August 2001. In this case Z_i is defined by the introduction of the Priority Access Policy in August 1999 and PD_i is defined by the policy's application to projects with a value of $150 000 or more. The results of this analysis are presented in Table 10.2.

Table 10.2 Estimated Coefficients for Equation on Bid Numbers on Government Non-residential Construction Contracts (Priority Access Policy), Western Australia 1997-2001

Variable	Coefficient	Probability
Constant	-4.2950	0.6142
Policy implementation date (PD)	-0.4990	0.3528
Contract above trigger value (Z)	0.9299	0.0007
Pre-tender value (PT)	-1.29E-07	0.0033
Region	1.4243	0.0000
Building cost index	0.0720	0.3394
PD*Z	0.0216	0.9612

Notes: Log-Likelihood: 1957.8; Nobs: 789; Method: OLS

The data in Table 10.2 indicates that the implementation of the Priority Access Policy in August 1999 *did not* have a significant effect on competition for government non-residential construction contracts in WA. The reduction in bid numbers observed around the time of the implementation of this policy was similar in 'market segments' subject to the influence of the policy (i.e. contracts with a value of $150 000 or more) and in other parts of the 'market'. The figures in Table 10.2 show, rather, that during the analysis period (August 1997 to August 2001) bid numbers varied between contracts firstly due to regional factors. The average number of bids on contracts in more remote regions was 1.42 bids less than the number of bids on contracts in the Perth, South-West and Peel group of regions. Bid numbers in the analysis period were also significantly affected by the value of the contract. Contracts with a value of $150 000 or more had, on average, close to one additional bid per contract than those with a lower pre-tender value. A somewhat surprising result is the lack of a statistical significant relationship between the building cost index and bid numbers. The most likely explanation for this is that, as was outlined in previous sections, the period 1997 to 2001 was a period of relatively stable economic conditions. There was little variation in the building cost index over the analysis period and, thus, this was not an important source of differences in bid activity.

Building Skills Policy

The results derived from the application of Equation 1 to TRS data relevant to the Building Skills Policy are presented in Table 10.3. In this case the analysis period spans October 2000 to October 2004; Z_i is defined by the introduction of the Building Skills Policy in October 2002; and PD_i is defined by the policy's application to projects with a value above $2 million. The results of this analysis are presented in Table 10.3.

Table 10.3 Estimated Coefficients for Equation on Bid Numbers on Government Non-residential Construction Contracts (Building Skills Policy), Western Australia 2000–2004

Variable	Coefficient	Probability
Constant	9.3524	0.0000
Policy implementation date (PD)	-0.4719	0.0516
Contract above trigger value (Z)	1.4512	0.1009
Pre-tender value (PT)	1.39E-07	0.0008
Region	1.2794	0.0000
Building cost index	-0.0436	0.0004
PD*Z	-1.4152	0.0986

Notes: Log-Likelihood: 1873.5; Nobs: 807; Method: OLS

The data in Table 10.3 provides some evidence of a negative impact of the Building Skills Policy on bid activity relating to government non-residential construction contracts in WA. Bid numbers on contracts affected by the policy (i.e. above $2 million in value and commencing after October 2002) were, on average, 1.42 bids lower than contracts not affected by the policy after 2002. However, this effect was only statistically significant at the 10 per cent level.

A further contrast between the results in Table 10.3 and those in Table 10.2 is the significance of building costs as a source of variation in bid numbers. The figures in Table 10.3 indicate a strong negative relationship between the building cost index and bid numbers. The difference between the results in Table 10.2 and 10.3 is likely to derive from the relatively large rate of change in the building cost index between 2000 and 2004, as compared to 1997–2001.

A similarity between the two sets of results is the measured importance of regional factors as a source of variation in bid numbers. In Table 10.3 the average number of bids on contracts in more remote regions was 1.27 bids less than the number of bids on contracts in the Perth, South-West and Peel region. Finally, bid numbers in the analysis period relevant to the Building Skills Policy were positively affected by the value of the contract.

DISCUSSION AND CONCLUSION

This paper has identified that the Building Skills Policy, but not the Priority Access Policy, affected bid activity for non-residential construction contracts in WA. Bid numbers were lower on contracts affected by the Building Skills Policy following the implementation of the policy in October 2002. This effect was distinct from the influence of changes in construction costs and regional and project size factors on bid numbers.

These results are significant for two key reasons. First, they indicate that the Building Skills Policy contributed to a lowering of competition for public construction contracts in the 48-month period surrounding its implementation. Such an impact has efficiency consequences for the public construction program, potentially contributing to higher costs and/or lower quality outcomes. Given that WA is currently under the influence of a range of economic pressures, these added costs are of particular concern.

However, this conclusion does not necessarily imply that the Priority Access Policy was a superior training policy. It is important to ask why the Priority Access Policy *did not* affect the willingness of construction companies to bid for public projects. One possible answer is that it did not impose high training requirements – or affects the training actions of construction firms in a significant manner. If this is the case, the evidence presented in this paper cannot be interpreted as supportive of the policy.

In sum, the results in this paper indicate that the Building Skills Policy affected the actions of construction companies, causing some to avoid tendering for public construction contracts. This result also suggests, however, that the policy was effective in influencing the inclusion/exclusion of public contractors according to their training commitments. There is little evidence that the Priority Access Policy affected bid activity in the public construction 'market'. Although this may be interpreted in the positive light – that is, of the policy not having negative competitive effects – it is also possible that the policy did not affect training outcomes on public works.

The two policies had similar objectives: to promote training and, thus, the availability of skills in the construction industry in WA. The fact that this paper has identified differences in the behavioural effects of the two policies raises additional research questions about their design. For example, were there features of the design and implementation of the Priority Access Policy that caused it to have very little impact? What can policy-makers interested in promoting training learn from a comparison of the two policies that will inform future policy development? Future papers will address these important questions.

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Relationships as Risk and the Need for their Effective Management in Projects

Graham Scott

INTRODUCTION

There is research and anecdotal evidence from project management journals and other literature (Argyris and Schon 1978; Reading 2000; Dick 1991) that suggests that project communications and relationships, or rather the communications and relationships between people in project teams, are major issues in projects. These researches suggest that communication, relationship, trust and leadership are all contributing factors to project success and failure.

A plethora of authors including Argyris and Schon (1978), Reading (2000) and Dick (1991) advocate that other dynamics such as human emotions, group processes, culture, leadership, values, and trust are all major threats or risks to a project as well, of course, to any human endeavour.

Throughout this paper a number of anecdotal 'cases' are discussed. There is no research to date that addresses cases empirically. The anecdotal evidence is from the author's experience and the validity is based only on over fifteen years experience and a Masters degree in Organisational Psychology.

Research into human behaviour over the years has developed a number of scientifically proven principles and laws relating to Human Behaviour. For example, Tuckman's (1965) Model of Group Formation found that groups evolve with the project cycle, whether they were conscious of it or not. He pointed out that groups evolve in five stages, which include Forming, Storming, Norming, Performing and Adjourning. According to Tuckman (1965) many work groups live in the comfort of Norming, and are fearful of moving back into Storming, or forward into Performing. This will govern their behaviour towards each other, and especially their reaction to change. Based on this model it can be suggested that while there is a level of dysfunctionality, it is accepted because to change is just too hard. Argyris (1990) reinforces this in his discussions on overcoming organisation defences where he states that individuals feel helpless about changing environments.

Applying Tuckman's model (1965) it can be seen that it is one example of a concept that is predictive in any group situation and therefore can be used to assess intervention strategies to change behaviour from a scientific point of view. This model has been empirically tested in a number of studies.

This paper will show that concepts like Tuckman's model (1965) can be applied in day-to-day project situations and an understanding of the models can allow an assessment of the likelihood of risk to the project. As an example, having a team that has not reached the 'perform' stage attempt a complex task could result in failure if team process is not closely monitored. Assessing the stage of group development facilitates a strategic, focused intervention to move to the next performance stage.

This is an example of process or relationship risk. Tuckman's model (1965) is one that highlights how group process can be managed. To form a base for this paper, however another model is necessary.

A MODEL FOR THE PAPER

This paper is based on a model proposed by Edgar Schien.

Schein according to Dick (1991) developed the notion that the most important management skills were technical, interpersonal and emotional. By emotional skills Schein meant the ability to make difficult decisions, to take responsibility, and the like. A simpler equivalent term is courage. Emotional skills, he said, were most important. Without emotional skills the interpersonal skills cannot be used to most effect, and without interpersonal skills the technical skills may be wasted (Dick 1991). The real gains are achieved, however, when you have the courage as well.

The usual forms of communication in our culture do not usually favour effective problem solving. There are rules which discourage people from giving the information, which is often important to developing a solution. Especially important are rules which forbid exchanging information about motives and about negative feelings. To communicate well you often have to change the rules. You have to renegotiate the unstated rules of communication. To complicate matters, there are rules against renegotiating the rules. There are rules against making the rules explicit. That is where the courage comes in. It is needed to challenge the taboos and renegotiate the rules. With courage, though, it usually works. The result, for both parties, is a clearing of the air and an improved relationship. This is most apparent when you are involved in difficult communication. Most people do act impulsively, and perhaps regret it later. To make matters worse, threat triggers a set of defensive strategies. Emotional skills are required for people to accept that they may be part of the problem. People are least able to understand their own contribution when they are most under threat (Dick 1991).

Every contract or project has relationship elements, which, from the model above, are dynamics that fall under the banner of interpersonal or emotional. According to Schien, these impact on, and are impacted upon, by process. Initially a contract or project is established as a business relationship designed to deliver optimum commercial benefits to all parties involved. *Relationship management is the effective management of the relationships between, and within, dynamics and process. These processes can be applied to any project regardless of size or commercial arrangements.*

Schien's model has been refined in this paper to include 'intrapersonal' skills or 'process' in replacement of 'emotional skills'. Whilst emotional skills are part of the mix, they are not the mix. The model proposed suggests that there are three levels of skills and process: technical, inter-personal and intra-personal. The process is between the three areas and the dynamics within the three that require skills to manage. Table 11.1 depicts this relationship.

Table 11.1 Technical, Inter-personal, Intra-personal Communications and Relationships

Technical	Inter-personal	Intra-personal
Document preparations Designs Reviews Construction Integration and test Sell off Operations Planning Scheduling	Negotiations Problem solving Issue resolutions Group processes Project interfaces/communication Conflict resolution	Emotional intelligence/Anxiety management Egos Personality Belief systems

Table 11.1 shows in the left-hand column the more technical processes in a project where inter-personal interactions (middle column) are needed to achieve the best outcome. But intra-personal dynamics (right-hand column) are much more closely related to the second column's inter-personal interactions. As an example, imagine a situation where a junior engineer who is skilled at scheduling, but not really experienced enough to be really confident, is working in a project. This engineer's manager is somewhat bombastic and can be rather overpowering and condescending. If we take a small sample of the interaction, say a meeting to clarify the schedule as an example, we could say that from a right-hand column perspective (intra-personal) the junior engineer experiences some level of anxiety, given her confidence and the relationship. This will impact on her ability to communicate, even avoid the truth, so now we have a 'middle column' (inter-personal) breakdown. If the communication is not based on truth, then the possibility of getting accuracy in the schedule is reduced. These conditions are a risk to achieving the best technical outcomes for the project. To achieve the best technical outcome of a project, strong inter-personnel communications and relationships need to be alive in the project. To achieve the best inter-personnel communications and relationships, not only do we need the structures and systems to support this, we also need to manage the intra-personnel processes of the individuals involved.

OTHER DYNAMICS

Dick's model (1991) is an example of the process flow that leads to a breakdown in problem solving and moreover a breakdown in communication in certain environments. In this model it can be seen that when we are threatened there is an automatic reaction – 'arousal'. This happens in milliseconds and at a subconscious level. The next part of the process is the response to the arousal. This is dependent on our confidence levels which are impacted on by power balances, skills levels, perceptions, and a host of other dynamics. The response is either to feel anxious or excited. The former is generally a defensive response to an irrational emotion which serves to protect from a real or perceived threat, while excitement is a rational preparation without the irrational defence.

Either response requires resolution or action. In the case of anxiety, this needs to be removed. So the action is to 'solve the anxiety'. If the response is excitement or rational readiness the action is more likely to be problem solving. Anxiety is the unpleasant emotional affect, usually accompanied by physiological sensation, that is characterised by worry, doubt and painful awareness that one is powerless to control situations. In contrast to fear, anxiety is irrational. Anxiety will lead people to avoid problems rather solve them.

A case example of the impact on this is also clear. A bid team review, where the team was the runner-up in a relationship contract bid (not price-based) identified that over half the team believed that the proposed project manager was not the best for the project and that his résumé was 'thin'. While team members held this belief during the process, it was not stated or 'put on the table' (despite the team espousing values of open and honest communication). The group's beliefs were reinforced by a feedback session from the client that confirmed that the project manager was indeed 'the weak link'.

Why was this not discussed earlier? Apply the 'anxiety-solving' and three levels of communications models and you should reach some conclusion – it is simply threatening and anxiety-provoking to discuss what is difficult to discuss, and furthermore it's hard to discuss that – best ignore it!?

The reasoning behind this, while complicated, is relatively simple to a behavioural scientist There are a number of dynamics at play that restrict 'open and honest communication' and processes need to be put in place in teams to enable this. The dynamics are about anxiety-solving; the interaction around the three levels of process and a number of others. This case shows an example of where these dynamics live on a day-to-day basis.

Linking the anxiety-solving model to the earlier case of the junior engineer attending the scheduling meeting, it could be seen that the reason for anxiety might be the fear of being publicly embarrassed by the manager. This will lead to, in a situation where the junior sees the only option as avoiding the anxiety, to perhaps not raise potential blockages to the schedule, or not ask advice, or simply present what she knows will be accepted with the least fuss. This is anxiety-solving behaviour.

In an environment where the junior felt safe to raise issues or question the manager we would see more problem-solving as an outcome. Looking at that scenario in the light of the anxiety-solving model, it can be seen that the threat comes in the form of the manager – the junior engineer is not confident so is more likely to become anxious. The anxiety-solving is then the presentation of the unrealistic schedule and the silence on other events, that may contribute to 'over reaction' by the manager. Unfortunately there is a 'tail' in the model – the next step is the 'cover up' of the process by the junior engineer. This is in the form of a rationalisation or denial or both. The rationalisation comes in the form of perhaps coming to a conclusion that 'it is easier to not make waves', or 'I will fix it later'. The denial more than anything is the denial that the process was in any way a defensive routine: 'It solved the problem'.

Argyris refers to this dynamic as skilled incompetence. The process of development in Western cultures and some Eastern cultures fosters this incompetence. As children we learn that humiliation hurts so as we grow we actively avoid any situation in which we could be humiliated. This is the reason we don't speak out, why we don't openly debate without emotion. We are trying so hard to avoid feelings of anxiety or, when they occur, to resolve them rather than dealing with the issue.

This paper advocates that the generally poor management of right-hand column issues leads to poor management of the middle-column processes which in turn leads to the breakdown in 'hard' process and ultimately project deliverables. These dynamics need to be treated as risk, and with the correct strategies by the most appropriate people, they can be managed. If we view the project as a total system that has a number of interactions and dynamics, the whole system itself is subject to failure or breakdown. The effectiveness of the system will ultimately impact on the project outcomes.

INTERNAL RISK IN SYSTEMS

View systems-thinking from, say, the viewpoint of a motor. If a motor vehicle breaks down we go to a mechanic. The mechanic runs a diagnosis and identifies a fault, say a faulty spark plug. The plug is removed, replaced and the vehicle is running, able to perform as required, get to a destination, on time, safely, appropriately consuming resources.

Using the same analogy, prior to going on a long trip, certain components are checked and, if necessary, replaced. During that check, worn hoses and belts will be identified, removed and replaced. An electrical lead too close to a heat source is moved and tied off. This process is an internal risk-management process. We identify potential risks and implement mitigation strategies.

Every endeavour has both internal and external risks. For example on our motor journey, taking the dry weather road in the wet season is an external or project risk, while the assessment of the vehicle is an internal risk.

Similarly, a project is a system, and has internal and external dynamics to manage. The external system takes in the project objectives, and as part of that management a risk assessment is conducted. Risks such as wet weather, resources, etc. are identified and strategies put in place to mitigate, or dollars put aside as contingency.

It is very rare however to see any project that has an internal risk management process, either before or during the delivery. It is not rare to see projects fail or blow out on a key result area because of poor process management or poor relationship management.

The Snyder process according to Dick (2002) uses systems concepts to break down the process flow. Systems models treat a program (or some other unit) as something which transforms inputs into outputs (resources into achievements).

When analysed in a project or a group context, communications and relationships related to Snyder process is: Cause > Effects > Outcome.

The Snyder process explains the process of the impact of the intra-personal effect on inter-personal interactions in a project. As an example, if lack of trust exists as a cause, it will lead to a poor information exchange, as the parties do not trust each other to provide all the information to resolve a problem. This could lead to most of the poor outcomes listed. This process can be cyclic in that an underlying cause can lead to an outcome that 'causes' a different outcome, i.e. unclarified assumptions lead to breakdown in trust that lead to information not being passed on that leads to rework. *This process needs to be treated as risk.*

Another example of human behaviour of individuals in a group environment was explained by Argyris (1990), i.e. how the progressive process of making observations, gathering information, making assumptions, and deciding action, is similar to climbing a 'ladder of inference.' Through his research, Argyris asserts that every person has tendencies to climb up the ladder of inference too fast. Almost instantly after seeing or hearing someone else speak or act, individuals integrate the new observation/information with their existing set of assumptions, sometimes prompting action that has only minimal relationship to what was originally spoken or observed. When this same ladder-climbing dynamic happens within a social or organisational setting, an environment for conflict is created that easily escalates. The ladder of inference (Figure 3 in Argyris 1990) is defined as the theories used to create the meanings imposed upon the culturally understood messages. Culturally understood messages are used to filter directly observable data relative to directly observable data, such as conversations. They include selecting data from what is observed, adding cultural and personal meanings, making assumptions based on meanings added by an individual, drawing conclusions, adopting beliefs about the world, and taking actions based on an individual's beliefs..

In a project sense, the ladder of inference can be seen in a problem-solving model or exercise. As an example, the following is from an actual case. In this situation, the meeting was convened to 'discuss' project schedule. Firstly, there was no clarity around what 'discuss' meant or what aspect of the schedule was to be 'discussed'.

The program was two weeks behind. (Interestingly enough, depending on the environment or culture, people often come to these meetings with an anxiety-solving focus so the attention is on blame – defend, or good old arse-covering.) In the case, the meeting got straight into solution, who should be doing what or who didn't do what. Looking at this from a ladder of inference base – the discussion never even touched on concrete facts – the meaning was fixed without discussion. The assumptions were not discussed, conclusions were individually drawn and actions proposed. This is a fairly typical process. A more powerful process would be to recognise where we are in our dialogue and pace through the ladder, flag assumptions as such and move progressively up. Solid process and solid facilitation will overcome this breakdown.

Taking from the discussion, *many teams and groups go round in circles banging their heads, getting effectively nowhere except raising anxiety levels because there is no understanding of the dynamic, let alone an understanding of how to manage it.*

The lack of understanding is in itself a risk.

Could you imagine an engineer designing a bridge with little knowledge of properties of concrete and steel? Why is it then that these same intelligent people attempt to solve problems with no understanding of the dynamics and processes necessary to manage these dynamics? Good problem-solving results often as a result of good luck more than appropriate process management.

LAWS OF HUMAN BEHAVIOUR: DISCUSSION

The concepts or theories of human behaviour are as real, as robust, and as valid as the laws of physics or any science. Human behavioural scientists can predict with up to one per cent accuracy the dynamics that will occur in certain given situations. These predictions can be the basis of the risk assessment referred to in this paper.

This paper is aimed at highlighting some of these concepts, and from there examining situations where history has shown that had there been some credibility given to these dynamics, major project catastrophies could have been avoided. Hindsight research into two of the major catastrophies of the late 20th century, the 'Challenger' and 'Columbia' space shuttle disasters, clearly show a path where the risk was known but nothing done

It has only been since the 1990s that researchers have noticed the significance of the project group and team, and communication in project management. (Katzenbach and Smith 1993; Argyris 1990; Senge 1990).

This paper suggests that like any project 'hard risk' relationship or process risk is real, tangible, identifiable, able to be mitigated. A common myth that exists is that relationship management is about getting people to 'get on' or like each other or that it's all about being 'touchy feely'. In the past a number of 'team building' exercises have focused on inappropriate games or exercises that in many cases the instigators who facilitated them had no real knowledge of, or the purpose for the exercise. Relationship management and 'team building' goes way beyond some pretentious, warm and fuzzy, futile exercise.

Relationship risk

Relationship or process risk exists in projects and can be managed in a similar fashion to 'hard risk'**.** This is about the risks in the system itself.

There are three stages that are the same for any project, hard or external risk. These states are 'latent', 'symptom and damage' and 'severe damage'. If any risk is identified in the latent stage it is much easier mitigated. It certainly costs less to mitigate early. The cost saving can simply be in the ability to make informed decisions before damage is done.

As in the previous example, it can be clearly seen that communication and relationship risks in a project have the same weight as any other hard risk to a project. Some of the generic latent condition areas are as follows:

- Clarity of: expectation/outcome/contract/role
- Potential for 'dysfunctional group dynamics'
- Individual differences – assumptions – governing values – belief system – personality
- Clash of cultures
- Existing 'silos'
- Proximity
- Existence of a safe team environment
- Existing levels of trust
- Level of process – relationship skills
- Project structure
- Contract type
- Interpersonal history
- Lack of systems or support for effective process management
- Interface alignment.

When nothing is done to mitigate the latent condition, symptoms of breakdowns start to appear. These could include the following:

- Increase in 'mail'
- Adversarial language
- Delays in responses to questions
- Delays in decision-making or poor decision outcomes
- Poor resolution of issues
- Dysfunctional meetings
- Appearance of strength in silos
- Expressed dissatisfaction
- Slippage in all or most 'hard' key results areas
- Noticeable decline in morale
- Minor 'niggling' conflicts
- Unresolved 'personality clashes' or dysfunctional issue resolution
- Differences of opinion
- Hallway/carpark conversations.

Fixing these defects will be more costly compared to fixing them at the latent stage (similar to not identifying latent poor ground conditions when constructing a road).

If no remedial action is taken to mitigate the risk of latent conditions and symptoms of communications and/or relationship failures, the stage is set for severe damages such as litigation, disputed claims and so on, at the later stages of the project.

It is clear that in projects where communications and relationships have failed, litigation, good people leaving the project/organisation, substantial losses in hard key results areas, individual stress-related issues, major project failures and disasters would be the end result.

Another aspect of the communication and relationship failure is the sometimes unrealistic project schedule pressure in meeting deadlines forced by external management. This could create problems such as relationships/communications breakdowns in projects. This could also create anxiety, which could result in failure to identify critical issues, and in turn adversely affect the project later. This will also have an impact on the project's critical path. Sometimes strong, rigid, regimentalism, forced on the project by the organisation or the project authority, could severely hamper communications and relationships.

In organisations and projects there is a crucial aspect to relationships. This is the dynamic caused by role. Research into role theory suggests that while we try to clarify roles through a series of rigid documents such as job or position descriptions we lose sight of the fact that the role the individual takes as a human is equally important and more often not considered. In essence, with all the technical training in the world, some are not capable of being project managers. Yet technical ability is the only parameter applied.

In examining role theory it is essential we understand the dynamics surrounding role. It is beyond the discussion in this paper, but certainly a major contributing factor to successful relationship management.

According to Richard (2000) 'the nature of human relations is evolutionary'. It changes over time as our society adjusts to our ever-changing environment. These changes can be positive or negative, and sometimes necessary changes have both positive and negative consequences on lives. It seems that when considering these relationships in the context of the workplace, it is an environment in which there is generally a high degree of personal interaction. His research shows, unfortunately, that not all workplace interaction is changing for the better. The lack of communications and the failure of trust in the workplace are blamed for the decreasing quality of human relationships in many companies.

Dyer (2006) found after surveying 134 projects that more than 95 percent of team members said that good communication was the reason for their success. More than 95 percent said that poor communication was the reason for their failures. Clearly, communication appears to be the key to project success according to her research. She also found that there are seven different root causes for team failure:

- fear
- misaligned expectations
- confusion
- loss of momentum
- dissatisfaction
- lack of commitment
- unconscious incompetence.

This is another indication that good communication is vital to a project.

Root cause #1: Fear makes team members feel the need to protect their own interests. When we feel the need to protect, we certainly are not going to be open; therefore communication is going to be stifled. Worse yet, our communications are likely to be an argument about why we are right and others are wrong. We feel the need to state our position and feel unable to solve even simple problems. This root cause is explained as anxiety-solving versus problem solving (Dick 1996b).

Root cause #2: Misaligned expectations; when the team members each have a different expectation on how things are supposed to work, you have misaligned expectations. The most common causes are over roles, responsibilities and authority. With misaligned expectations, no matter how hard each side tries, they just can't seem to get together. The team may be 'communicating' but understanding is not happening.

Root cause #3: Confusion; where there is confusion, chaos will break out. Again, this can be caused over roles and responsibilities, or over processes. When people are not sure what they are supposed to do, not only does the team lose productivity, but also there is chaos as people move around trying to figure out how things are supposed to work. This is true at all levels of the project. If a decision is made but no one understands how it is supposed to be implemented, then you will end up with different people implementing different solutions, leading to chaos and what appears to be poor communication. This situation was explained as the ladder of inference (Argyris 1990).

Root cause #4: Loss of momentum; when everyone on the team is not in the boat, facing the same direction and rowing toward project success, the project loses momentum. The more frustration there is, the more loss of momentum you will have. Frustration is caused when the team goes forward but keeps getting pulled back. Soon the project is behind schedule and communication switches to finger pointing, causing even more loss of momentum.

Root cause #5: Dissatisfaction; research Dyer (2006) shows that when project teams look forward to going to their jobs (the level of job satisfaction is high), the project is highly likely to be on time and on budget. When project teams 'dread' going to work, the projects are in serious trouble. When a project is not fun to be on and a sense of dread appears, communication between project team members will be strained at best.

Root cause #6: Lack of commitment; when people are not really committed to the success of your project, you have 'slack'. This is similar to slack in a rope. You do not have a strong team focused on what it will take to succeed. Inadequate resources can also cause 'slack'. The project team loses faith that they can achieve the project goals. Lack of communication is usually the result.

Root cause #7: Unconscious incompetence; inexperienced staff can face a very steep learning curve. Even one inexperienced person in a key role can cause havoc on a project. They do not know what they do not know, so they focus on what is available to them: the specifications, contract and drawings. They must learn how to resolve specific project problems as they occur. Often, the documentation becomes the focus instead of problem solving. The above case study clearly shows that good communication and relationships are vital to a successful outcome on a project.

Defensive reasoning relies on the idea of deterministic causality, the claim that 'X will cause Y.' This reasoning process fails to recognise the richness and uniqueness of concrete situations. Inevitable gaps, between stored knowledge and knowledge required to act effectively in new situations, go unrecognised. Therefore, the need to change the *status quo*, the present status of knowledge, gets overlooked. Not recognising that any innovation is likely to be inadequate, the need to monitor the change gets bypassed.

These root causes and others can be identified early as latent conditions, or from other symptoms. It's far too late when they contribute to critical incidents.

CONCLUSION

The chapter highlighted that:

- theories of human behaviour, like theories of physics, can be rigorous, applicable and used to predict outcomes in a scientific manner
- relationships are at risk and present a risk to project success from the outset, and can be managed
- these things can be demonstrated by examples and their applications in a project environment.

The paper has not gone into detail to discuss strategies and methodologies to mitigate risk at the various stages. This is another series of papers or more.

The dynamics mentioned are only a minor part of the total spectrum of understanding human behaviour.

Other examples where there is a strong need for understanding and management of process is performance management. Performance management is really not complicated if the time is taken to do it from a dynamic management point of view. Understanding the real values of a project and the drivers of behaviour are good start points to effective management.

A starting point for project managers and project owners would be to recognise that as safety and environment have become major issues and specialist areas in infrastructure and civil projects, relationship management deserves the same rigour and scientific approach.

We can no longer rely on 'coaches' or facilitators who come with a series of 'off the shelf' solutions, and are not specifically trained. Projects need specialists trained in understanding behavioural science. In many cases administration or engineering staff are elevated to 'manage the soft' areas. This paradigm will lead to continual failure and the reinforcement of the belief that we 'can do nothing about people issues'. There is a time for a new paradigm.

It needs an approach that recognises human behaviour as a science, and engages resources accordingly. This approach also considers that relationship risk and opportunity can be identified and mitigated. It also acknowledges that relationship or process objectives can be identified, measured and strategies set in place to achieve.

This paper is a starting point. It was never intended to be an empirical document, but moreover to raise awareness. It poses the powerful questions about the effective management of process dynamics and relationships in projects, and why after years of studies and more papers, not a lot changes. It offers a solution and that is an approach that says that Behavioural Scientists like Doctors; Engineers; and Motor Mechanics can identify latent conditions as risk to the project. They can identify symptoms and like Doctors; Engineers and Motor Mechanics design and implement effective strategies to mitigate that risk.

For future success this area must be treated as a specialised discipline.

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CHAPTER 12

Procurement Risk Management and Planning: Methods for monitoring supply markets for the public sector

Abraham Ninan
Tony Plucknett

INTRODUCTION

Developments of the past three to four years have seen a large increase in the amount of projects in the civil construction market in Queensland. The Queensland Department of Main Roads (QDMR) has been particularly affected by these changes and is now faced with the difficult task of adapting to this new environment.

Procurement Development and Research Branch (PDRB) within Program Procurement Division (PPD), is developing innovative methods for determining and monitoring the procurement risk inherent in critical supply items for the department. The approach is twofold: quantitative statistical analyses continually identify volatile, high-risk, national and state-based economic indicators to monitor and capture civil construction market changes; secondly, qualitative research is employed to refine quantitative findings. Initial risk forecasts will be generated by second-generation linear regression models and projected time series data with modelling error. The findings also inform Procurement Delivery Branch's risk planning strategies. The paper's contribution is innovative industry best practice in terms of procurement risk monitoring, cost escalation management and procurement planning.

Procurement Delivery Branch (PDB) with PPD handles implications for industry best practice in terms of procurement risk management, cost escalation management and procurement planning. Procurement strategies developed by PDB are informed by PDRB quantitative–qualitative analysis and reporting.

OVERVIEW

The Procurement Market Risk Indicator (PMRI) will consist of two indicators, one capturing risk in terms of market competition, and the other capturing risk in terms of cost. This section will give an outline of the various methodologies utilised by PDRB in producing the PMRI. These methods span both the macro and micro aspects of economics, and draw on data from various market indicators. Additionally, experimental outputs and risk-scale criteria will be presented for each of the four areas. This paper will be investigating the supply of concrete products as the test case.

Four research methodologies are used to inform procurement planning strategies that guide procurement risk and program and project delivery. The four methodologies to be described are:

- market competition risk indicator (MCRI) – economic multipliers, supply chain linkages/market outlook, principal component analysis (PCA)
- cost risk indicator (CRI) – cost escalation road input (CERI) index (Ninan et al. 2006).

Output from the four methods will be used to build a reportable risk matrix. Each method will establish a risk rating from -5 to +5 for critical items as determined by Main Roads. The methodology involved in the development of this risk quadrant will also be discussed.

METHOD: A CASE STUDY APPROACH

The paper adopts a case-study-based approach to analysis. Case study methodology was deemed most suitable because it asks the 'how' research questions (Yin 1993; 1994) and thus suits the paper's key innovation-based research question. Several theorists report that case study research methodology has received increased notice in the past decade, with major efforts being made to establish it as a reliable methodology by insisting on rigorous design (Lee 1989; Yin 1981; 1993; 1994). Glaser and Strauss (1967), and more recently Strauss and Corbin (1990; 1994), have contributed significantly to the justification of case study as a credible research method.

ECONOMIC MULTIPLIERS

In economics (Eckstein 1983; Baumol and Blinder 2003), the multiplier effect refers to the idea that an increase in primary spending can lead to even greater increase in national income.

Two multiplier tables were developed in such a way that a concrete 'economy' was manufactured, with one table capturing the major suppliers to the concrete industry, and the other capturing the major consumers of the concrete industry. Specifically the relationships between the simple output multipliers were investigated (refer to Figure 12.1 below, in the section 'Cost escalation road input (CERI) index'). A ratio between both the consuming versus supplying simple multipliers and supplying versus consuming simple multipliers was determined. As a result the relationship that has been hypothesised is:

1. The more positive the value the less adequate the supply; therefore the risk involved in purchasing concrete may be increased.
2. The lower/more negative the value the more adequate the supply; therefore the risk involved in purchasing concrete may be reduced.

The risk value for concrete was determined for four time periods (see Table 12.1). The value represents the pressure on the industry in terms of supply and demand.

Table 12.1 Concrete Risk Values

Year	94–95	96–97	98–99	01–02
Ratio value	-0.24	-0.14	-0.014	0.34
Risk value	-2.4	-1.4	-0.1	3.4

Table 12.2 illustrates the process for the conversion of the economic multiplier ratio value to the uniform risk rating value.

Table 12.2 Risk Scale Criteria: Economic Multipliers

Risk Value	Criteria	Resource
-5 to -4	Ratio value > -0.5	Supply of available resource: decreases as ratio value becomes more positive
-4 to -3	Ratio value >- 0.4	
-3 to -2	Ratio value >- 0.3	
-2 to -1	Ratio value > -0.2	
-1 to 0	Ratio value >- 0.1	
0 to 1	Ratio value > 0.0	
1 to 2	Ratio value > 0.1	
2 to 3	Ratio value > 0.2	
3 to 4	Ratio value > 0.3	
4 to 5	Ratio value > 0.4	

SUPPLY CHAIN LINKAGES/MARKET OUTLOOK

A supply chain is 'a coordinated system of organisations, people, activities, information and resources involved in the procurement and transport of a product or service from supplier to customer' (Cohen and Hau 1988; Towill 1991; Davis 1993). In investigating supply chain linkages and market outlook the following data was used:

1. Department of Main Roads Specification documents – The Australian and New Zealand Standard Industrial Classification (ANZSIC).
2. IBISWorld reports – recent independent research on over 500 industries: provides statistics, analysis and forecasts.
3. Consultation with internal QDMR staff.
4. Company financial reports.

A top-line quantitative analysis method was used for the procurement analysis. 114 different types of SAP entries were considered. Spending patterns trends were identified over the timeframe and one-off high/low spends. Total amounts spent were also considered. The supply chain map was constructed by referring to QDMR Specification documents for materials used in the item, consultation with QDMR specialist staff, Australian Bureau of Statistics' ANZSIC codes, and IBISWorld Industry reports. Each market's outlook (see Table 12.3.) was sourced from the key players' financial reports, IBISWorld Industry reports, and by consultation with QDMR specialist staff. Risk has been ranked from 5 to -5, 5 being the highest level of risk and -5 being no risk (Table 12.4). Each rating was calculated by using IBISWorld's percentage growth in revenue, going from 2006–07 (actual growth) to 2011–12 (all forecasted growth).

Table 12.3 Market Outlook: Downstream Concrete Product Manufacturing

Concrete Product Manufacturing								
Key Players	James Hardie	CSR Ltd	Boral Ltd	Fletcher Building Ltd	Hanson Australia Pty Ltd	Adelaide Brighton Ltd	Brickworks Ltd	Other
Market Share	12 - 17%	10% - 15%	10% - 15%	10% - 15%	10% - 15%	7% - 9%	3% - 5%	9% - 38%
Market Outlook	Moderate revenue growth 2.5% p.a. (GDP 3.1% p.a.) through forecast period, although this forecast is still above previous 5 years revenue (adjusted for inflation)		Growth corresponds with housing, non-residential, engineering, roads and bridges construction markets		Growth barriers: relatively small scale of the domestic building and construction market and the difficulties in exporting the often heavy and bulky products.		Larger players have expanded internationally; James Hardie moved its head office to USA	
Financial Year	06-07	07-08	08-09	09-10	10-11	11-12		
Risk Rating	3	0	-5	-2	0	5		

Table 12.4 Market Outlook Risk Values

Supply Chain Level	Year	06-07	07-08	08-09	09-10	10-11	11-12
Upstream	Construction Material Mining	-5	5	0	-3	-2	0
At Level	Concreting services	-5	-2	3	1	-1	-2
Downstream	Concrete Product Manufacturing	3	0	-5	-2	0	5

PRINCIPAL COMPONENT ANALYSIS

Principal component analysis (PCA) is a technique used to reduce multidimensional datasets to lower dimensions for analysis (Silverman 1986; Fukunaga 1990; Green and Silverman 1994). PCA is mostly used as a tool in exploratory data analysis and for making predictive models, and risk analysis impacting project costing (Merrow 1981; Morris 1990; Frye 1996; Oberlender 1998, 2001). Results of a PCA are usually discussed in terms of factor loading and component scores. PCA is a tool that identifies influential variables of the Queensland macro and micro economies. A broad trend of influential variables has been identified since 1998. Risk is identified when this broad trend varies. The process used for The PCA includes the following:

1. **Identification of statistical measures that represent the Australian and Queensland economies:** Ninety Australian Bureau of Statistics (ABS) indices or variables were identified as a broad representation of Queensland's macro and micro economies.
2. **Data collection and preparation:** Variables were selected to ensure the integrity and robustness of the PCA output with data collected then prepared and cleaned for analysis.
3. **Analysis:** PCA of these indices was carried out using SPSS Base 15 statistical analysis software and a Varimax method of rotation was applied for simplicity and extraction of components.
4. **Interpretation:** PCA groups correlating variables into components with the primary component of interest is component 1 as it accounts for 67 per cent of variance within the dataset, although when all components are examined, 100 per cent of variance within the dataset can be captured.

The market monitoring ability of PCA comes from the consistent grouping of like variables capturing different economic phenomena into components. Yearly data analysed from 1998 to 2007 have reported consistent groupings of variables into components. Risk is identified when variables not previously reported in a component appear.

The example in Table 12.5 demonstrates the strong appearance of ASX200 and established home prices in Brisbane in 2007 and would flag these variables as potential contributors to risk. In order to determine the risk value further qualitative or quantitative research is conducted to determine the rationale behind the variables movement and therefore its level of risk.

Table 12.5 PCA Output: Top 15 Components

Component Rank	2005 Variable name	Factor loading	2006 Variable name	Factor loading	2007 Variable name	Factor loading
1	PPI-MatsUsedCoalMining-Open	0.9721	PPI-Out-BuildConst-Qld	0.9965	New Motor Vehicles	0.9876
2	PPI-MacEquipHire	0.9646	PPI-Out-GenConst-Qld	0.9961	PPI-PlantHire	0.9817
3	PPI-Out-BuildConst-Qld	0.9618	PPI-Out-NResBulidConst-Qld	0.9945	PPI-MacEquipHire	0.9797
4	PPI-Out-GenConst-Qld	0.9603	PPI-Out-NBuildConst-Qld	0.9944	S&P/ASX 200 Accumulation Index	0.9733
5	PPI-Out-ResBulidConst-Qld	0.9593	PPI-Out-RaBConst-Qld	0.9944	Pop-Qld	0.9713
6	PPI-Out-NResBulidConst-Qld	0.9583	Pop-Qld	0.9935	ExpP-AgForestFish	0.9699
7	MUIHB-SteelProd-6Cap	0.9574	PPI-Out-ResBulidConst-Qld	0.9934	MUIHB-SteelProd-6Cap	0.9688
8	DwellingPurchValue	0.9568	Total credit	0.9928	PPI-Out-HouseConst-Qld	0.9664
9	MUIHB-StlBeams-6Cap	0.9547	Earnings	0.9916	EstHomeP-Bris	0.9629
10	Employed	0.9545	HrlyRoP-All Indus.	0.9899	PPI-Surveying	0.9547
11	Earnings	0.9513	MUIHB-	0.9873	MUIHB-StlBeams-6Cap	0.9544
12	Pop-Qld	0.9496	MUIHB-PaintCoatings-6Cap	0.9864	MUIHB-Sand-6Cap	0.9524
13	MUIHB-Sand-6Cap	0.9464	VWD-All-Con-Qld	0.9855	PPI-Out-BuildConst-Qld	0.9520
14	MUIHB-All-6Cap	0.9454	Terms of trade	0.9849	VWD-Pu-B-Qld	0.9482
15	MUIHB-CementProd-6Cap	0.9426	HrlyRoP-Const.	0.9842	MUIHB-OthrElecEq-6Cap	0.9473

COST ESCALATION ROAD INPUT (CERI) INDEX

Cost overrun is defined as excess of actual cost over budget. Cost overrun is also sometimes called 'cost escalation,' 'cost increase,' or 'budget overrun.' Cost overrun is common in infrastructure, building, and technology projects. Research has indicated that cost overrun exists in nine out of ten projects (Chatfield 1975; Blair et al. 1993; Karshenas 2003; Wilmot and Cheng 2003; Touran and Lopes 2005). Overruns of 50 to 100 percent were common, overrun was found in each of 20 nations and five continents covered by the study, and overrun had been constant for the 70 years for which data was available (Flyvbjerg, Holm and Buhl 2003).

The CERI index utilises an innovative model to map a broad suit of economic factors into a single weighted index. There are three components in CERI index construction:

- cost escalation calculation
- identification of lead indicators using principal component analysis
- CERI index calculation.

Figure 12.1 CERI rate

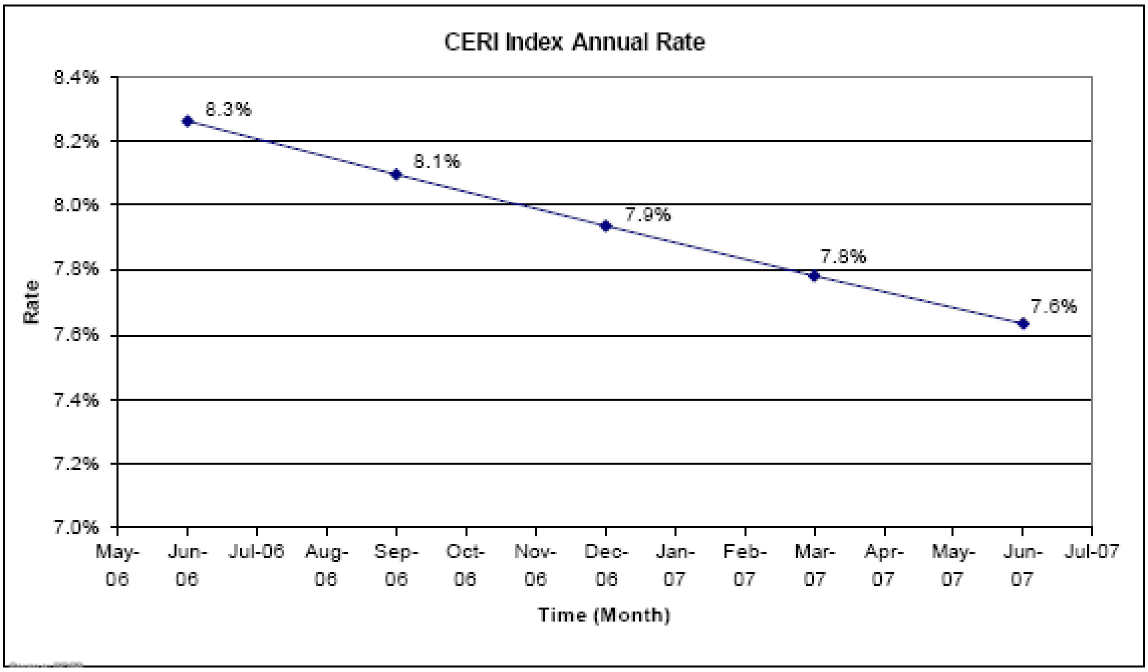


Table 12.6 illustrates the process for the conversion of the CERI to the uniform risk rating value.

Table 12.6 CERI to Risk Rating Conversion

Risk rating	Interval starting	Interval ending	Interval gap
5	7.44	7.99	0.55
4	6.88	7.43	0.55
3	6.32	6.87	0.55
2	5.76	6.31	0.55
1	5.2	5.75	0.55
-1	4.64	5.19	0.55
-2	4.08	4.63	0.55
-3	3.52	4.07	0.55
-4	2.96	3.51	0.55
-5	2.4	2.95	0.55

PROCUREMENT MARKET RISK INDICATOR

As part of the risk management process integration of the four methods above will be used to create a risk index for each of Main Roads critical items. The output values of this index will enable identification of potential problems and risks ahead of time, before they pose negative cost and/or scheduling impacts. Additionally, the output will enable implementation of informed strategic purchasing plans for Main Roads.

In the example below (Table 12.7) each of the four outputs for concrete has been entered for the quarter. The average of these four values was then found and used as the risk value for concrete for that quarter. Using the four outputs allows the model to capture a broader range of market pressures. By combining macro and micro inputs, risk in the wider market and risk specific to production/purchasing of QDMR critical items is more accurately reflected.

Table 12.7 Procurement Market Risk Indicator

Concrete					
		Quarter 1	Quarter 2	Quarter 3	Quarter 4
Market Competition Risk Indicator (MCRI)	Economic Multipliers	3.5	3.5	3.5	3.5
	Supply Chain / Market Outlook	2	2	2	2
	PCA	4	2	3	5
Market Competition Risk Indicator (MCRI)		**3.17**	**2.5**	**3.5**	**3.5**
Cost Risk Indicator (CRI	CERI	4	4	4	4
Cost Risk Indicator (CRI)		**4**	**4**	**4**	**4**
Procurement Market Risk Indicator = AVG (MCRI, CRI)		**3.75**	**2.75**	**3.25**	**4.25**

PROCUREMENT RISK: CONSTRUCTION IMPLICATIONS

The paper approaches the identification of procurement risk and its implications for stages of construction in the context of earlier research conducted on the Department of Main Roads. The change in project cost, or cost growth, occurs from many factors, some of which are related to each other, and all are associated with some form of risk. Determining the existence and influence of cost overrun risk factors in construction projects can ultimately lead to better control on project cost estimates and assist in identifying possible solutions for avoiding future estimate overruns.

Overall resource risk: project stage

This section will discuss the application of the Procurement Market Risk Indicator (PMRI) in assigning risk values to various stages of road construction. The PRMI can be used to predict risk in relation to both resource availability and price.

A hypothetical risk table for the requirement of concrete during a road construction project is illustrated in Table 12.8. In developing the table a requirement rating has been allocated to each stage of the project stages. This value is determined using the approximated requirement for the resource at the individual stage as determined in the project planning stage.

Table 12.8 Hypothetical Risk Values for Project Stages: Fourth Quarter Values – Concrete

		Construction Project Procurement Risk Quadrant – X Axis	Construction Project Procurement Risk Quadrant – Y Axis	
Project Stage	Resource Requirement Ranking (1 to 10) 1 Lowest, 10 Highest R	Cost Risk - - Project Stage =[R/10] x CRI	Market Competition Risk - Project Stage =[R/10] x MCRI	PMRI Project Stage = [MCRI+CRI]/2
1. Planning	1	0.4	0.35	0.38
2. Pre-Construction Design	5	2	1.75	1.88
3. Site Preparation	2	0.8	0.70	0.75
4. Drainage	9	3.6	3.15	3.38
5. Excavation Work	7	2.8	2.45	2.63
6. Pavement	8	3.2	2.80	3.00
7. Surfacing	10	4	3.50	3.75
8. Furnishing	6	2.4	2.10	2.25
9. Landscaping	4	1.6	1.40	1.50
10. Electrical	3	1.2	1.05	1.13

PROCUREMENT RISK QUADRANT

The supply positioning technique provides a mechanism for discriminating between the components of the total purchase requirement, whether goods or services, and a tool for developing specific strategies to meet the needs of the organisation with respect to each group of purchases (Steel and Court 1996, 51). The aim of the quadrant is to give purchasers an easily understood reference tool that can be used to determine risk for a specific item or items. By analysing the outputs of the PMRI a quadrant can be developed that incorporates risk to both cost and resource supply/production (grouped in the quadrant as competition). The two risk factors pertinent to procurement are:

1. **Increased risk: market competition** – fluctuations in both production and demand for critical items. When either production or demand fluctuates, the risk associated with the item in question will be impacted either positively or negatively.
2. **Increased risk: cost** – seasonal and economic pressure on prices influence risk in terms of cost when purchasing items. When cost fluctuates, the risk associated with the item in question will be impacted either positively or negatively.

Figure 12.2 Procurement Risk Quadrant

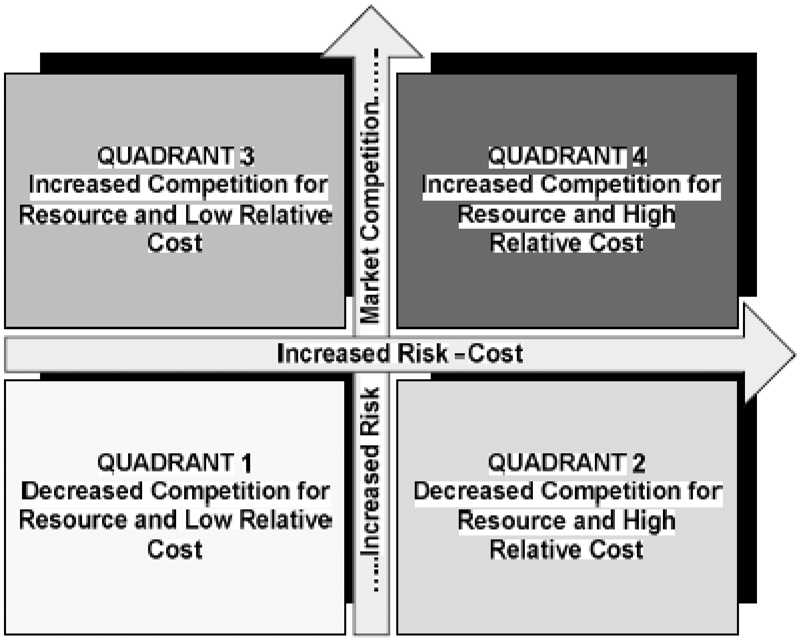


Figure 12.3 Procurement Risk Quadrant: Concrete by Project Stage

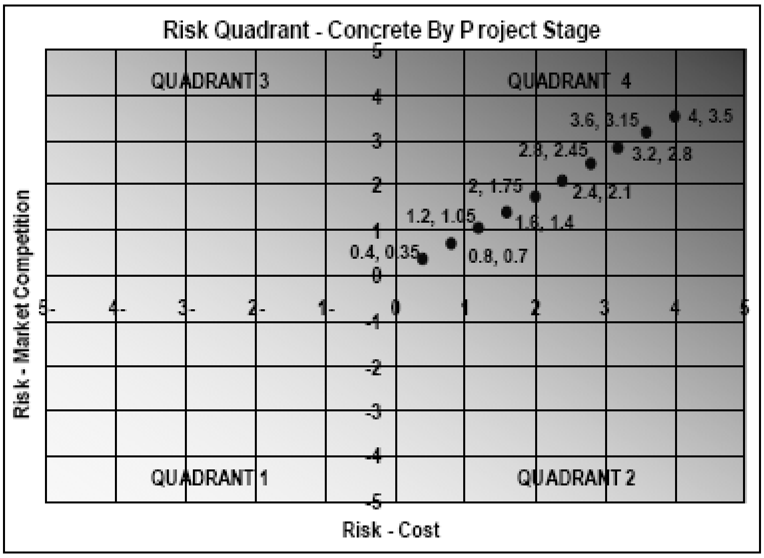


Table 12.9 Interpreting the Procurement Risk Quadrant

Quadrant	Interpretation
1	Main Roads critical items with a decreased level of competition and a low relative cost. Typically items with a value of -5 to 0 on both cost risk indicator (CRI) (x) and market competition risk indicator (MCRI) (y) axis; **low risk items**.
2	Main Roads critical items with a decreased level of competition and a high relative cost. Typically items with a value of -5 to 0 for MCRI and a value of 0 to 5 for CRI; supply/production of item is sufficient for Main Roads needs, however cost of items may be fluctuating/inflated; **medium risk items**.
3	Main Roads critical items with an increased level of competition and low relative cost. Typically items with a CRI value of -5 to 0 and MCRI value of 0 to 5; supply/production of item may be insufficient for Main Roads needs, however relative cost of the item is stable/low; **high risk items**.
4	Main Roads critical items with an increased level of competition and low relative cost. Typically items with a value of 0 to 5 for both CRI and MCRI; supply/production of the item may be insufficient for Main Roads needs, additionally the relative cost of the item may be fluctuating/increasing; **very high risk items.**

FORECASTING PROCUREMENT RISK INDICATORS

The procurement risk indicators (MCRI, CRI and the PMRI) can all be forecast using a 2nd generation linear regression, while reporting statistical modelling error. At this point the paper proposes this segment of methodology development, refinement and application as part of the future research agenda. In particular there is need for longitudinal historic data that will emerge from future reporting of the risk indicators.

PROCUREMENT RISK IN HEATED MARKETS

Successful timely completion of road construction projects is possible only through the reliable scheduled provision of components such as precast concrete products. James (1995, 73) identifies the division and allocation of contractual responsibility, that circumstances will dictate whether or not the particular work or supply can be completed. Accordingly, it is essential to understand the market from which these components will be purchased. By understanding the risks and deficiencies, appropriate procurement strategies can be developed that will minimise the risk of failure of supply. In terms of contract responsibility,
the principal adopts a procurement behaviour that best suits the market circumstances.

Understanding the market: supply market analysis: precast concrete manufacturers

Procurement Delivery Branch undertook a supply market analysis of the precast concrete industry in Queensland. During the course of the project, the precast concrete manufacturers in Table 12.10 were visited by the project team. All of these manufacturers are located in the greater Brisbane area. They are not the only manufacturers in South-East Queensland but they are the major firms in the precast concrete industry in this location.

Table 12.10 Precast Concrete Manufacturers

1	Contec	867 Boundary Road, Richlands
2	ENCO Precast Pty Ltd	73 Counihan Roadtek, 17 Mile Rocks
3	Humes	59 Sugarmill Road, Meeandah
4	James Hardie FRC Pipes	46 Randle Road, Meeandah
5	Rocla Pipeline Products	3726 Ipswich Road, Gailes
6	Wagners Dowstress	20 Airy Street, Wacol

Summary of findings

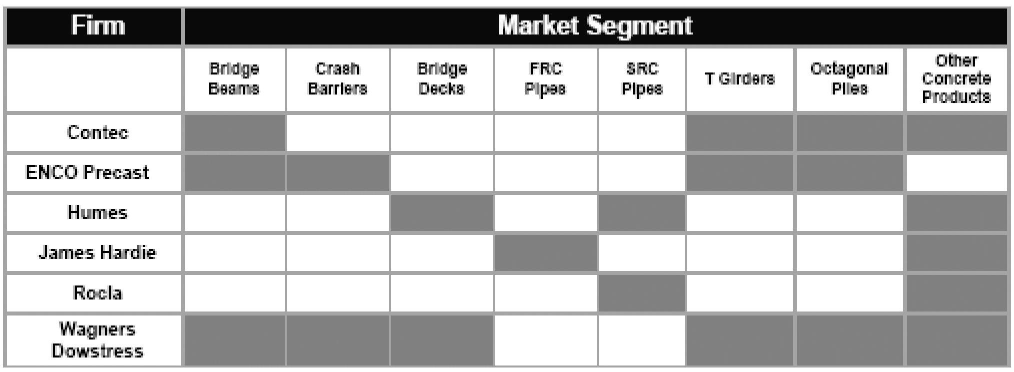
Set out below is a summary of all findings gathered from precast concrete suppliers visited.

Market segment

The primary focus of the supply market analysis was with current manufacturers of prestressed bridge beams. However, the team also visited reinforced concrete manufacturers which had at some time been manufacturing prestressed bridge beams but were no longer involved in this activity. These manufacturers are Rocla and James Hardie. Humes, which is a manufacturer of fibre reinforced concrete pipes, was not in the business of prestressed bridge beams. A summary of the market segment occupied by each of these firms is set out in Figure 12.4.

All manufacturers see the Department of Main Roads as a significant customer although much of the work undertaken by them was through contractors engaged to build roads/bridges by Main Roads. Some like attribute up to 50 per cent of output to Main Roads projects. Of course the percentage varies according to the projects undertaken at any particular point in time.

Figure 12.4 Market Segments for Each Firm



Marketplace

All manufacturers are running near to capacity and all have plans (to varying degrees) to increase production over the coming 12 months. This involves taking measures such as investing in capital expansion to increasing working hours at the plant. They see the market as continuing to heat up and remaining in high gear for the next three to five years.

Despite the activity in the marketplace, it is not predicted that any other suppliers will start up in the local market with the substantial barrier to entry being the $1m-plus cost of setting up each precast bed.

Market risks

To varying degrees, each manufacturer had problems with recruiting and keeping staff. In particular, all (except for one company that used a hire firm) had difficulties recruiting tradespeople and one company had even gone to the trouble of recruiting tradespeople from Europe. There were some shortages of professionals (engineers) but this was nowhere near the problem with the tradespeople.

The reason for the shortages in professional and tradespeople was put down to the infrastructure development and mining boom. It is believed that these labour shortages will continue for at least the next three to five years. The difficulty in securing good unskilled labour has long been a problem and will continue.

The manufacturers find it difficult to maintain outputs when there is a continual turnover of staff. The peaks and troughs in demand in the prestressed industry exacerbate this problem. If the work goes down and good staff are put off, it is then very difficult to replace them. Alternatively, the staff are retained even when the work is not there and this is costly (Bateman 2006).

Market competition risk indicators

Current supply chain analysis and market outlook studies confirm that the precast concrete product manufacturers are at full capacity. There are significant barriers to entry for new suppliers or expansion of existing capacity because of cost and skilled labour considerations.

PCA can be used as an early warning indicator for the organisation to proactively react to market trends to minimise potential supply shortages and associated risks. For example, increasing volatility within concrete and concrete-related industries is highlighted using PCA. Strategies to negate the effect of increased demand/reduced production of concrete can then be implemented.

Shifts in economic multipliers risk values can be interpreted as changes in market dynamics, from positive to negative supply ratios. By monitoring these values it is possible to determine where (in time) the concrete market will swing from positive to negative supply. Additionally, once the supply of concrete is determined the economic multiplier risk value classifies the relative level of positive or negative supply within the market. By investigating this procurement, strategies can be planned to minimise shortages of concrete supplies.

Cost risk indicator

The CERI index informs the cost risk indicator allowing procurement planning based on risk in terms of cost. Monitoring of the CERI will allow the organisation to determine risk in terms of when to purchase concrete. Analysis of the CERI will provide an up-to-date indication of risk, additionally providing the capacity to observe season trends in concrete pricing. Purchasing strategies can then be developed to alleviate increased cost due to these fluctuations.

PROCUREMENT STRATEGIES

The PMRI will furnish PPD with functional, well informed data that will allow the development and application of procurement strategies. Some possible strategies include:

- sourcing products earlier to ensure delivery when required by recognising when a shortfall in production is expected or competition for available concrete is increasing
- principal (QDMR) prepurchases requirements and supplies to contractor by negotiating price and volumes required with contractors – unpredictability within the market can be negated
- principal purchases 'blocks' of future production to ensure requirements are scheduled with manufacturer – by purchasing 'blocks' future availability of concrete is secured allowing project requirements to be met without encountering delays or increased cost.

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Alliances in Australia: A long-term joint venture?

Steve Rowlinson
Fiona Yan Ki Cheung

INTRODUCTION

Management literature has shown a steady rise in the number of papers reporting studies on the implicit link between organisational culture and performance (Handy 1985; Wood and Ellis 2005). Benefits of partnering such as win-win relationships, time and cost savings, trust, motivation and open communication are highlighted in a stream of literature (Bennett and Jayes 1998; Wood and Ellis 2005; Wood, McDermott and Swan 2002; Bresnen and Marshall 2000). Numerous reports published in the past decade, such as the Tang Report on *Construct for Excellence: Report of the Construction Industry Review Committee*, the Hong Kong Housing Authority report on *Quality Housing: Partnering for Change*, *Building for Growth* by Australia NatBACC and the Egan report on *Rethinking Construction*, all indicate the way forward for the construction industry. These reports advocate a move away from adversarial relationships and towards the use of relational contracting approaches. However, such approaches require a culture change.

Construction supply chains and sustainability

More recently, the NAO report on modernising construction and Sir John Egan's report on accelerating change, both highlight the construction industry's need for better management of construction supply chains and more engagement with the supply chains to achieve sustainable construction. Relationship management is a sustainable approach to the industry in terms of social, environmental and economic sustainability and can provide a positive contribution to sustainability and help to satisfy client and stakeholder interests (Blau 1963; Darwin 1994; Darwin, Duberley and Johnson 2000; MacNeil 1978, 1985; Rousseau and Parks 1993). It provides the means to achieve sustainable, ongoing relationships in long and complex contracts by an adjustment process of a more thoroughly transaction-specific, ongoing, administrative kind (Kumaraswamy and Matthews 2000). Although the potential benefits of relational approaches (for example, construction partnering, alliancing, PPP and relationship management) have received strong interest in the construction industry, relational approaches are not yet the dominant choice of procurement strategy (see Phua 2006 for example).

Relational contracting

Relational contracting is predicated on a broader view of the procurement system; it implicitly incorporates supply chain engagement, essential if the performance indicators of best value, community benefit and innovation are to be achieved. It is about moving away from adversarial relationships in order to develop a team, and perhaps a long-term commercial relationship. Thus, relational contracting approaches, such as partnering, alliancing and relationship management, are about communication, cooperation, trust, culture, mutual objectives and risk sharing (European Construction Institute 1997; Liu and Fellows 2001; Matthews 1996; Sanders and Moore 1992; General Contractors of America Associated 1991; Bennett and Jayes 1995). According to Rowlinson and Cheung (2002), relationship contracting (referred to as relational contracting above) is based on a recognition of and striving for mutual benefits and win-win scenarios through more cooperative relationships between the parties. Relationship contracting embraces and underpins various approaches, such as partnering, alliancing, joint venturing, and other collaborative working arrangements and better risk-sharing mechanisms. Relationship contracts are usually long term, develop and change over time, and involve substantial relations and development of trust between the parties.

RESEARCH APPROACH AND RESULTS

A number of recent studies address innovation and change in the context of interorganisational collaboration in project-based settings (Rowlinson 2001; Alderman and Ivory 2007; Cox and Ireland 2002; Winch, Millar and Clifton 1997). Organisational structure, culture and commitment are identified in these works as being significant in shaping organisational performance, and they form the main parameters of this research. Thus one objective of this research is to investigate the impact of the various cultural variables on project performance, which then allows patterns and characteristics leading to successful collaboration amongst firms to be identified. By using independently collected data, it was possible to verify the thinking of key individuals in the organisations as to the strengths and weaknesses of the systems currently in place. A questionnaire survey was conducted to find out where the organisation currently stands and interviews and case studies were conducted to validate the results. This paper reports the findings captured from a survey undertaken with a public organisation focusing on the supply chain relationships and a series of interviews within public sector case studies. The survey stemmed from an initial, extensive grounded study which identified key variables in relationship management and supply chain engagement, namely: organisation culture and its fit, organisational commitment, organisational structuring, situational leadership and technology context.

Information collection includes conducting a questionnaire survey and face-to-face interviews, collection of archival data such as meeting minutes and written material documenting the purpose and nature of the alliance team, and observation of a number of team meetings. The response rate for the questionnaire survey was thirty-two of a total of fifty staff members, which represents a sixty-four percent representation of the whole alliance team. Eleven one-hour interviews were conducted with key members from a variety of positions including design, services, alliance management and construction. Interviews were also conducted with an external facilitator and a project alliance board member. Team dynamics and communication processes in the alliance management team were examined by sitting in and observing team meetings.

Organisational structure

Van de Ven and Ferry's (1980) organisational assessment was used to explore organisational structuring. The aim is to assess the organisation performance in relation to how it is organised and to the environments in which it operates. Using the results generated from the survey and interviews, it is noticed that although the organisation was initially expected to follow the logic of developmental group mode, the logic of a cross between systematised impersonal mode and discretionary personal mode is more closely followed. This reflects the results derived from Handy's instrument (Handy 1985). The professionals should be and expect to be following a developmental group mode and do prefer working in a task culture but are actually in a mix between role/power cultures and follow the systematic/discretionary mode. In subsequent interviews with survey respondents, the senior management was often described as a power centre, where information and decisions were diffused from the top.

Alliance organisational structure

The alliance organisational structure is usually made up of three levels – project alliance board, alliance management team, and integrated project team. The driver of this alliance is the client. However, although the client has good design skills, the organisation has experience only in traditional lump sum project delivery methods. There is clearly a need for sharing knowledge and resources between the alliance partners, including the top management level. Skills identified in this project as essential in an alliance include:

- **The ability to work as part of a team.** It is important for team members to participate in group decision-making and be comfortable with group consensus. This is exemplified in the *esprit de corps* generated that allows members to work together to solve the problem, rather than taking the easy option and pulling out from the project.
- **The importance of communication skills:** Highly relevant to group decision-making skills. Communication skills emerged as particularly important when interacting with people from different disciplines but also when dealing with stakeholders and the community, to members from other organisations and these involved day-to-day plant operations.
- **The ability to think broadly and creatively:** Thinking outside of one's own discipline, thinking 'outside the box', and being open to new ideas. The consequences include encouragement of creative thinking and brainstorming, which leads to moving people out of their comfort zone to foster innovation.

Senior management role

The study indicated strong top-down support being received for the alliance relationships. The project alliance board provides overall direction and continuous support to the alliance team. The high level of support from senior management has been reflected in the questionnaire survey result, with an overall mean score of 5.48 (the maximum score is 7). Bresnen and Marshall (2000) point out that senior management support is vital in making a collaborative approach both credible and legitimate. Alliancing is generally championed at the highest level of the organisation, where goal alignment and good relationships are crucial. Both individual and group flexibility also are seen as important. However, results indicate bottom-up support for alliance relationships, group resilience and coordination are slightly weaker until all members can be convinced of the benefits of buying in. Observations showed that individuals and groups are both able to adapt to necessary shifts in opinion, plans and behaviours (when planned and clearly communicated). Furthermore, the role of leaders and project managers is critical to maintaining relationships and direction in the alliance project. On the other hand, group resilience, defined as ability to handle unpredicted or unexpected change, was found to be low, suggesting individuals would be more adversely impacted and less likely to be effective if an unexpected change was to occur. This underlines the principle that strong commitment and support from all levels are required for an alliance to be successful.

The alliance infrastructure

Alliancing is a system that provides a collaborative environment between people and which provides a framework to help them adapt their behaviour to project objectives. It is about sharing resources and experiences, exposing the 'hidden' risks. The case study suggests that leadership has a strong influence on the alliance climate. Analysis of the questionnaire survey indicates the overall mean of work unit leadership is above 5 (the maximum score is 7), with little variation across the variables (vision, intellectual simulation, and inspirational communication). Commitment and action by the project alliance board (and parent organisations) has a strong impact on the team and alliance culture, indicating that alliancing has a high chance of failure when there is inadequate support from top management. The inter-organisational rivalries and barriers must be quickly knocked down and open communication and trust developed and maintained. The questionnaire survey results also reveal relatively lower ratings on the group coordination measure (an overall mean of 4.91, with a median of 4), suggesting work units can find it relatively difficult to work well together, particularly without the presence of leaders (managers). This again reinforces the important role of the leader in an alliance project. Leadership is especially important in construction projects in facilitating and encouraging timely decisions and dispute resolution, as well as clarifying issues. Leaders need to act as mentors of the alliance management team and, nurture a team culture. Leaders need to be visible, available and attentive, showing respect to alliance management team processes which motivate employees. Another crucial role of leaders is constant communication with their subordinates on wider goals.

NO BLAME: THE ROLE OF TRUST

Like all relational contracting approaches, trust between alliance partners is important because it creates an opportunity and willingness for further alignment, reduces the need for partners to continually monitor one another's behaviour, reduces the need for formal controls, and reduces the tensions created by short-term inequities. Various interviewees expressed the view that alliancing is about sharing resources and experiences, with risks placed on the table, focusing on the results rather than on 'who to blame' when an incident arose.

This alliance project takes a further step towards reinforcing the trust element by placing a No Dispute clause in the alliance agreement. The No Dispute clause states '… there will be no arbitration or litigation between the participants on any alliance disagreement…' and 'Each of the participants waives its rights of action against each of the other participants arising out of any act or omission in connection with this PAA (Project Alliance Agreement)…'.

Agreements between participants are reached in conjunction with commercial drivers. Alliancing is based on a totally different legal platform where there is to be no blame, no dispute, developing a win-win culture. There is a total ownership between all alliance partners by sharing of risk and outcome. Decision-making focuses on 'best for project': such an approach leads to individuals from the project team having a sense of ownership and focusing on solutions/outcomes.

Interviewees also expressed the view that decisions are encouraged to be made at the lowest possible level within the team, and only escalated to higher levels if the team cannot arrive at a decision. It is the project team at operational level which has hands-on experience and deals with the everyday issues such as design and materials. By bringing in subcontractors and designers into the alliance project team, a more direct communication between the frontline staff (contractor, subcontractor and designer) is obtained. Rather than working through layers and layers of contract procedures, all key personnel are bound together and talk, rather than generating back-and-forth communication, sometimes leading to miscommunication. In an alliance project, all participants put their personal interests aside and focus on 'best for project' during discussions; a focus on outcome rather than immediate responsibility.

Open-book access to financial records is another key feature of alliancing. It is crucial for the alliance parties to be open and honest while communicating, exposing the possible risks in the project and there should be no hidden agenda. Studies show that, in an alliance contract, as the project's risk/reward outcome was tied to the collective performance of the alliance partners, the 'no blame, no dispute' clauses ensured each partner maintained an interest in maximising the performance of the other partners rather than simply serving their own best interest.

DISCUSSION

The degree of match and mismatch between organisational culture and structure has an impact on staff's commitment level. The concept of relationship management needs to filter down to all levels in the supply chain if participants are to retain commitment and buy-in to the relationship. A sustainable supply chain requires proactive relationship management and the development of an appropriate organisational culture, and trust. Relationship management will not succeed without parties' strong buy-in and commitment to the concept. Project parties need to recognise the benefits of relationship management. They also need to be familiar with relationship management principles and relationship management in practice for effective integrations.

The 'no-claim' alliance contracting approach presented in this paper demands the buy-in of all members of the project team, including the client side of the process by educating, perhaps re-educating, the project participants to ensure that a no-claim contract can be successful. The principles of relationship management are documented widely but few commentators have looked at linking the relationship to a no-claims contract. The infrastructure required to develop and maintain this no-claims approach is expensive; for instance, in this US$98m contract there was a sum of about five per cent of the project manpower budget set aside for relationship management issues. Without a positive approach to relationship management a no-claims approach is impossible.

So, one might conclude that the 'alliancing' and 'no-claims contract' terminology is essentially tautological. A no-claims contract cannot exist without the help of a clear relational vision, that leads to both soft and hard infrastructure to assist decision-making and relationship building. As a minimum, such an approach requires a facilitator who regularly returns to re-facilitate the project as the project progresses and as team members enter and leave. An agreement to an ongoing commitment of personnel within the organisation is necessary to ensure that the no-claims culture is maintained throughout the life of the project. An innovation manager and an alliance psychologist are also prerequisites for the daily maintenance of positive relationships.

To conclude, if a no-claims contract with a relationship management infrastructure is fully implemented at the outset of a project then success can be achieved, albeit with an upfront cost. Further discussion on the nature of relationship management can be found at Cheung et al. (2005) and Rowlinson and Cheung (2004a; 2004b; 2002) and the CRC for *Construction Innovation*.

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Part 4
Improving Efficiencies through Information and Communication Technologies

CHAPTER 14

'Space' at 1 Bligh: Smart and green with building information modelling

Rodd Perey

INTRODUCTION

'Space' at 1 Bligh is intended to be Sydney's exemplar 'green' building for the next decade. Throughout the process of its development, the design has been tested and optimised by the use of state-of-the-art building information modelling technology. Building information modelling (BIM) is an approach to the design, documentation and coordination of buildings where a digital computer model is created of a building. This model contains elements that are analogues of their real-world counterparts, with equivalent geometry and properties. Properties can contain any information pertinent to the object, as well as derived properties such as area. Documentation is created by the BIM software extracting the relevant information from the building model in the form of plans, other architectural views, schedules, material take-off, and 3D views. Architectus Sydney has implemented BIM, embracing the concept and the cultural changes that accompany it. The 'Space' 1 Bligh project in Sydney represented a unique opportunity to extend the power of BIM through the design process and beyond to construction and facilities management.

Project description

Designed by Architectus and Ingenhoven Architects for client DEXUS Property Group, 'Space' at 1 Bligh is a moderately sized skyscraper of 29 levels and 42 000m^2, costing $230m. Key features are its elliptical form, atrium and dual glass skin, condensing the best available technologies into its flexible design, which promises to become Australia's first 6-Star Green Star Rating highrise.

PROJECT INITIATION

Application selection

Architectus commenced using the BIM approach in early 2003, after considerable research into available applications. Autodesk Revit was selected as being the most comprehensive, mature and well supported of the three true BIM applications available in Australia. We have since acquired a substantial skill base and have literally thousands components (structural elements, fittings, fixtures, equipment etc.) for use in projects. 'Space' at 1 Bligh was therefore commenced using our established platform in July 2006.

Building model establishment

Architectus set up the project BIM according to our established standards and procedures. At this early stage, conceptual elements can be used in place of building elements. An important benefit of Revit is its ability to host within the model a number of 2D and 3D CAD formats including DWG, DXF and DGN. 2D information is located with the correct spatial relationship to the rest of the project. Thus floor plans are held on the correct floor levels. Survey information, for instance, is linked into the project file and is always available to the project team. Sketch design work in CAD formats, and even as image files, are merged with the BIM data in the project file. These techniques allowed design inputs from Ingenhoven in Dusseldorf to be viewed from within the BIM, and to be included within the printed deliverables directly from the application. This model is also used to generate all the standard architectural views required for submissions, consultation and discussion.

Stage 1 Development application

Architectus commenced the Stage 1 Development Application (DA) in late 2005 with the purpose of establishing the building form, envelope and use. The BIM was used for:

- 3D zoning envelope studies
- surrounding context
- hosted site survey
- alternative massing schemes
- establishing floor plates
- shadow studies, with particular attention paid to potential overshadowing of adjacent public spaces.

The Stage 1 DA was approved in March 2006.

Design competition: Concept design

In early 2006 a design excellence competition was announced for the site, and Architectus teamed with Ingenhoven, ultimately designing the winning entry, which was announced in August 2006.

SCHEMATIC DESIGN AND DEVELOPMENT APPLICATION

Schematic design in BIM

The schematic design recommenced from May 2007. This stage of the design process made use of the power of the BIM model in a number of groundbreaking ways:

- True elliptical geometry of a large building held in single discipline-based model files for structure and architecture (architectural file size over 300MB).
- All information intended to be tagged or scheduled, or to have revisions propagated held within this file.
- The breadth of analysis produced from the file.

Team environment

A noteworthy aspect of true BIM applications (Revit, ArchiCAD, CATIA) as opposed to object CAD applications (Bentley Architecture, AutoCAD Architecture, Vectorworks etc.) is the use of a single database to hold the entire project file, apart from those parts that are linked-in. This presents a number of issues regarding file size and working in a team environment, but ensures that the BIM model is dynamically updated, internally consistent, and that relationships between building elements are maintained.

Worksharing

BIM applications allow for a team to work on a single database by dividing the project into conceptual units that can be opened for editing by team members. There is no limit on the team size. Under the leadership of design architect Ray Brown and project architect Mark Curzon, the architectural model was created by a team of four in short timeframes – a small team by our previous standards. It is notable that BIM results in smaller, but far more highly-skilled, teams than CAD processes.

Model topology: linking 3 models

As each of the major design disciplines was using discipline-specific versions of the Revit platform, it was determined early that the best methodology for creating integrated BIM data was to link the three main models together:

- The architectural model hosts the structural and services models
- The structural model hosts the architectural and services models
- The services model hosts the architectural and structural models
- Additional models can be set up with the same topology.

Note that a modified form of this topology would need to be used if model data were not interchanged in native format. The same structure with IFC would require the use of intermediate files for each data interchange.

Independent models

It can be seen that in this topology each model is independent of the others. This resolves a number of problems regarding ownership, authorship and responsibility, as well as the practical difficulties related to the physical location of the model files, and the need for a number of team members to work simultaneously on the files.

Model 'equality'

In the topology described above there is no master model. If the linked models are all up to date, then any of the models can be used to export a comprehensive BIM showing all the data.

Merged model

For the purpose of providing a complete model, as the basis for facilities management for instance, the models can be merged and exported in native, IFC, or DWF formats. This creates a model containing all the relevant data from all parties to model creation.

Infrastructure

No specific infrastructure is required using this topology. Some interdisciplinary model creation topologies use 'model servers' and Internet and WAN connections between the discipline components of the master model. We consider this topology to be cumbersome, expensive and experimental, and representing an unnecessary risk to the timely delivery of the model. With the model topology described above, models are hosted on the networks of the consultant firms. No additional hardware or software is required. Cost recovery problems are avoided, and lines of responsibility and authority are clear.

Protocols

From the time when models are being shared (i.e. beyond the earliest schematic design stage) protocols were put in place to govern the sharing and updating of the BIMs. Key features of the protocols were:

- **Issue of revised models on a regular agreed timeframe:** There is no need or value in having hosted models dynamically updating between the agreed dates, as this simply represents the status of part-completed tasks.
- **Issue generally by CD:** This was found to be less effort and expense than alternative methods such as FTP sites and dedicated servers on a WAN. If it was necessary, for instance because of the geographic location of the parties, a WAN would have been investigated.
- **Established procedures for checking model status and integrity:** This is discussed further below.

Two-way associativity

Changes made in any of the models will be reflected in all of the others when the links are updated. Changes to monitored 'shared' elements such as columns can be accepted, rejected or postponed, as described further.

Satellite models and linking

Architectus provided a current copy of the building model to the structural and MEP services engineers. This model can be used by other disciplines to:

- create a template for their own model
- copy and monitor shared architectural elements to their own model
- dynamically link into their own model; this is regularly updated by the issue of revised models by Architectus.

Consultant models are then linked back to the Architectus model, and interference checking and copy/monitor processes are applied. Each model is complete in itself, synchronised through the linking process, allowing the model to be edited in a number of locations.

Hybrid topologies are possible

Information created in other BIM platforms and in CAD can be linked into the model.

Clash detection

An inbuilt toolset allows for the detection of geometric clashes within the model, and between two linked models. The objects to be reviewed can be selected and limited to manageable sets for a methodical workflow.

Structural engineering

A BIM was created in Revit Structural by Enstruct, using the methodology previously described. Elements such as columns and floors can be transferred from the architectural model to the structural model, whereby they exist in both models but are monitored for changes during the life of the project. The model was exported to Strand7 and RAM Concept for finite element analysis of the structural design. The Strand model was used to analyse vertical and wind loadings and refine the structural design. Similarly RAM was used for the analysis and design of post-tensioned and reinforced concrete floor systems with their substantial cantilevers and high structural efficiency.
The changes indicated by the analysis were then made to the Revit Structure model by a manual process, likely to be superseded by automated processes in the near future. The revised structural model link was then updated in the architectural model, and the copy/monitor and coordination review tools were used to identify changes. These changes can be accepted, rejected or postponed pending further discussion.

A report can be generated describing the coordination actions taken. Architectural elements affected by structural changes can then be revised. On completion, interference checking (clash detection) is used to identify any remaining issues.

Mechanical, electrical, fire services and hydraulic engineering

Mechanical services for a typical level were modelled in Revit MEP by Arup. The MEP model sits 'inside' the linked Revit architectural model from Architectus, which (since structural elements are also architectural) also contains structural elements copied and monitored as just described. This modelling would need to be extended throughout the building to allow for clash detection, energy use calculations etc. Hydraulic, electrical and fire services were drawn in CAD using traditional techniques, but can be hosted in the BIM with correct spatial relationships for coordination purposes.

ESD initiatives

Airconditioning

A cooling system has been selected based on achieving the ABGR rating (Australian Building Greenhouse Rating), providing high levels of comfort as well as responding to the unique zoning requirements that circular buildings have. The façade cooling load is provided by a passive perimeter chilled beam with a low temperature VAV system for the central zones.

Energy generation

The building uses an innovative trigeneration system that uses gas and solar energy to generate cooling, heating and electricity. A hybrid cogeneration system is being developed that can use gas to generate energy, or it can use an array of 500m^2 of roof-mounted evacuated tube solar panels that provide solar energy to directly power the absorption chiller.

Energy consumption

'Space' at 1 Bligh will cut energy consumption by more than half that of a standard tower.

Water conservation

Waste water is treated through a central blackwater treatment plant and recycled for toilet flushing and the cooling towers. On-site blackwater treatment can handle 25 000 litres of sewage and recycling, tapping into the city sewer and treating another 75 000 litres a day for use in the cooling towers, the green wall and for toilet flushing. A 65kL rainwater tank recycles rainwater for irrigation. Water-efficient appliances are used throughout, with 4-star showerheads, 6-star handbasin taps and 4-star toilets.

Façade engineering

The façade forms a key component of the building's 6-star rated ESD performance. Façade engineering was performed in Germany by DS Plan. Geometry exported from the Architectus model was developed in Microstation Triforma as 2D/3D CAD data for detailed design and analysis of the façade elements. By hosting the CAD information into the BIM, the revised profiles and setout were modelled into Revit's curtain wall components by copying the geometry from the CAD file. This remains a necessary procedure where the source is not BIM or where transfer methods (say IFC) fuse the curtain wall components together.

The façade system consists of an inner skin of performance glass and an outer skin of clear glass separated by an accessible cavity which is externally naturally ventilated. The cavity contains a fully automated blind lowered to pre-set positions depending on sun angles. The blinds can remain in the horizontal position providing optimum solar control and daylight reflectance while maintaining views. Overall the façade system will achieve a shading coefficient of 0.15 which is approximately twice as efficient as a standard best-practice façade solution.

View analysis

View analysis was performed by Architectus from the BIM in order to determine the degree of occlusion with the blinds in various of the preset positions.

ESD analysis

The sustainability strategies proposed have the potential to achieve a 5-star ABGR and 6-star Green Star Rating while excelling in the IEQ (indoor environment quality) and energy categories. The high ESD performance required of the building meant that it was necessary to analyse a number of performance characteristics in order to optimise the design. As ESD consultants, Cundall used data from the model in a number of specialist applications to obtain feedback on the building's performance. This analysis was performed in conjunction with the evolving schematic design produced by other parties. Overall for the total Green Star performance, a weighted score of 77 is indicated.

Providing a tempered environment

All the breakout spaces that are located on the south side of the atrium have been designed to achieve year-round comfort without using any additional energy to heat or cool the spaces. The breakout spaces are predominantly naturally ventilated by a series of automated glass louvres. Free heating is provided by in-slab pipework supplied by the heat that is normally rejected via the cooling towers and spaces are cooled on hot days by the relief air from the main office spaces. The entire lobby is naturally ventilated using in-slab heating and relief air cooling to temper conditions during the very cold and warm days.

Perimeter cooling load variation

This was simulated by Cundall using Ecotect, in order to optimise the airconditioning.

Air change effectiveness

Airpak Computational Fluid Dynamics (CFD) software developed by Fluent was used to simulate the air change effectiveness.

Daylighting

Within Cundall's derivative of the BIM model parameters such as geometry, materials, luminaires, time, and date and sky conditions allowed the simulation of daylighting effectiveness using Radiance software. Calculated values include spectral radiance (i.e. luminance + colour), irradiance (illuminance + colour) and glare indices. Simulation results may be displayed as colour images, numerical values and contour plots.

Glare

Glare simulations were produced by Cundall using Radiance.

Atrium natural light

Ecotect was used by Cundall to host a special purpose BIM for testing natural light penetration to the atrium. It is envisaged that there could be further refinements to the process of transferring data to and from the Ecotect model host and the Revit Architecture model. Additional parameters can, for instance, be added to building elements as required for environmental modelling.

Development application submission

The development application was submitted in July 2007 and approved in December 2007. The use of a BIM process facilitated the generation and preparation of data for the development application submission. Standard architectural documentation is produced by extracting the information from the model. Additionally, presentation images were produced using the integrated rendering capability of Revit.

FUTURE DIRECTIONS

Construction sequencing

A BIM is capable of containing project phasing information without limit. This can then be tied to construction and project review applications such as Navisworks and construction programming applications such as Primavera. A fully sequenced building model substantially reduces construction risks and increases the viability of a construction management approach. Reduced risks should directly equate to lower project costs.

The 'Space' at 1 Bligh project has been sequenced by Architectus on behalf of Laing O'Rourke, using a construction specialist as a consultant to the project. Construction sequencing information was built into the BIM, allowing for the creation of sequencing animations and construction sequence schedules. Material quantity, cost and cashflow information can be derived from the model. Model information was linked to Primavera. Alternatively it can be linked to applications such as Microsoft Project, Excel, and Navisworks.

Facilities management

At the end of the construction phase, Architectus is able to provide a building model for use in maintenance, facilities management, leasing, and tenancy fitout. The model can be in native format for development of fitout options, and in DWF or 3D PDF use by non-technical professions. DWF technology also links Autodesk Revit and Autodesk FMDesktop, Autodesk's suite of applications for organising and reporting facility-related information.

As-built model

Following the completion of construction, and 'as-built' model is created by the merger of the architectural model and the linked models, and the export of this model in IFC, DWG, DWF and/or native formats. An as-built drawing set is also created. The model can be exported in formats to suit the requirements of end-user applications.

Tenancy fitout

All base building information can be provided from the building model. For each tenancy, the base building information is linked into the project file for the tenancy, and tenancy detail is added. Tenancy information such as leased areas is added to the architectural model. A provided model base for the tenancy fitout can be used to:

- model and schedule furniture, fixtures, and equipment (with consultant input, this information can be tied to ongoing building maintenance programs)
- link into DWF and FMDesktop
- link to building management systems.

Facilities management and building maintenance

The data in the BIM, tenancy model, and merged data from consultant models can be used as the basis of facilities management applications.

CONCLUSION

Key achievements

It would not have been possible to handle the complex geometry of this project using CAD techniques. The ability to cut live sections through any part of the building is just one example of the power of BIM. BIM has been used as the basis for many hundreds of extracted drawings at all stages of the process supporting the projects needs from marketing to complex analysis. Complex structures require modelling for analysis, and the existence of a BIM from which to derive the structural model streamlines this process. The high ESD goals of the project cannot rely on 'rules of thumb' to prove and test. BIM has allowed many types of simulations that are not possible otherwise. In this case BIM has been used with greater depth on a project of greater size and complexity than previously attempted. Data transfer protocols and interoperability protocols have proven to be effective.

Limitations

It has been a complex task to shoehorn the large (300MB+) file sizes of the data models into processor, operating system and RAM limitations. We eagerly await the next generation of hardware and software to reduce these technical difficulties. Uptake of the technology remains patchy, limiting our ability to realise the opportunities of the technology. Continual investment in staff skills and process development is required.

Opportunities

BIM is only now breaking out of the various disciplines. Its tremendous potential is self-evident, but will require substantial skill increases across the entire construction industry for it to be realised.

CHAPTER 15

Estimating Indoor Air Quality Using Integrated 3D CAD Building Models

Selwyn Tucker
Stephen Brown
Stephen Egan
Fanny Boulaire
Lidia Morawska
Congrong He

INTRODUCTION

Current assessment of indoor air quality in buildings focuses on the measurement of pollutants to assess their compliance with recommended guidelines. At the design stage, experience is the main source of information for deciding on choice of materials on the basis of indoor air quality. There does not exist any model or tool which is specifically aimed at predicting the indoor air quality of a building at the design stage, yet a method/tool for predicting pollutants would assist designers in creating optimum indoor air environments. A method for predicting optimised indoor air quality and the use of appropriate performance measures are key prerequisites for developing a building code for indoor air quality, and to provide estimates of indoor quality from which environmental and occupant health consequences can be minimised.

In the Indoor Air Quality (IAQ) Estimator (Tucker et al. 2007), the pollutant emission properties of major pollutant sources in offices are used to predict their impacts on indoor air quality. This prediction is made using a software tool for building designers so that they can select materials and appliances that, in combination, are sufficiently low emitting to prevent emission goals for indoor air pollution from being exceeded.

The principal objectives for IAQ Estimator were to:

- create a database of air pollutant emission rates for common large-area building materials and contents, focusing on typical examples of paints, adhesives, floor coverings, plasterboard, reconstituted wood-based panels, office furniture and copiers/printers
- use this database to estimate the effects of different ventilation scenarios on indoor air quality for a single zone of an office building in a 3D CAD model
- estimate the submicrometre particle levels and urban air toxics in mechanically ventilated office buildings for different levels of urban air particle pollution, particle emissions from copiers/printers, and ventilation system filter efficiency
- integrate the above three factors for estimating indoor air pollutant levels within a building zone directly from the materials information available in a 3D CAD model or from information introduced manually.

INDOOR AIR POLLUTION

The primary sources of indoor air pollution in office buildings are considered to be:

- emissions from large-area building products
- emissions from office furniture and equipment
- pollutants from urban air introduced by ventilation.

Emissions from large-area building products are volatile organic compounds (VOCs) and formaldehyde from paints, floor covering systems, wallboards (plasterboard and wood-based panels), and fixed furniture materials (structure and surfaces).

Emissions from office equipment are VOCs and submicrometre particles from operating office equipment, linked to the frequencies of operation of such sources in office buildings. Emissions from office furniture are typical emissions of VOCs and formaldehyde from office furniture such as workstations.

Pollutants in ventilation air in mechanically ventilated office buildings are from outdoor urban submicrometre particle and air toxics pollution and are dependent on the ventilation flows in the enclosed space and efficiency of HVAC filtration.

It was considered that the IAQ Estimator must use a methodology for estimating indoor air pollution from key materials and contents through:

- identifying the dominant volatile organic compounds and airborne particles present in indoor air in office buildings
- loading the building space (volume) at quantifiable ratios with materials and contents
- interfacing with pollutants introduced from outdoor air and the effect of HVAC filtration
- estimating the changing profile of emissions over time after construction
- comparing the estimated pollutant levels with health-based criteria.

INDOOR AIR QUALITY MODELLING

A model for indoor air quality in commercial buildings was developed by combining existing indoor air measurement, product emission and ventilation/filtration knowledge into a practical tool for estimating the indoor air quality of rooms/spaces over time. The estimated pollutants were for a single, fully mixed and ventilated zone in an office building.

Existing product emission models were considered and an approach was determined for the level of detail required for emissions into enclosed spaces. Goal levels of pollutant exposure were derived from Australian and international health-based standards. Pollutants were not included if such standards were unavailable.

Emissions to air from selected materials

A list of 20 key VOCs (including formaldehyde) was derived from existing knowledge of the VOC species found in Australian buildings and emitted from materials and appliances (Brown 1999a; 1999b; 1999c; Brown 2002). It was essential that a health-based environmental criterion existed for each (WHO 2000; NEPC 2007; ISIAQ 2004). The compounds and maximum concentration goals within IAQ Estimator are presented in Table 15.1. Available Australian air emission data for building and furniture products for these 20 key compounds were collated into a database of representative products. The building products for which low, typical and high emission examples were selected included:

- paints (zero emissions, low odour and acrylic, solvent-based) on plasterboard or other substrates
- floor covering systems (carpet/underlay/low- and high-emitting adhesives, tile, wood panel floorboards, timber lacquer)
- wallboards (plasterboard and reconstituted wood-based panels, including MDF)
- fixed furniture materials (shelf units, workstations).

Emissions from some products had to be measured if emission information was unavailable.

Table 15.1 Pollutants and Goal Values for IAQ Estimator Tool

Pollutants	IAQ Estimator goal
VOCs	**($\mu g/m^3$ unless stated)**
Acetaldehyde	300
Benzene	60
2,6-Di-tert-butyl-4-methylphenol	500
1,4-Dichlorobenzene	800
1,2-Dichloroethane	700
Dichloromethane	1,100
Diethylene glycol ethyl ether	6,000
Ethylbenzene	800
Ethylene glycol ethyl ether	200
Formaldehyde	40
Isobutyl methyl ketone	500
Naphthalene	30
Phenol	300
Styrene	500
Tetrachloroethylene	100
Toluene	300
Trichloroethylene	150
Total VOC (TVOC)	500
m-/p-Xylene	300
o-xylene and o-/m-/p-xylene	300
Particles:	
PM2.5	25
PN1 Particles	5000 particles/cm^3

Emissions from operating equipment

Emissions from one copier and several laser printers from the late 1990s were assessed previously and a chamber methodology for assessing such appliances was developed (Brown 1999a; 1999b). One significant finding was that the emissions were related directly to the number of copy operations and could be quantified as pollutant mass per copy. It was found that:

- the copier and the new laser printers were very low emitting for ozone, while an old printer emitted significantly higher quantities
- emission of formaldehyde and nitrogen dioxide were low or below detection
- emissions of respirable particles were higher for laser printers than the copier
- emissions of VOCs were generally higher for the copier, and species showed some variation with manufacturer (aromatics were the most common VOC)
- the irritant and odorant nonanal was observed in the emissions from an old printer – this was probably a secondary emission formed from reaction of ozone and the aromatics in chamber air.

While the above presented a detailed assessment of office equipment of that period, digital copier technology was introduced soon afterwards, such that documents are scanned one time (instead of one scan per copy) and then reproduced in multiples as needed. Laser printer technology is believed to have remained similar since the late 1990s, relying on positive corona discharge (rather than negative discharge), a process that releases much lower ozone than negative discharge. However in a recent study of laser printer emissions, He et al. (2007) have reported the emission of high numbers of sub-micrometre particles (0.02 to 1.00 micrometre diameter, which are referred to here as PN1) from some printers.

Thus, IAQ Estimator emission data for office equipment includes VOCs, respirable fine particles $PM_{2.5}$ (mass concentration of particles smaller than 2.5 micrometre cutpoint) and sub-micrometre particle numbers as PN1 from the studies described above (goals for the latter two are also presented in Table 15.1). However, since emission data was lacking for currently produced digital copiers, further assessment of these was undertaken. These and earlier data are included in the emissions database, expressed as pollutant mass per copy, and IAQ Estimator requires an estimate of copy rate per hour for model operation.

Emissions from office furniture

Typical air emissions of the 20 key volatile organic compounds from office furniture were identified and provision made in the model for point source emissions linked to the level of loading of such sources in office buildings. Emissions from additional products were measured where emission information was unavailable.

Pollutants in ventilation air

The particle filtration system of mechanically ventilated office buildings was linked to three real-world categories of outdoor urban particle pollution according to building location (e.g. busy road, urban and rural). The model estimates the impact of different filtration performances on indoor pollution by particles for such categories. In addition, urban air levels were estimated in the same three categories for VOCs of heath concern, commonly referred to as BTEX (benzene, toluene, ethylbenzene, xylenes), as well as total VOC (TVOC) levels.

Emissions database

An IAQ Estimator emissions database was constructed for major indoor materials/appliances:

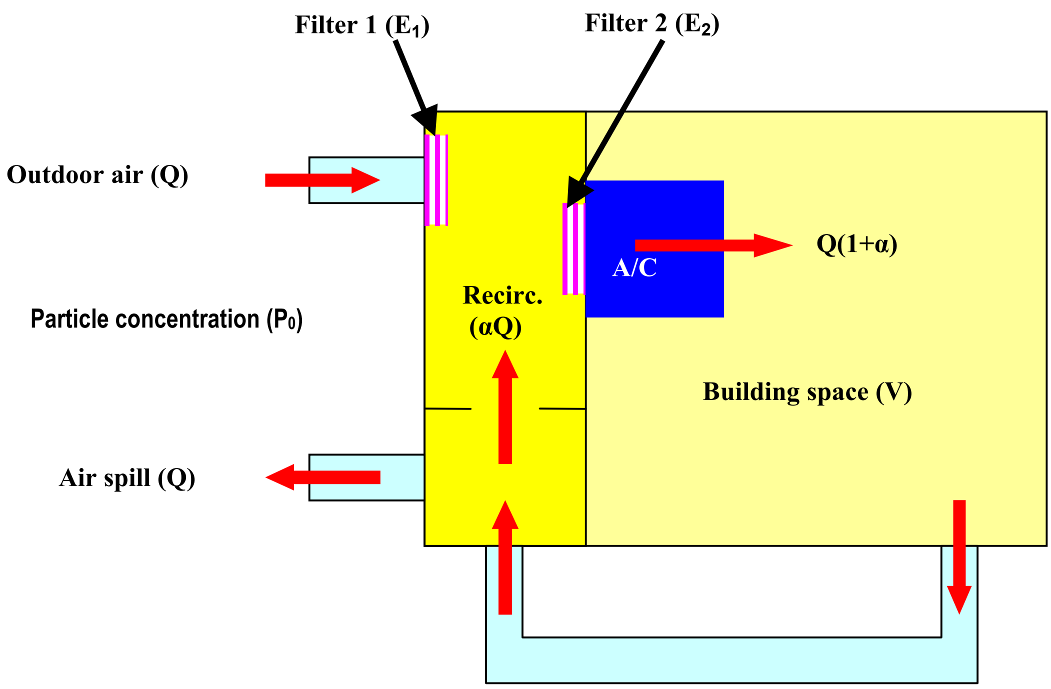
- paints
- floor coverings
- furniture/wood-based panels
- copiers/printers.

For each material/appliance, an emission factor (EF, mass of pollutant/area/time, or mass of pollutant/copy) was documented for the selected pollutants. EFs were documented at specific times, selected as relevant to occupancy of new buildings: 1 day, 3 days, 7 days, 14 days, 28 days and 6 months with data at the latter two times often being unavailable and having to be extrapolated from measurements at earlier times. IAQ Estimator estimated an indoor air concentration of each pollutant at each of these times.

Filtering of recirculation air

Most HVAC systems are believed to pass the recirculated indoor air plus the outdoor air intake through a filter (i.e. the recirculated indoor air will have multiple passes through the filter). IAQ Estimator is based on a model that incorporates this general feature plus the added feature of a second filter for the outdoor air intake, as seen in Figure 15.1.

Figure 15.1 Schematic Diagram of Air Circulation and Filtering



This model has the following characteristics:

- Outdoor air is supplied at flow rate Q (m^3/h) through Filter 1 (efficiency E_1) into the airconditioning (A/C) plant.
- Air from the building space is recirculated to the building at a flow rate of αQ; hence the flow rate through the airconditioning plant is Q (1 + α).
- The airconditioning plant has a second filter, Filter 2 (efficiency E_2).

The indoor particle concentration with a multiple filter system can be simplified to:

$$dC/dt + \alpha C = \beta$$

$$\alpha = [Q_{RA} + Q_{OA} - Q_{RA}\ (1\text{-}E_2)] / V$$

$$ß = [C_{OA}\ Q_{OA}\ (1\text{-}E_1)(1\text{-}E_2) + \Sigma_i\ G_i]/V$$

and at steady state:

$$C_\infty = ß/\alpha = [C_{OA}\ Q_{OA}\ (1\text{-}E_1)(1\text{-}E_2) + \Sigma_i\ G_i] / [Q_{RA} + Q_{OA} - Q_{RA}\ (1\text{-}E_2)]$$

where C_{OA} = concentration of particles in outdoor air
Q_{OA} = outdoor air flow rate into building
$\Sigma_i\ G_i$ = sum of indoor particle source emissions = $\Sigma(EF_{copy/print}\ n_{copy/print})$
E_1, E_2 = particle removal efficiencies (0 = no removal; 1 = 100% removal) of outdoor air and supply air (OA + RA) filters, respectively

Note that this model ignores deposition losses of these particles to interior surfaces since this was considered to be too variable a factor, and such simplification prevented the possibility of underestimation of particle levels.

It was assumed that there would be no removal of VOCs and formaldehyde by the ventilation system, or by surface losses (‘sink’ effects) within the building. As for particles, this prevents under-estimation of pollutant levels. Also, IAQ modelling is reduced to a simple summation of emission factors multiplied by surface area loading ratios (or copy rate) for each material/appliance and divided by the building air change rate.

COMPUTER SOFTWARE

The computer model was assembled as a proof-of-concept integration of:

- acquiring dimensional data for the indoor spaces from a 3D CAD BIM via IFC files, an application of DesignView software (Egan et al. 2007)
- emissions from static building products, emissions from fitout, and impacts of ventilation filtration efficiency.

Validation was limited to comparing estimates with published building measurements (Brown 2002) and specific data collected for one test building (Brown 2007). As currently available, it is considered a proven concept tool and is a significant step towards a commercial product.

The prototype software acquired its dimensional data for the indoor spaces from the 3D CAD model or alternatively from a list of building components and their sizes entered manually. Ventilation data was limited to three scenarios of typical particle filtration. Finishes on the building components in the 3D CAD model and the types of office equipment were identified by the user.

Outputs were indoor air pollutant concentrations at seven time intervals as presented earlier, each designated as pass/fail by comparison with the goal concentrations.

The use of the DesignView platform as the driving engine of the workbench for the Indoor Air Quality Estimator provided powerful functions besides the ability to view IFC files, such as a:

- plug-in architecture based on the Eclipse Rich Client Platform (Eclipse 2007a) and Eclipse Modeling Framework (Eclipse 2007b) which allowed multiple analysis applications to sit alongside DesignView and interact with it
- navigator panel which allowed selection of a particular model for viewing
- ‘tree view’ which allowed the user to rapidly select sections of the building model to visualise and was synchronised with the viewing panel
- properties panel which displayed tabular information which was attached to a selected building component in the viewer panel or the tree view
- problems list which displayed a list of missing information that had been identified by DesignView on loading a building model
- tasks list that allowed people to enter ‘to do’ lists to ensure that things were not forgotten during design development.

DesignView was developed as a ‘next generation’ viewer which has embodied lessons learnt in implementing and using previous versions of IFC viewers. The open and flexible plug-in architecture provides a foundation for other tools to be built on top of it, allowing developers to concentrate on the particular problem that tool addresses.

The key feature of DesignView which was attractive to IAQ Estimator was the ability to add finishes to any building object in the 3D CAD model and see the object visually. The system was modified for IAQ Estimator to add paints and panels from the material emissions database and expanded to be able to add office furniture and equipment into the space. These finishes could be visually inspected in the 3D Viewer.

The key features of DesignView most useful in IAQE are the 3D Viewer, the Model Outline, the Navigator and Pollutants views.

The 3D viewer displays a real-time fully rendered 3D view of a building model. The user may use the mouse and keyboard to explore and interact with the model. The camera can be panned, zoomed and oriented in any direction, and the user can select individual building elements using the mouse.

The Model Outline displays the hierarchy of the building model in a tree structure. The model may be traversed according to four different hierarchies: building, element type, space type and material type. The Model Outline view is linked with the other views in the workbench perspective which simultaneously displays multiple windows on the one screen so that a range of aspects of a model can be manipulated and worked on by selecting the required window. Selecting elements in the Outline highlights their visual representations in the 3D Viewer (if they are visible). Conversely, selections made in the 3D Viewer are reflected in the Outline.

The Navigator view is used to display and navigate through the workspace and functions just like the Explorer in MS Windows.

The Pollutants view provides a list of pollutants and their levels at 1, 3, 7, 14, 28 and 6 months intervals. The pollutants can be expanded by a simple click to show the sources of the pollutants (e.g. paint, furniture, outdoor) and the contribution of each source. A further breakdown shows the contributions from individual building components. A report indicates by ticks or crosses (and double crosses if more than double the maximum level) whether health-based criteria have been met.

The current proof-of-concept software was considered to be very flexible, adaptable and robust, and was found to be functional and effective in assessing indoor air emissions in demonstrations to potential users. For example, for hypothetical buildings, it:

- showed the impacts of high-, medium- and low-polluting sources
- was possible to refine the building design to meet goals by not only selecting low-emission products, but by reducing surface areas, increasing ventilation rates or delaying time to occupancy.

Proof of the tool in a test building was limited by the low-emission design of that particular building and delays in getting access to it after occupancy (six weeks or more). However, IAQ Estimator predicted that indoor concentrations would be very low (much below all goals) and this was found to be the case. Particularly the formaldehyde concentration was predicted to be very low (~1 $\mu g/m^3$) and was measured to be 5–9 $\mu g/m^3$, which was considered particularly low for such a new building.

IMPLICATIONS FOR INDUSTRY

The Indoor Air Quality Estimator is considered to be an integrated, proof-of-concept model development comprising:

- acquisition of dimensional data for the indoor spaces from a 3D CAD BIM via IFC files
- manual entry of building components and office equipment details when 3D CAD is unavailable
- a methodology for estimating indoor air pollutants over time from quantities and unit emissions from large-area materials, office equipment and furniture and ventilation air sources, flow rates and filtration efficiency
- an assessment approach based on health-based criteria for indoor pollutants.

Stand-alone software, which can import IFC models directly, is likely to have the most impact as the potential users are not 3D CAD specialists.

IAQ Estimator enables building designers to estimate the impacts on indoor air quality of different materials, finishes, office equipment and ventilation practices. By selecting different scenarios, the possibility of IAQ goals being exceeded can be understood, different strategies can be adopted (short-term increase in ventilation, delayed occupancy) and pollutant exposures can be reduced. The tool has many simplifying assumptions, such as:

- a building level would be treated as one, fully-mixed zone
- only large-area materials are included
- the emissions database is not extensive in the materials considered (though it can grow with applications)
- only the 'dominant' VOCs found in building air or product emissions are included
- pollutants without health-based goals are not included
- losses of pollutants to surfaces are not considered
- filtration efficiencies are for new filters.

However, in general these will lead to overestimates of indoor air pollution and so this should not be considered a fully predictive tool. The key benefit of IAQ Estimator is that it will make choices more transparent at an early stage. It is not expected to replace the need for IAQ assessment of new buildings but it should reduce the likelihood of unacceptable indoor air quality.

Overall, IAQ Estimator *is*:

- an office design tool for selection of materials, office equipment, ventilation filtration
- useful in design towards optimised IAQ
- a tool that allows control of indoor air pollutants from:
  - new materials (aimed at first six months of construction)
  - long-term factors such as office equipment, filtration system and urban air.

IAQ Estimator *is not*:

- a means of distinguishing *a priori* whether indoor air presents health risks
- a method of predicting IAQ with precision
- a way of dealing with all aspects of IAQ (e.g. provision/distribution of ventilation air, maintenance, indoor activities, other pollutants such as microorganisms, combustion gases)
- a tool for use in regulations.

FURTHER RESEARCH

Products in the emission database are far from providing comprehensive coverage of current products. Further product emission testing is needed wherever possible linked to the materials used in buildings, for example:

- typical water-based and typical low-emission paint on plasterboard, as distinct from on glass, since limited data has been gathered for the former
- carpet adhesive emissions as part of a carpet/underlay/adhesive system
- MDF and particleboard emissions (particularly low-emission products) since these have decreased in emissions in recent years and long-term emission data is not available
- furniture emissions without several months' delay
- photocopiers with current technology.

Further application research is needed to:

- calibrate the results against known building cases
- test the ease and speed of assessment for building designers using 3D CAD or manual inputs
- evaluate the type of decisions which can be made using IAQ Estimator
- identify other forms of presentation of results which would be of benefit in making decisions.

ACKNOWLEDGMENT

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CHAPTER 16

Model-Based Estimating for Concrete Bridges: A feasibility study

Kwok-Keung Yum
Thomas Froese
Guillermo Aranda-Mena
Willy Sher
Nigel Goodman

INTRODUCTION

Designing and estimating civil concrete structures is a complex process which to many practitioners is tied to manual or semi-manual processes and cannot be further improved by automated computer-based processes. This paper presents a feasibility study for the development of an automated estimator for concrete bridge design, and demonstrates that such estimators can add significant value to interactive design and estimating and, because of this, offer themselves a future.

An earlier CRC for *Construction Innovation* project on automated estimating has shown the key benefit of *model-based design methodologies* in building design and construction to be the provision of timely quantitative cost evaluations (Drogemuller 2003). A building model was input into the estimator which automatically produced the estimated prices of the concrete trade for the building's construction. The speediness of cost estimation has produced an important impact on building design – the easier cost estimation is obtained, the better it can be used to guide the design of buildings. From a theoretical perspective, Yum (2005) has shown that using a model-based approach during building design can improve the design options, result in shorter design turnaround times and better design quality as well as lower costs. The question is: Do the benefits of efficient estimation warrant further development of automated estimators outside the realm of buildings?

There are few, if any, automated estimating applications for civil engineering structures. The research partners in *Construction Innovation* expressed interest in evaluating whether it would be feasible to extend automated estimation for buildings to the realm of design for civil concrete structures. This paper presents the work done on these investigations, with the view that they can add value to the research and development of automated estimators for civil concrete structures in the future.

The scope of the study is to investigate whether it is feasible to develop an automated estimator for civil concrete structures. Questions asked are:

- Do such estimators add value to the design and construction of concrete structures? And if the answer is 'yes'…
- Where does the benefit lie?
- What is the functional form of the estimator?

The following aspects are beyond the scope of this study:

- A fully developed business case for an automated estimator for civil concrete works
- Designing processes for the ideal model-based design approach
- Designing schemas for the planning/design/estimating of bridges
- Implementing the above designs in supporting software applications.

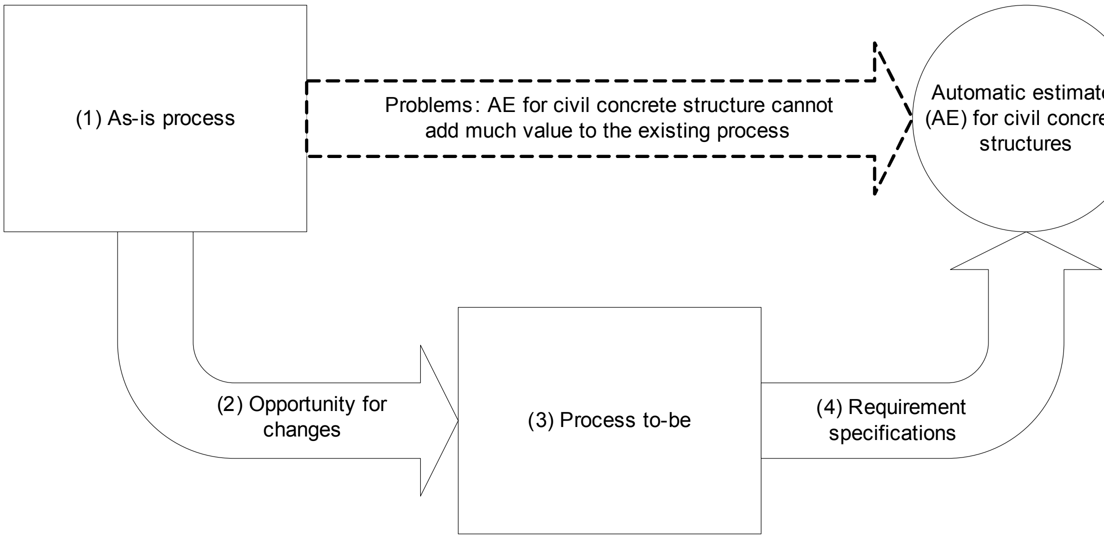
The contribution of this paper is threefold: (a) to identify points where values can be added to the processes of design, assessment and construction of concrete bridges, (b) to embed such values into the process of automated estimating, and (c) to specify the functional requirements of the automated estimator.

METHOD

Figure 16.1 shows the context and method used to investigate the feasibility of developing an automated estimator for civil concrete works. The study first established that there are two types of estimating in the current practice of bridge estimation. Of these two types only the type of *estimation for design* has potential to add significant value to the whole design–estimating process. The second part of the study, 'Opportunity for change' in Figure 16.1 identified the opportunities of improvement, that is model-based technology adds efficiency and functionality to software that supports the interaction of design and estimating. A value proposition is established: an efficient automated estimator can add value to the design–estimating process, i.e. reducing estimation errors, shortening the duration of success estimates, and increasing the benefit of doing cost estimation when compared with the current practice. The value proposition rests on the availability of an efficient automated estimator for design–estimating interaction – if such an estimator is available, the use of it will add significant value to bridge design and thus enable the tool to grow in the commercial market.

The last two parts of the study were in step with each other: designing typical use scenarios for use of the model-based estimator efficiently, and identifying the functional requirements for an efficient automated estimator for bridges.

Figure 16.1 Context and Method for the Research



CURRENT PRACTICE OF ESTIMATION

From this section onward estimating is considered within the context of planning and design, because estimating and planning/design are always intertwined to give the planner/designer some assurance of the quality and economy of the work. Also, in practice, the planning and design of bridges is always considered in the context of roads planning/design. As a result of these contextual dependencies, we have to consider the current practice of *bridge estimating* in the context of *roads planning/design*.

The Queensland Government Department of Main Roads (QDMR) has developed a full set of estimating standards (e.g. QDMR 1999; 2002; 2004; 2005), including standard work breakdown structures (WBS), to facilitate the infrastructure project tendering processes of the Queensland Government. We believed that investigating the current practice of estimation in Queensland would perhaps give us a good starting point in this feasibility study.

Estimating is executed in the context of project management in order to be an integral part of a system of interdependent core inputs of scope, resources, time, cost and quality.

A typical project budget results from the approval of a business case concept estimate at the end of the concept phase. This estimate is based on a sound definition of scope of the preferred option derived from completing a scope analysis. Once the project is justified, it is placed in the Roads Implementation Program (RIP) for further development. The total development time in RIP is about five years (indicative only). It is expected that project scope and details are progressively refined. As more information is added to the design over time, the estimation percentage errors relative to the final total cost of the project are expected to decrease.

The preliminary design estimate is used to confirm the budget before the project moves into the last two years of firm RIP. At the end of the detailed design period, the design is completed; and tender documents are prepared for contractors to bid on.

Macro-level estimating

The planning and design of roads and bridges is a very complex process. To overcome the complexity, planning and design processes may be compartmentalised into lifecycle stages: concept stage, preliminary design stage, and detail design stage. The estimating process at the end of each lifecycle stage is needed for project budgeting and approval. Each project lifecycle stage has its own timeframe (with a duration ranging from months to five years) and a scope of work. It needs considerable work to get a project to progress from the concept stage to the next; and it needs even more work if a preliminary design plan is scrapped and work reverts to the conceptual design stage. Due to the long duration of the project lifecycle stage (months or years), the estimate for each stage cannot be used to fine tune the design options – too many design hours have gone into the plan and it would be inefficient to redo it all.

Estimating at the end of a project lifecycle stage is referred to as *macro-level estimating.* It is used for managing the *total* cost and/or estimating budget, but it is a blunt tool for planning and/or design.

Micro-level estimating

While the previous estimating process is related to project management, this subsection discusses estimating during the *design* process. The main difference is that the former process is performed to get approvals from one management lifecycle stage to another (total cost estimating), whereas the latter process is performed by a project team so that, at any time during the design of a structure, cost factors may be incorporated for partial and total cost estimation.

QDMR (2002) is a road/bridge planning and design manual that provides a comprehensive set of design parameters, including traffic parameters, human factors, speed parameters, safety barriers, sight distance, alignment design, intersections, transport systems, bridges, and so on. These parameters (formerly called *design domains*) and their values are selected for the justification of a design, based on empirical safety research, or theoretical physical models, or both.

Any design with respect to a design domain is a compromise between competing requirements, expectations and contextual information (i.e. in terms of location and geometry problems, cost, safety, driver expectations, economics, environmental and social impacts). Figure 16.2 shows a qualitative cost and benefit analysis of the selection of the width of a motorway shoulder (a paved strip beside the motorway). Selection of a value within a design domain depends on a trade-off between the issue context and various benefits and costs.

The estimated cost is a part of the multi-criteria assessment (MCA) that helps select a solution from various design options. The key design parameters, such as traffic parameters, speed parameters, cross-sections, safety barriers, lighting, bridge deck, piles, a design domain (design parameter) is evaluated according to multiple values (such as mobility, maintenance cost, capital costs, environmental impact, accident rate) This loop defines the *micro-level estimating* which assesses the cost of *any part of the design at any planning/design time*.

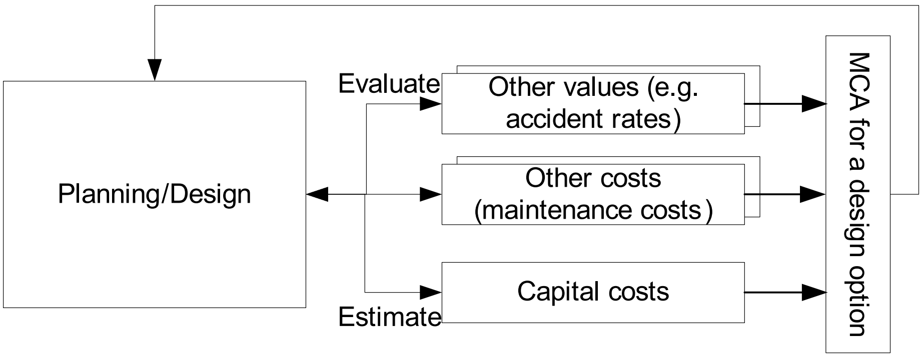
In current practice, the decision points at various micro-levels of estimating are based on the judgment of bridge design experts, because there are no computerised tools to facilitate the decision process.

The most logical approach to automating the processes of micro-level estimating is to split the cost information and splice it with the components of various *design models* along the design life of the bridge. But before doing that, we need to answer these fundamental questions: What is the benefit of doing so? Is the benefit so significant that it will support the cost of developing the automated estimator?

VALUE PROPOSITION

This section develops the overall value proposition that an automated estimating system provides considerable advantages over the current process. It describes the areas where an automated estimating system adds value to civil works projects, discusses some of the issues impacting cost–benefit considerations, and suggests ways in which the characteristics of such an estimating system impact on an estimating strategy.

Figure 16.2 Micro-level Estimating and Multi-criteria Assessment (MCA)



Technological context: Model-based design

A model-based automated estimating system requires a semantically-rich project data model as input (e.g. a building information model, IFC model or similar). The project data model is an integrated model that can be used across a number of disciplines, such as geometry design of the road/bridge, structural loads, traffic requirements, stormwater systems, or electricity equipment, and is not simply limited to estimating.

It is only advantageous to develop an 'automated estimator' when this is based on model-based design so that estimators re-use the data from the design model to assess costs. There is little benefit in requiring the user to manually re-enter design data into the automated estimator to evaluate costs.

Model-based technologies add value in two broad categories:

1. they add efficiency and functionality to individual software tools by allowing automatic generation of 3D views and design versions for project management
2. they improve data sharing, integration, and interoperability between design and estimating (i.e. the geometry design data of bridges can be re-used for the purpose of structural engineering design and cost estimation).

By comparison, the general building construction industry appears to be in the early stages of adopting model-based technologies, and those companies that have made the transitions are experiencing positive overall outcomes. There is no reason to expect that the civil engineering industry would not similarly benefit from model-based technologies, although the required software systems, standards, etc. may be less well-developed at present.

Organisational context: Alliancing contract

In the traditional form of civil works project organisation, the owner engages design consultants who complete the project design before a contractor is appointed through the competitive tendering process. Increasingly, variations in projects' organisational forms introduce a range of new relationships, tasks, and sequencing among the project participants. These organisational forms include design–build contracts, alliancing agreements, public–private partnerships etc. Some of the outcomes of these organisational evolutions lead to a blurring of the boundaries between the design stage and the construction stage, increasing collaboration between design and construction parties, and increasing participation of contractors earlier in the project.

The greater the interaction between design and construction throughout the early project phases, the greater the opportunity for automated estimating systems to be used to produce frequent, reliable costs estimates throughout the design and tendering phases with minimal time, effort, and cost. This increased value arises because designers are able to provide early design information and take advantage of improved cost estimates to guide design decisions, contractors are able to provide construction methods decisions and costing information to improve estimates' reliability, and the estimating system is able to convert this information to cost estimates with a high degree of automation (with a consequent reduction of time and cost).

Designer's value-adding proposition: Estimating utility theory

The most salient characteristic of model-based automated estimating is that, by automating quantity takeoff and other estimating tasks, a significant reduction of time and effort is required to produce estimate results. This increased speed and efficiency provides the following advantages:

- substantial savings in the cost of producing estimates
- quicker turn-around times for estimates, making estimating more convenient and timely
- relieves pressure on estimating resources; for example, it would increase the capacity of a single estimator and reduce the likelihood of bottlenecks in the design process
- ensures that estimates are of higher quality than might otherwise have been the case because measurements are prepared consistently and rigorously.

The less direct, but potentially greater value, proposition lies in the premise that, because it is much quicker, cheaper, and easier, estimates will be produced much more frequently throughout the design process and will thereby lead to better design outcomes. In its simplest form, this value proposition suggests that the outcome of any civil engineering project will be improved if an accurate cost estimate could be produced at any point throughout design and construction 'at the touch of a button'. This value arises because improved cost forecasts facilitate better planning, design, and construction decisions. This proposition is clearly hypothetical – complete and accurate cost estimates can never be provided with no time and cost. Yet, acceptance in principle of this hypothetical value proposition motivates an examination of how near to this ideal practical estimating solutions can approach, and how much value these solutions can provide.

A final value proposition is that cost-related risks could be reduced if better cost information were available throughout the planning and design phases.

Conceptually, the *value* of producing an estimate is taken to be the monetary *benefit* of producing the estimate divided by the *cost* of producing it.[17] If the value (i.e. benefit/cost) is greater than 1.0, it should be worthwhile to produce an estimate, and given a range of possible estimating strategies, the alternative that yields the highest value should be chosen. To assess this value, the benefit and cost of producing an estimate need to be evaluated.

Planning and design practices involve a lengthy sequence of decisions intended to produce a final outcome that meets cost and other project objectives. Given perfect information and prediction capabilities, the outcome would be very nearly optimal. However, information and prediction capabilities are not perfect, so results follow a bounded rationality – they are the best choices available given the limited information available.

With respect to cost objectives, explicit cost estimating provides the best available prediction of project costs. However, this explicit cost estimating is carried out only infrequently during the design process, and it is only at these infrequent times that the designers have the best possible cost information upon which to base their design decisions. In between these estimate points, design decisions are not arbitrary with respect to costs, but are based on cost-related judgments that designers are able to predict *without* the benefit of full cost estimates.

The *benefit* of cost estimating arises from the difference in cost between the design that would be produced without the estimate information, and the cost of a more optimal design that could be produced with the estimate information. (The estimate information may also allow more optimal design decisions with respect to other project objectives such as lower risks, better decisions about additional features that could be included within budget targets, etc.) A number of factors impact the extent or magnitude of this benefit, including the accuracy of the estimate, and the time intervals between successive estimates.

The benefit of the cost estimate will be proportional to the accuracy of the estimate. Very accurate estimates provide near-perfect cost information and are clearly better than the assumptions that designers make without cost estimates. Very inaccurate estimates may be little better than a designer's judgment, thus providing negligible benefit. There are, of course, significant inherent uncertainties involved in predicting future construction costs, so there are very real practical limits to the accuracy attainable with cost estimates. Yet up to these accuracy limits, the following relationship exists: greater estimate accuracy can be achieved with greater estimating effort (i.e. the more accurate the estimate, the more costly it is to produce the estimate).

The combined effect of benefit/cost, as shown in Figure 16.3, relates the value of the estimate to the accuracy achieved. This relationship suggests an estimating strategy: that for a given situation, there will be an optimal level of accuracy to try to achieve (more accuracy will lower value by disproportionately increasing costs, less accuracy will lower value by disproportionately decreasing benefit). Using a similar argument, the relationship between the value of estimating and the time interval between estimates is shown in Figure 16.4.

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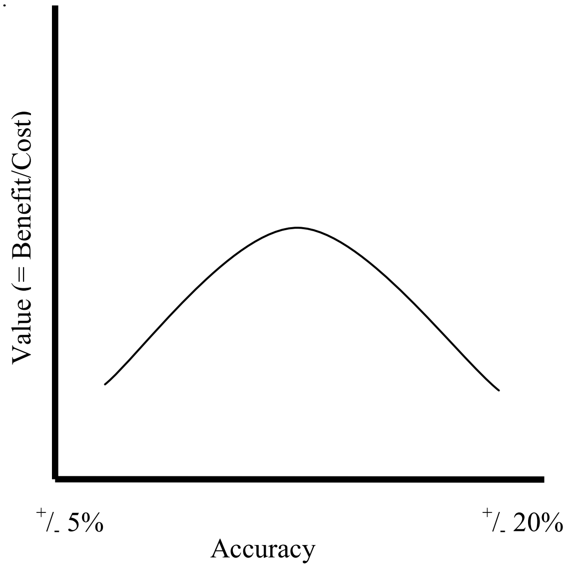
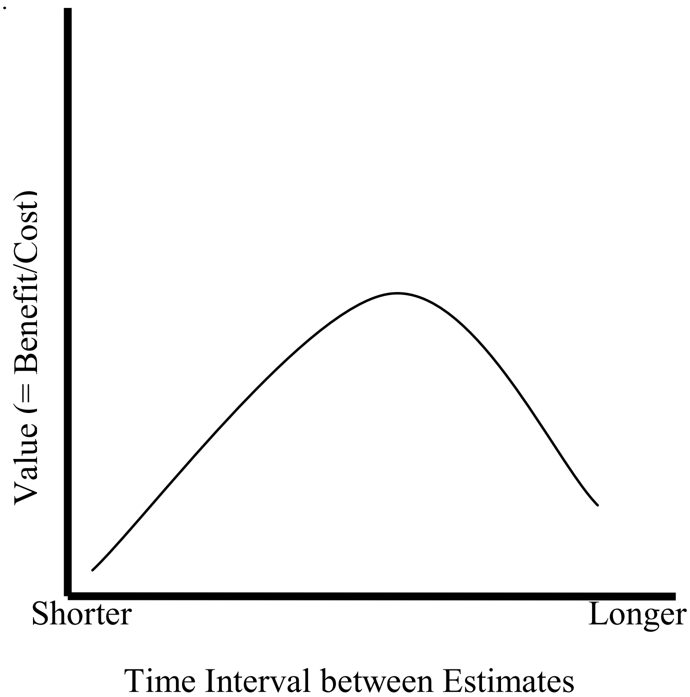
[17] In this section, the term 'cost' is referring to the *cost* of producing estimation. It is different from the terms like 'project cost' and 'cost estimating', which refers to the cost of the project.

Figure 16.3 Value of Producing an Estimate Versus the Accuracy Achieved



Note: Value is defined as the benefit/cost

Figure 16.4 Value of Estimates Versus the Time Interval between Successive Estimates



Figures 16.5 and 16.6 show the effect of automated estimating. The greater estimating efficiency will increase the relative value of the estimates and will shift the points of maximum value to the left in both figures. This will lead to a change in estimating strategy that constitutes the motivation for designers to use automated estimating: the total cost of producing estimates will be less, estimates of greater accuracy will be produced more frequently, the overall value of the estimates will be higher, and the design outcome will be more cost-optimal.

Figure 16.5 Value of Producing an Estimate Versus the Accuracy Achieved with Current Practice and with Automated Estimating

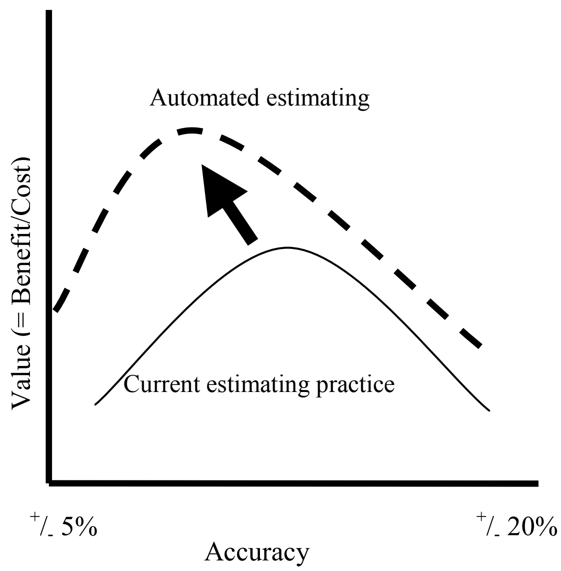
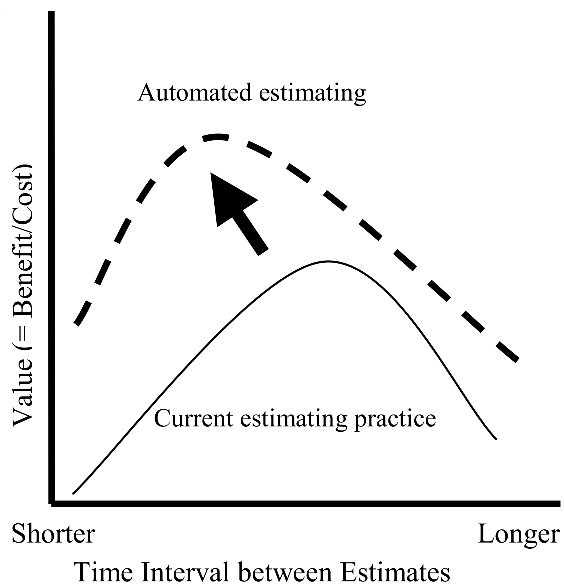


Figure 16.6 Value of Estimates Versus the Time Interval between Successive Estimates with Current Practice and with Automated Estimating



The exact degree of these changes is difficult to predict until model-based estimating systems are more fully developed. At the extreme, the estimating process will be highly front-end loaded, with the bulk of the work required to produce estimates coming near the beginning of the design process. In this scenario, each successive incremental estimate could be derived from the design model at essentially no cost, thus providing essential continuous and 'real-time' cost estimates during design.

Contractor's value-adding proposition: Contractor's early input to design

If contractors use a model-based automated estimating system solely to produce total project estimates *at the time of bidding*, then the value proposition lies in the fact that they will be able to produce these estimates more quickly and at less cost. This value proposition is very narrow in focus, because it produces little or no impact on design quality.

A more far-reaching value proposition arises in situations where contractors have an opportunity to provide input throughout the design process, as in alliancing agreements, design-building contracts, etc. In such cases, one of the primary roles of early construction input is to provide cost-related advice on the whole and/or parts of the bridge design to improve the design constructability and overall value. This requires cost estimating activities at multiple times throughout the design process. Here, the value proposition parallels that of the designer's value proposition shown previously, except that the contractors have the potential to produce even more accurate and therefore significant cost information throughout the design. Doing so is closely associated with an increase in their scope of work over their traditional role, and can result in substantial value improvements to the overall project outcome.

PROPOSED PROCESSES

This section provides a series of scenarios that describe typical processes (use cases) of using an automated model-based estimating system**.**

Generate WBS From project model

The estimating system takes a semantic project information model of a bridge as input (e.g. output from a model-based CAD tool, IFC file, or similar). By evaluating the contents of the bridge model, the system must be able to derive a work breakdown structure (WBS) for the proposed project. This WBS is a 'quantity takeoff' type of WBS (called 'assemblies' in some estimating systems): it lists the units of work to be completed at a level of detail that corresponds to the quantity measurements derived from the design information. In addition to the input project model, the system will receive input from some standard or master WBS (a list of all possible work items), and a component that maps, or reasons about, the linkages from the project model to the WBS. Users may be required to enter information about projects that are not contained in the project model (any such information should be retained for use in subsequent estimates).

Generate quantity takeoff

Given the project model and the derived WBS, the system must apply geometric and semantic reasoning to calculate the quantities associated with each WBS item. Most input will come directly from the project model but, again, some additional user input may be required and should be retained for successive estimates.

Derive detailed WBS

From the 'quantity takeoff' or assemblies WBS and the calculated quantities, the system will apply mapping rules to develop the WBS at the level of individual estimate line items. This step is identical to the 'assemblies-to-estimate items' that is performed by traditional estimating systems.

Determine unit prices

The system determines the appropriate unit prices to apply against each estimate item. The process of selecting unit prices from a database containing prices for each type of estimate item is quite straightforward. However, the system should also be able to apply adjustments to these unit prices to reflect the specific context of a project that will lead to price variations from historical averages (e.g. remote and difficult locations, novel technologies, work force shortages). These adjustments may be either automated or entered manually. Some such adjustments may be reasonably simple to apply, but other adjustments will require increasingly complex levels of reasoning if they are to be automated.

Complete estimating calculations and present results

When the WBS, quantities and unit costs have been developed, the final estimate costs and mark-ups can be computed. The resulting estimate can then be presented in a suitable output format. This includes mapping the detailed estimate WBS to any standard WBSs required by tendering or reporting requirements. Optionally, the resulting cost information may be transferred into a combined project data model to be available for appropriate uses by others.

FUNCTIONAL SPECIFICATIONS

The following is a summary of functional requirements of the model-based automated estimator for concrete bridges.

Support direct and indirect cost

The estimate must be able to include both direct and indirect costs associated with a project (including all temporary works, all construction equipment and project overhead costs, etc.). Since there will typically be no direct element in the project model that corresponds to indirect costs (e.g. the costs associated with providing general cranage on-site), the system must be capable of reasoning from the direct product components to the required indirect costs. Where possible, indirect costs should appear as explicit line items in the detailed estimate, but some indirect costs may appear as mark-up values to be applied to the total direct project costs.

Support project lifecycle conceptualisation

The value propositions require that the estimating system be able to provide cost advice throughout the design process. Thus, it must be able to produce cost estimates based on preliminary, conceptual and incomplete design information. As a result, changes in the middle of project lifecycle stages can re-use what has been established up to that point.

There are at least three principal approaches for achieving this requirement:

- **Conceptual estimating through separate estimating modules:** One possibility for providing estimates throughout the design process is that the system has multiple modules for a variety of different stages of the design. For example, the system may have distinctly different modules for estimating at conceptual stage, preliminary design stage, detailed design stage, etc. Each module may have distinct work breakdown structures, mapping and quantity takeoff rules, unit prices, etc. This approach may offer the best potential for taking early design information, as it currently exists, and yielding reasonable cost estimates. However, it has several significant drawbacks, such as the very onerous task of developing and maintaining several different versions of the system, or the fact that estimates can still only be produced at certain 'milestone' points during the design.

- **Conceptual estimating through template project models:** An alternative approach for providing estimates throughout the entire design process is to use template project models. With this approach, template (typical) project models would be developed for each different type of project. There would be some degree of modification of the standard template models to adjust them for the current project (e.g. adjustments for inflation, size scaling, and numerous other parameters). The template model, then, would be a complete and detailed model from which a detailed cost estimate could be produced. The resulting estimate would provide a crude estimate of the actual project costs, since the template model will only loosely reflect the actual project. Then, as the design of the actual project progresses, the actual design information will begin to replace the template model information, until at the end of the design, the entire model reflects the actual project design with no remaining traces of the template model. In this way, a complete model (and therefore a complete estimate) is available throughout the design process, but the degree of accuracy of the model information and the cost estimates increases throughout the design process. This approach provides an elegant solution to the model-based estimating requirements, but it requires the use of template models in a way that does not exist in current practice, and further development is required to determine the practicality of the approach.
- **Conceptual estimating through parametric approaches:** Another option for achieving estimates throughout the entire design process is to rely on parametric approaches such that, by selecting a number or parameters that define a proposed bridge structure, allow the system to automatically generate appropriate design solutions (as design models, from which the estimates can be produced). This approach is not limited to an estimating technique; rather it introduces a full design paradigm. This is a potentially extremely powerful technique, and certain elements of road and bridge design appear to have been parameterised in current practice. Nevertheless, it represents a significant systems development effort to adopt this approach.

Support incremental estimating

In addition to supporting estimates throughout the design process, the system should be able to support a process whereby estimates are developed incrementally. For example, estimators or designers should be able to use the system to compare the relative costs of two design alternatives based on relatively minimal information about the two options. The system should be able to support multiple versions of an estimate developed throughout the project lifecycle, including roll-back capabilities, etc.

Accommodate non-model-based information

While the central characteristics of the estimating system are that it can automate estimating from a project model, it should restrict itself only to pricing the contents of the model. Even in a fully model-based design process, there will be many items that contribute to the overall project cost that simply do not appear in a project data model. In other cases, the project will follow only partial model-based processes. The estimating system should be able to accommodate non-model-based estimating in much the same way as traditional estimating systems. This should extend all the way to serving effectively as a traditional estimating system if no model-based information is available.

Interface with legacy systems

The estimating system must be able to interface with all relevant legacy systems, such as unit price database systems.

Support for estimators and designers

The system should support use by both estimating specialists and by designers who may have relatively little estimating expertise (possibly two different modes or even versions of the system).

Support for visualisation

Like model-based design processes, the automated estimating system will be equipped with visualisation capability. Both line items and their corresponding 3D view of bridge elements are automatically generated from the model.

COMPARISON BETWEEN THE CURRENT PRACTICE AND THE NEXT GENERATION ESTIMATING

Currently, design engineers analyse designs using computer-based simulators of theoretical models such as Spacegass, Aces, Coldes and many in-house designed spreadsheets and DOS-based programs. Input and output data from all these tools are likely to have minimal compatibility with each other. As design experience accumulates over time, design parameters are collected in project databases. This simplifies design processes. With the help of these design databases, they can zero-in on a mature estimation of the design prior to computer-based modelling and analysis.

Once the design has been verified to meet alignment, geometric, aesthetic and any hydraulic requirements (e.g. flood forces, speed environments, flood immunity), it is handed over for drafting finalisation. Designers can then draw on their database of previous drawings to efficiently produce drawings to suit new projects. This often saves significant time during the drafting process. Customisations of computer-aided design software packages are sometimes used to draw at least part of each drawing and, in the case of deck units, all of the drawing.

Cooperation and interaction between drafters and engineers occurs during the preliminary fixing (e.g. fixing span lengths, skew, coordinates, type of deck) and design stages and is more pronounced during a complex or one-off design. This may include some 3D drafting to provide models for Spacegass analysis. All drawings are produced in a 2D environment (plan/elevation/section) unless there is a case-specific need to do otherwise.

The above can be compared with the processes of model-based estimating as follows:

- Unlike the current uncoordinated practice of design and estimating, model-based estimating is derived from a project data model of a bridge (e.g. the equivalent to a building information model or IFC model). Such a model must either be produced as a result of a preceding model-based design process, or must be produced as the first step in the estimating system.
- Estimated items in automated estimating are generated from a bridge project data model, whereas the current practice requires full manual intervention to list them.
- The estimate items in automated estimating will include temporary works (e.g. falsework), costs associated with specific construction methods (e.g. cranage), etc. whereas the current practice requires full manual intervention to list them.
- The automated estimating system can produce a quantity take-off by evaluating the geometric and non-geometric parameters of the project data model to derive the quantities required for the estimate items, whereas the current practice requires full manual intervention to list them.
- The automated system will be able to apply appropriate unit prices to the estimate items, which combine with the quantities to produce the overall cost estimate. This is similar to what is done in the current practice through a semi-automatic system using price databases linking to WBS tables.
- The automated estimating system is likely to work with multiple sets of estimate items at varying levels of detail, e.g. a higher level of assemblies or standard estimate items, which map to a lower level of detailed estimate items.
- The automated system offers partial as well as whole estimates. It supports partial and complete planning/design. In contrast, the current manual estimation process focuses on the estimation of the complete bridge/road system.
- The automated system may use 'template estimates' to provide default values for information that is missing during early design phases. This is similar to what is done in the current practice through a manual process.
- The automated estimating system supports various stages of project lifecycle conceptualisation. It allows users to jump into various points of change while allowing them to re-use what has been established up to those points of change. This is by far the most efficient way of re-using established data – in contrast, the current manual way has to re-draw the design on a 2D diagram from scratch.
- The automated estimating system generates automatically 3D view (drawing) from the (modified) model, whereas the current practice must redraw the 2D drawing every time when changes are made.
- All of the steps described above will be largely automated, but are likely to require certain manual inputs and decisions (e.g. selection of certain construction methods).
- The automated system enables users to make changes at any point in any lifecycle stages without the need to repeat what has been correctly established. On the other hand, for every change made, the design drawings must be re-drawn.

CONCLUSIONS

This paper has represented a feasibility study of model-based automated estimating for the civil works/bridge industry. The research has defined and assessed relevant contextual issues, such as the state of model-based design and estimating in the building construction industry. It has examined current practices and systems used in the design and estimating of roads and bridges. It has then developed value propositions for moving to model-based automated estimating and has developed a series of use cases to outline the functional requirement of such an approach. Finally it compared the new model-based automated estimating processes with the current practice to highlight similarities, differences and points where efficiency is derived.

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Part 5
Construction Health and Safety

CHAPTER 17

Leaders in Safety

Helen Marshall

LEADERS IN SAFETY

Leaders and senior managers can change cultures. Culture is dynamic and subject to change. It is a set of shared values and attitudes within a group, learned in childhood and carried throughout life. Most of all, it's the way we do things, here and now. By paying careful and systematic attention to workplace cultures and by demonstrating a commitment to improving health and safety on construction sites, leaders and senior managers can change cultures. This is the guiding principle behind the Federal Safety Commissioner's (FSC) publication, *Leaders in Safety: A guide to developing senior management safety behaviours in the building and construction industry*.

Leaders in Safety was published in 2007. Developed from discussions and consultation with industry, it highlights five key steps to developing and demonstrating safety behaviours for senior managers. Each step builds on the last and increases the commitment to changing the attitudes and beliefs managers have about safety.

Step 1: Understand how behaviour works

Employees tend to mirror the attitudes and beliefs of their senior managers. If senior managers adopt attitudes and beliefs that are conducive to occupational health and safety (OHS) then the attitudes and beliefs of the industry will follow. For example, if a CEO visits a site and ignores a safety issue – what message does that send to employees?

Step 2: Define the behaviour you want senior managers to demonstrate

By defining the 'behaviours' and the 'practical application' of these behaviours you are providing a clear, easy to understand framework from which your senior managers can work. For example, challenge, inspire, and encourage people to think about things in different ways and engage in issues.

Step 3: Start influencing, developing and supporting senior management attitudes and beliefs

The attitudes that senior managers have towards safety will be the driving force behind their broader behaviours. By implementing behaviour change programs you can influence behaviour amongst individuals in their organisation. Creating positive attitudes and beliefs across your management team will result in a real change in their behaviours.

Step 4: Develop and ensure senior managers' ability and opportunity to undertake safety behaviours

If senior managers are equipped with the appropriate knowledge, skills and beliefs they will be more confident about promoting safety in the workplace. If management is encouraged and rewarded for promoting safety, then their safety behaviours will reflect a growing commitment to safety in the industry.

Step 5: Build an environment that supports and encourages senior management safety behaviours

By nature, people are social and group-based beings. A well-performing team is one where an individual's behaviour is tolerated and accepted by others in the group. Senior managers have the potential to encourage and affirm positive safety behaviour amongst individuals in their organisation. Creating positive attitudes and beliefs across your management team is essential to change their behaviours. In other words, walk the talk!

The five steps: walking the talk

These five steps guide senior management to adopt and develop their beliefs about safety in the workplace and will bring about real changes in the culture of the industry.

Leaders in Safety has been positively received by the building and construction industry. Most noteworthy, is the interest from other industries such as the oil and gas industry, health industry and public and private sectors. There have been many requests for copies of the guide from a range of companies so that they can be provided to all senior staff.

Cultural change must occur from the top down to make a sustainable difference in the industry. While it is never easy to change long-held attitudes and beliefs, it is possible to make a difference with the right level of experiences, rewards, motivation and commitment. Commitment is essential for strong corporate values, which create a clear direction. With this commitment comes systems development, sufficient resources, and, of course, effective communication to tie everything together. This is how to set the wheels in motion for the change that is needed.

SAFE DESIGN

Safe design describes the integration of hazard identification and risk assessment methods to eliminate or minimise the risks of injury throughout the life of the product or structure. Like senior management commitment, it is one of the six criteria for accreditation under the Australian Government OHS Accreditation Scheme (the Scheme). Before gaining accreditation, contractors need to demonstrate that they consider the principles of safe design at the planning and procurement stages of the project to reduce or eliminate hazards and control risks.

For example, in the event of design changes during the construction phase, the company demonstrates it has a process for managing the new OHS risk. Additionally, these design changes are communicated to site workers, at a daily toolbox meeting for example. While safe design can be a difficult concept to implement, it is the process that can make the biggest difference in eliminating or minimising the risks of injury throughout the life of the project.

Safe design makes good business sense, not just good OHS sense. The benefits of safe design include:

- improved useability of products, systems and facilities
- improved productivity with work completed safely and on time
- reduced costs (by reducing the costs of having to go back and re-design, and fewer injury costs)
- compliance with legislation
- innovation (safe design demands new thinking and creativity).

These benefits also reinforce the idea that safe design assists and protects workers rather than placing them in vulnerable situations. The opportunities to create safer workplaces are most cost-effective in the design phases of the construction cycle. It is much cheaper, easier and more effective to design safety into a project during the concept stages than half-way through construction. It can also be more difficult, expensive and time-consuming to retrofit safety measures that were not considered or were omitted earlier.

CONCLUSION

Improving OHS in the industry takes commitment. It is up to everyone in the industry to build a safety culture, where leadership is demonstrated through action and behaviour. A culture where all managers and staff know that safety is being taken seriously. It is up to you as an individual, and your colleagues, to be prepared to say to the person working next to you, ‘that’s not safe practice’ or ‘that could be done better’.

In summary, there needs to be a more marked shift in the culture of the industry, or in other words ‘the way we do things, here and now’. We can do this in many ways, such as the two ideas presented in this paper: a stronger senior management commitment to safety and safe design. If we get our systems into place, start to apply safe design into our work and continue to communicate and consult together, we can reach our goal of improving OHS performance in this industry.

If we do not, it will prove costly for all, both in terms of capital and lives lost. Nobody wants to be needlessly injured – or worse still killed – while just trying to get their job done and earn an income for their family.

CHAPTER 18

Developers Delivering Safer Projects by Measuring What They Value

Linda Sokolich

WHO ARE LEND LEASE COMMUNITIES?

Lend Lease Communities (LLc) is the town creation and urban regeneration business for the Lend Lease Group, which has market capitalisation of over $6b.

LLc has over 20 large-scale projects across Australia, and along with its commitment to deliver core values of innovation, integrity and excellence, LLc strive to continually innovate its approach and investment in safety. The Australian residential construction industry continues to have many preventable injuries and fatalities. Statistically, the residential construction sector in Australia is no safer than the commercial sector. Often, many organisations have assumed that, because of the lower working heights and scale of buildings, the residential sector was safer.

Why are we so interested in the safety of our projects?

About five years ago, Lend Lease was challenged by a large multinational company about its attitude to safety. The company claimed Lend Lease had an attitude that accepted that ‘accidents will happen’ because ‘construction can be a dangerous industry’. These comments went on to kick-start Lend Lease’s journey to develop an ‘Incident And Injury Free’ approach to safety where ‘no incident is acceptable’.

Following initial research into company policies and procedures, LLc identified a number of opportunities to influence the safety values during the delivery of projects in a variation of the approach used by the construction division business, Bovis Lend Lease.

However, with low incident rates in the LLc business, it was a challenge for functional and site managers to identify where to best expend their efforts to prevent incidents. This led to the concept of ‘lead indicators’ which compares projects and contractor safety performance and improves safety practices based on the reporting details.

Other projects and research

Research surrounding the concept of lead indicators was limited when LLc began investigating Incident and Injury Free initiatives in 2005. The last notable construction industry research was by NOHSC (2001). Interestingly, the five key measures that NOHSC’s research recommended were: planning and design, management processes, risk, culture, and reporting. These measures, along with LLc’s own processes, provided a solid foundation for developing a safety reporting framework.

While there were many established processes within LLc, selecting those that could impact safety by their improvement was a challenge. To overcome this, LLc consulted the CRC’s *Construction Site Safety Culture Report*. Compiled in partnership with Australia’s leading construction companies, the report identified, based on SLID research, the processes and attributes of a good safety culture relevant to the LLc business. These included: specific leadership communications, programs to develop good attitudes and behaviours to safety, and actions by staff and contractors that personalise the approach to safety.

ISSUES FOR DEVELOPERS?

Community and corporate expectations for construction are constantly evolving. No longer is it acceptable to consider that ‘accidents will happen’. All families expect their loved ones to return home safely every day. Developers have an increasing role of influence in their negotiations with clients, councils, contractors and community stakeholders. Legislation will increasingly place responsibility on designers and developers to ensure the communities and buildings they design are safe in terms of defined risks to contractors and end users.

OUR APPROACH

LLc began with the processes we valued most and were consistent with the CRC research. From each of the elements that we valued, devising their measurement was an important discussion. Each lead indicator needed to be able to demonstrate its direct impact on work practices, leadership, behaviours and safer end-user outcomes.

Key values to measure

Leadership

More recently, LLc had measured ‘safety leadership performance’ by implementing self-assessment criteria based on a set of statements about the behaviours, attitudes and outcomes by project directors. The most **Reactive** criterion was judged as ‘C’; **Proactive** was ‘B’; and **Creative** was ‘A’. This enabled leaders to compare their safety leadership performance and identify which key areas to focus on.

LLc's leadership assessment ratings were assessed in an open forum by regional EHS managers and project directors. Creating an environment where conflicting opinions could be voiced and debated was important. This gave an opportunity for LLc to investigate what processes its staff believed could effectively facilitate best practice safety leadership. Over three years, the leadership assessment criteria have been updated based on the leader's feedback.

LLc also recognised the importance of engaging all employees, from the design and engineering teams to the administration support staff, in the development and implementation of safety initiatives. In this context, there were two aspects to consider: the workplace safety culture and the skill in safety management for the team. These are needed for safe designs, safe management of construction and ongoing support of the safety efforts by the wider team. The criteria involved site-wide, inclusive initiatives, including health and wellbeing, sun-safety, skills in risk management/hazard identification, evaluation of contractor safety plans, and the development of designs that are safer to construct and live in.

Industry and contractor influence

LLc also identified a number of opportunities to influence the accepted standards of work practices and safety leadership. Therefore, LLc has worked with a number of its key contractors and others to encourage the implementation of a number of initiatives that encourage incident- and injury-free workplaces. These include:

- safer installation practices for roof trusses
- additional training on risk assessments for site contractors
- sun-safety initiatives
- behaviour-based training for manual handling
- builder production of safety newsletters
- LLc orientation sessions with key contractors introducing our safety culture/values regarding safety at work and home.

These arrangements often have commercial implications for projects and require discussion and negotiation. For example, one builder rescheduled the sequence of construction activities to enable scaffolding to be present at all times. Although it was initially believed that it would add cost to the project, the outcome was not only cost-neutral but saved construction time and enabled seamless changeovers between the various trades.

The peak body for residential home builders, the Housing Industry Association, and LLc entered into an memorandum of understanding to develop training initiatives to raise the standard for builders and their subcontractors. Projects would then establish local initiatives, if appropriate, to implement the spirit of the memorandum of understanding.

Our contract arrangements with building, civil engineering and landscape contractors form most of the activities where the risk of falls from heights are most likely to occur. These were the contractors we focused our efforts on.

The project contract arrangements require initiatives to develop relationships and practices that foster safer work practices. To date, evidence has been that initiatives often start modestly, but with time and support, contractors and staff become proactive rather than being driven by a Head Office.

Influencing contractor's processes and procedures in relation to workplace health and safety outside of Lend Lease projects remains a goal of LLc.

Design and planning review

The project design can have a direct impact on the safety of project contractors as well as end users. Therefore, it is important to continually review the risks and opportunities of the design concept throughout its development.

The Lend Lease ROAD (Risk and Opportunity At Design) process is a brainstorming session where the proposed design is reviewed from a builder's perspective and an end user's perspective with a set of risk events. The extended stakeholder groups of the project are involved. Therefore, consultants, contractors and administration staff in the project all provide unique contributions to this process.

Following the reviews, the challenge then lies in ensuring the documented issues are followed-up in a continuous, timely manner. The method for follow-up will vary depending on the maturity of the project, the skill of the staff, the leadership's experience and degree of risk with the sections of the project being reviewed.

Similar design review processes are used by many other organisations such as NSW WorkCover's and Sydney Water's CHAIR (Construction Hazard Assessment Implication review) process.

Reporting and auditing performance

LLc projects conduct monthly health and safety audits to review on-site project incidents, such as serious near misses or first aid requirements. These lag indicators provide a useful indication of areas which require immediate attention. The most common outcomes are 'toolbox talks', 'lessons learnt reviews', additional training, and reviews of work methods.

With minimal incident rates in its civil construction activities, quarterly business audits often provide useful information on where potential incidents lie. Each project's safety status is reviewed through a site inspection, contractor interviews, ROAD updates, and outcomes from fall mitigation plans. Contractor safety processes (risk assessments, SWMSs, inductions and subcontractor competency) are also reviewed.

Creating safe communities

LLc's internal research of its communities revealed that residents consider a safe community one that engages with residents by addressing personal safety, community safety, road safety, and recreational space design in respect to safety. The delivery of these safe community initiatives by projects offers opportunities to prevent road, personal and home invasion incidents.

Community development managers are appointed within each project to engage with residents and create awareness of safety initiatives, including emergency response procedures, personal security, road safety, water safety, etc.

Rewards, recognition and advocacy

Recognising projects and staff who deliver strong results across all areas of business is a core value within Lend Lease. Creating safety recognition programs for staff and contractors is part of creating an open safety culture, which ensures discussions about the impact of safety on-site and at home become 'part of what we do'. In developing lead indicators, LLc originally included industry advocacy but removed this measure because it is often done at the functional or regional level rather than the project level.

The current lead indicators

The earlier version was too complicated. The final product had simpler assessment standard that incorporated a three-tiered colour coding system. The format and a defined set of criteria made project comparison easy. During their self-assessment, the active discussions on the initiatives and their relative merits remain an important part of the use of the lead indicators.

OUTCOMES

Each quarter, project directors assess their safety performance using the lead indicators for senior management review.

Initially, the reports were difficult to interpret and assessment responses were variable in assessing what was best practice and what was a fair standard practice. There were also inconsistencies in a number of areas. Based on feedback from staff, a number of changes were made to the reporting process, including:

- keep to one simple colour scheme for judging (traffic lights: red, amber, green)
- reduce the number of assessable areas and avoid sub-categories
- provide a very clear set of criteria that all projects could use
- general manager one-on-one review with project directors
- ensure the criteria are aspirational and not too easy to achieve.

The principal benefits have been:

- targeting the quality of the ROAD reviews
- continuous focus on leadership qualities that impact project and community safety.

Developing solutions for these two areas in particular is more effective, in terms of resources, than addressing a large number of processes and developing multi-discipline plans.

CONCLUDING REMARKS

LLc's lead indicators have provided a platform for:

- prioritising and managing site safety processes
- discussions with managers on various safety processes on projects
- comparison of projects (the lead indicator reports provided objective evidence of observations and opinions).

Implementation by other developers

LLc's lead indicators continue to fit with the recommendations from earlier research. In particular the CRC's Construction Site Safety Culture 'top 3' safety culture items were consistent with LLc's key lead indicators:

- specific leadership communications (leadership, contractor influence, industry influence)
- programs to develop good attitudes and behaviours to safety (ROAD reviews, audits, safe communities initiatives)
- actions by staff and contractors that personalise the approach to safety (employee skilling and culture, rewards culture).

All developers can implement their own lead indicators using the same process. The process can be summarised as:

- identifying existing processes used against CRC's 'top 3' safety culture items
- consultation for projects about the quality of their implementation
- identifying no more than eight indicators and using simple colours to identify two to four 'grades'
- developing assessment criteria that are specific in the expected outcomes for the median standard
- expecting to go over a number of versions before everyone is contributing well
- using the lead indicators to discuss safety performance improvement areas and assessing if these conversations improve the safety standard on projects.

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CHAPTER 19

Towards Harmonisation: Accreditation schemes and construction OHS

Janet Pillay

INTRODUCTION

Following the recommendations of the Cole Royal Commission into the building and construction sector, the Commonwealth Government has embarked on a series of initiatives that focus on improving safety practices in this sector. These include the introduction of the Office of the Federal Safety Commissioner, the Building and Construction Accreditation Scheme, and the *Building and Construction Improvement Act* (Department of Employment and Workplace Relations 2003), and are in addition to those already in place in Queensland state government agencies such as the Pre-Qualification System (PQC) for Building Industry Contractors, and workplace health and safety legislation. The introduction of these and other initiatives has resulted in contractors being required to maintain occupational health and safety (OHS) standards that vary in scope and across jurisdictions.

In efforts to ensure that OHS standards in construction remain comprehensive yet feasible, this paper provides an overview of the activities currently being undertaken by the Construction Strategy Group, Workplace Health and Safety Queensland (WHSQ) to harmonise the OHS standards applied across construction accreditation schemes, and towards improving OHS performance in the Queensland building and construction industry. This paper outlines the scope of the safety-focused construction accreditation schemes that are currently available to Queensland-based contractors. The issues associated with contractors being accredited under multiple schemes are considered, and the WHSQ response is outlined. The core considerations in implementing these initiatives are then discussed in an attempt to strengthen the capacity of government to influence OHS outcomes, whilst also developing the capacity of business operators, and workers to manage OHS effectively.

OVERVIEW OF CURRENT CONSTRUCTION ACCREDITATION SCHEMES

At present there are two construction accreditation schemes that impact upon the business of Queensland-based construction companies: the Pre-Qualification (PQC) System for Building Industry Contractors, and the Building and Construction OHS Accreditation Scheme. The PQC adopts a systems approach to objectively assessing a contractor's capabilities, financial capacity and commitment to continuous improvement in all work undertaken (Department of Public Works (DPW) 2003). It operates on the premise that contractors wishing to tender for Queensland Government projects exceeding \$250 000 in value must first be prequalified and registered with the Queensland Department of Public Works (DPW 2003). In contrast, the Building and Construction OHS Accreditation Scheme is administered by the Office of the Federal Safety Commissioner (OFSC), and applies to construction contractors throughout the country. Under this federal accreditation scheme, contractors may only contract as head contractors for construction projects in which the Commonwealth Government is the client (Office of the Federal Safety Commissioner (OFSC) 2006a). This federal accreditation scheme applies both to directly and indirectly funded construction projects within a predetermined value (OFSC 2006a).

Under the OFSC-administered scheme, contractors must be accredited in order to be eligible to tender for directly funded government construction projects that are valued at \$3m and above (OFSC 2006a). Contractors must also be accredited in order to tender for projects that are indirectly funded by the Commonwealth Government (OFSC 2006b).

In specific terms, this applies to projects that receive federal government funding that is equivalent to a minimum of \$5m, and represents at least 50 per cent of the total value of the construction project (OFSC 2006b). Alternatively, the scheme applies to contractors wishing to tender for indirectly funded projects that are equivalent to or exceed \$10m in value, irrespective of the proportion of the funding received from the Commonwealth Government (OFSC 2006b). In contrast, the PQC applies to all contractors wishing to tender for government-funded projects valued in excess of \$250 000 (DPW 2003).

In order for contractors to be accredited under the OFSC-administered scheme, and PQC, they must satisfy a number of prerequisite criteria. In the pre-accreditation stage of the PQC, contractors wishing to prequalify at the higher levels (levels 3 and 4) are required to provide evidence that their OHS management system (OHSMS) is aligned with *AS/NZS 4801: 2001 Occupational Health and Safety Management Systems – Specifications and Guidance for Use* (DPW 2003). The OHS history of contractors who apply for PQC registration is also reviewed at this stage (DPW 2003). In contrast, the OFSC-administered scheme requires contractors to provide evidence that their OHSMS is certified with either AS/NZS 4801:2001, or OHSAS 18001:1999 *Occupational Health and Safety Management Systems – Specifications* (OFSC 2006a). This certification is required to be undertaken by a third party accredited by the Joint Accreditation System of Australia and New Zealand (JAS-ANZ). In addition to this certification, contractors seeking accreditation under the OFSC-administered scheme must also be able to demonstrate their capacity to improve OHS by satisfying each of six focus points that the OFSC regards as essential to improving OHS in the industry (OFSC 2006a). These focus points include demonstrated senior management commitment to OHS, integration of safe design principles into the risk management process, whole-of-project OHS consultation and communication, demonstrated effective subcontractor OHS management arrangements across building and construction projects, whole-of-project performance measurement, and OHS training and competency to deal with safety risks (OFSC 2006a). Contractors are also required to demonstrate an ability to manage construction hazards and high-risk activities, in addition to providing information relating to their

OHS performance history (OFSC 2006c). This information is reviewed in a desktop assessment of a contractor's construction safety plan, and the implementation of these practices is verified through a site inspection (OFSC 2006c).

Once contractors are prequalified and registered under the OFSC-administered scheme or PQC, their OHS performance is routinely monitored. Within the PQC, following the award of a contract, contractors are required to submit a copy of their construction safety plan for review by external auditors, referred to as WHS Auditors (Construction) (DPW 2003). These auditors assess the contents of the construction safety plan against predetermined OHS criteria. Construction work can only commence on-site when the WHS Auditor (Construction) confirms that the provisions in the construction safety plan are aligned with the OHS criteria set by DPW in collaboration with WHSQ. A similar approach is undertaken for the OFSC-administered scheme, in the desktop assessment and site inspection previously described (OFSC 2006c).

The final tier of auditing under both the PQC and OFSC-administered scheme relates to the site inspection. Within the PQC, projects that exceed 16 weeks in duration require one site inspection to be undertaken for every 13 weeks of construction (DPW 2003). These inspections focus on verifying the implementation of the construction safety plan at the site level in addition to ensuring that other site-based hazards/risks are effectively controlled in order to minimise the potential for OHS-related injuries (DPW 2003). In a similar vein, the OFSC-administered scheme mandates that project safety audits of accredited contractors are undertaken on a quarterly basis (OFSC 2006c). These project safety audits are undertaken by auditors external to the OFSC, referred to as Federal Safety Officers (FSOs), and apply the OHS criteria set by the OFSC (OFSC 2006d).

The Queensland Department of Main Roads (QDMR) is currently developing and implementing a program that is similar in scope to the PQC, titled the External 13 Week Safety Audit Program (ESAP). ESAP operates on the premise that in order to be eligible to tender for civil construction contracts valued over $3m and 16 weeks in duration, contractors must be prequalified and registered. The intention of ESAP is to conduct independent audits and assessments of the safety practices of a contractor at the procurement and planning stages of a project, and on-site during construction. Contractors registered under ESAP must have an OHSMS that is aligned with AS/NZS 4801:2001. Once a contract has been awarded, an assessment is undertaken of a contractor's construction safety plan and traffic management plan. A site inspection is also undertaken.

ISSUES ASSOCIATED WITH THE CONCURRENT OPERATION OF CONSTRUCTION ACCREDITATION SCHEMES

With the PQC and the OFSC-administered scheme operating simultaneously, there is potential for contractors to be accredited under multiple schemes, and therefore subjected to multiple inspections with varying OHS standards, and audit criteria. This issue is heightened with the forthcoming introduction of ESAP. Within each of the accreditation schemes, contractors are also expected to comply with different reporting requirements and associated paperwork. Moreover, contractors are also required to discharge their obligations under the workplace health and safety legislation, and may also be visited by a safety inspector at any time. With these accreditation schemes concurrently operating, it is important to consider whether there are sufficient numbers of auditors available to undertake the audits, assessments, and inspections, and how auditor impartiality can be maintained. The next section outlines how these types of issues will be addressed in the PQC and ESAP.

Responding to the complexities of multiple accreditation

In an acknowledgment of the issues associated with contractors being accredited under multiple schemes, WHSQ is undertaking a number of activities. These are briefly outlined below.

Updated checklists

In order to ensure that a consistent OHS standard is applied across all three accreditation schemes, WHSQ has updated the checklists used in the OHSMS audit, construction safety plan assessment, and site inspection. For civil construction contracts, a separate checklist for the traffic management plan assessment has been developed in collaboration with QDMR. These checklists are aligned with the hazard-based OHS criteria applied by the Office of the Federal Safety Commissioner, VicRoads, and the Roads and Traffic Authority of New South Wales. In order to assess the feasibility of these tools on-site, these checklists have also been trialled by WHSQ construction inspectors on civil and construction projects.

Providing contractors with a summary of the OHS criteria applied in audits, assessments and inspections in advance

The OHS criteria contained within the updated checklists, although consistent with other jurisdictions, is at times above the standard required by Queensland OHS legislation. Given that the PQC promotes best practice in OHS, and that a number of contractors are accredited under multiple schemes, it is not unreasonable to expect contractors to abide by a revised OHS standard. In order to support contractors whilst also pursuing improvements in OHS in the industry, contractors should be provided with a summary of the OHS criteria applied in audits, assessments and inspections in advance. These criteria will be made available to contractors once accreditation has been granted.

Creation of a function titled 'WHSQ Safety Program Administrator' for all PQC and ESAP-related communication between the WHS Auditor (Construction), WHSQ and other agencies/individuals

The WHSQ Safety Program Administrator will be the central point of contact for all PQC and ESAP-related queries from external and internal stakeholders regarding the OHS component of the PQC and ESAP. The WHSQ Safety Program Administrator accredits, monitors and evaluates auditor activity, researches contractor OHS history prior to PQC or ESAP accreditation being granted, and assists in administering the OHS component of the PQC and ESAP in collaboration with DPW and/or QDMR.

Intra-agency and inter-agency collaboration in scheduling site inspections

In the scheduling of the site inspections, the WHSQ Safety Program Administrator will liaise with the WHSQ inspectorate, and officers from the OFSC to ensure that inspections are undertaken at times that are independent of one another.

Site inspection to reflect recent enforcement action by WHSQ

When contractors are issued with improvement, prohibition or infringement notices by WHSQ inspectors, they are expected to improve their OHS practices across the entire business, not just one construction site.
At present, accredited contractors simultaneously undertake projects for the public and private sector. In principle, if a WHSQ inspector issues an accredited contractor with a regulatory notice on a private sector project, the OHS improvements should transfer to other projects, irrespective of the sector in which work is undertaken. At the moment, it is unclear whether this transfer of learnings occurs.

Given that the PQC and ESAP promote best practice in construction, it would be opportune to include a direct link between inspectorate activity and contractor OHS conformance in the site inspection. By including the OHS history of a contractor as part of the site inspection process, WHSQ, DPW and QDMR would be working towards a cultural and behavioural change in the Queensland building and construction industry. This approach is consistent with the underlying systems approach of the PQC and ESAP.

Contractors to produce copies of recent self-audit results

Within AS/NZS 4801:2001 contractors are required to undertake internal audits of their OHSMS. Contractors will be asked to provide a copy of their most recent self-audit results for review by the WHS Auditor (Construction) during the site inspection.

Evaluation of WHS Auditors (Construction)

As part of the process of ensuring a robust audit process for PQC and ESAP, the WHSQ Safety Program Administrator regularly evaluates the conduct of WHS Auditors (Construction). This process involves a senior officer from WHSQ accompanying a WHS Auditor (Construction) during a site inspection and evaluating their conduct against set criteria. These criteria have been developed by WHSQ in collaboration with DPW and QDMR and focus on:

- adherence to audit processes
- knowledge and application of relevant OHS information
- construction-specific knowledge and skills.

The conduct and impartiality of each WHS Auditor (Construction) will be evaluated by this mechanism regularly.

IMPLEMENTING THE INITIATIVES: CORE CONSIDERATIONS

The initiatives described in the previous section are consistent with the objectives of state and federal regulators towards improving OHS performance in the building and construction industry. They continue the UK-based principles of an integrated approach to accident and illness prevention through regular enforcement, advice, and teamwork advocated by Robens (1972), Egan (1998), and Latham (1994). By progressing the harmonisation of construction OHS across state and federal boundaries, the initiatives previously described also work towards advancing the principles of national uniformity advocated by Cole (2003). They are also consistent with the view of the Australian Chamber of Commerce and Industry (2003, 6) that governments and policy-makers must 'make change practical, meaningful, clear and consistent.'

In an attempt to ensure that the initiatives previously described are practical and meaningful, WHSQ has engaged in stakeholder consultation prior to the implementation of these arrangements. Internally, WHSQ has consulted with Principal Inspectors (Construction) from throughout the state, and sought their feedback on the updated audit tools. In addition, the updated checklists were trialled on-site on both building and civil projects. As a result of this internal consultation, the checklists were modified to ensure feasibility of use on-site. In a similar vein, an existing WHS Auditor (Construction) was asked to review the updated checklists. By drawing on the audit experience of this particular auditor within the PQC system, the checklists were amended to reflect the auditor's view as to how the checklists could continue to be practical and meaningful. Finally, before implementing the initiatives, key players within the Queensland building and construction industry were asked to provide feedback relating to the proposed activities. This external consultation was undertaken with the Australian Workers' Union, Builders' Labourers' Federation, Civil Contractors Federation, Queensland Master Builders Association, and the Construction, Forestry, Mining, and Energy Union. WHSQ, QDMR, and DPW are in the process of communicating the scope of the initiatives to contractors. Likewise, WHS Auditors (Construction) have recently been briefed about the initiatives at an auditor forum, via a newsletter, and auditor guidelines document. Through this level of collaboration, and consultation with other government agencies, and industry, it is envisaged that safety will receive more attention as a priority in the Queensland building and construction industry.

CONCLUSION

The initiatives described in this paper have been designed to enhance the capacity of contractors and workers to effectively manage construction OHS. By engaging external auditors to undertake audits, assessments, and inspections, the PQC and ESAP ensure that the recording of OHS performance is a task that is conducted independent of the government agencies with whom the contractor contracts. By providing contractors with prior notification of the acceptable OHS standard, government and industry are working together to improve OHS in construction. These initiatives are not intended as the 'solution' to improving health and safety, but rather as the next step in a series of endeavours aimed to improve OHS performance in this sector. It is a means of initiating cultural and behavioural change in the industry, and promoting a focus on construction safety in the long term.

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CHAPTER 20

Harmonisation of OHS Regulation in Australia: An evaluation of three initiatives

Kerry Brown
Craig Furneaux
Don Allan

INTRODUCTION

Recently released research reports into the construction industry in Australia argued that improved consistency in the regulatory environment could lead to improvements in innovation (Manley 2004; Price Waterhouse Coopers 2002), improved productivity (Productivity Commission 2004) and that, research into this area should be given high priority (Hampson and Brandon 2004). Productivity gains from an improved regulatory system have been estimated in the hundreds of millions of dollars (ABCB 2003).

The Cole Royal Commission (2003) highlighted occupational health and safety (OHS) in the construction industry as an area needing concerted effort to improve the conditions of workers, and the need to develop a national regulatory framework. Despite numerous industry submissions advocating a national OHS system, Cole (2003) concluded there was little prospect of the development of a national framework, apart from through the development and adoption of national OHS standards.

We argue that there are several harmonisation mechanisms that have been overlooked as a possible framework for understanding and operationalising a systematic approach to OHS. Harmonisation is concerned with coordination of regulation between jurisdictions that does not necessarily require 'sameness' across a national arena (Majone 1999). Consistency, especially on a national scale, has been the favoured approach (Cole 2003); however, there have been variable degrees of success in achieving a nationally consistent model and indeed significant barriers to pursuing this option.

Three initiatives to improve the harmonisation of OHS regulations across Australia are reviewed in this paper. The first is the *Occupational Health and Safety Act 1991* (Commonwealth) which enabled certain organisations to opt out of state-based regulatory regimes. The second is the standards, codes of practice and guidance documents developed by the National Occupational Health and Safety Council (NOHSC). The third is the attachment of conditions to special purpose payments from the Australian Government to the states, in the form of OHS accreditation with the Office of the Federal Safety Commissioner.

This paper examines and evaluates each of these attempts to promote consistency across Australia. It concludes that while there is a high level of information sharing between jurisdictions, particularly from the NOSCH standards, a fragmented OHS policy framework remains in place across Australia. The utility of emergent industry initiatives such as the Best Practice Guideline to enhance consistency are briefly discussed. Firstly, however, a broader discussion about achieving consistency in federal systems of government is undertaken to frame and evaluate the outlined initiatives.

FEDERAL SYSTEMS OF GOVERNMENT

Under a federal system, powers are divided between a central government and regional governments. In Australia, power was divided between the Commonwealth Government[18] and the governments of the six colonies, which were renamed 'states' by the Constitution. Specific areas of legislative power ('heads of power') were given to the Commonwealth Government and the states (Australian Government 2005).

Despite this there has been considerable tension between the various spheres of government, as the wording of the Constitution has often created situations where the Commonwealth and the states both claim the authority to make laws over the same matter (Australian Government 2005). As OHS is historically viewed as the responsibility of the states (Cole 2003), achieving consistency across all of the states and territories of Australia can prove challenging. Indeed, there are limited options for improving consistency in OHS regulations, and these are outlined in the next section.

ACHIEVING REGULATORY CONSISTENCY IN FEDERAL SYSTEMS OF GOVERNMENT

Mechanisms to improve regulatory consistency in a federated system of government have been identified from the literature, and they are summarised in Table 20.1. The mechanisms, which we have termed options, are listed from most coordinated to least coordinated.

[18] The terms 'Commonwealth Government' and 'Australian Government' mean the same thing. Both terms are used in this chapter to match the reference material, or to reflect the contemporary use in a historical context.

Table 20.1 Mechanisms for Harmonising Regulations in Federal Systems of Government

least coordinated	*Option 1*: Unilateral exercise of power by the Commonwealth	Creating uniformity in regulation in Australia by the Commonwealth legislating in such a way as to override all similar state and territory regulations. For such an approach to work, legitimate authority in the constitution, termed a 'head of power', needs to be determined. As the Commonwealth lacks head of power for OHS this option is difficult to enact, although the Commonwealth can attach conditions to funding to the states.
	Option 2: Reference of power to the Commonwealth	The states can elect to refer a state power to the Commonwealth under the Constitution. If a 'matter' is referred to the Commonwealth by a state, the Commonwealth is then able to legislate. The Commonwealth government attempted this recently when it requested that the states refer workplace relations powers to the Commonwealth. This attempt failed when the 'states advised that they will not refer their [industrial relations] powers' (COAG Communiqué 2005) to the Commonwealth. Cole (2003) suggested this was also unlikely to occur for OHS regulation.
	Option 3: Incorporation by reference	The incorporation by reference application is where the various parliaments adopt the legislation of a single jurisdiction as amended from time to time in accordance with an intergovernmental agreement (Saunders 1994, p. 8). The advantage of this form of coordination is that there is need to only change a single piece of legislation, rather than several pieces of legislation although it requires extensive consultation. The *Building Code of Australia* could be considered an example of this. This option was endorsed by Cole (2003) as the most viable for the construction industry.
moderately coordinated	*Option 4*: Complementary or mirror legislation	This option requires that the Commonwealth and states work together to achieve legislative coverage of a particular policy area, particularly where there are dual, overlapping and or uncertain division of constitutional powers. In these instances, each jurisdiction enacts laws to the extent of its constitutional capacity and the matter is addressed by the participation of all of the legislatures of the federation. 'The Commonwealth and all participating states would pass separate, but totally consistent (although not necessarily identical) pieces of legislation' (Allen Consulting Group 2002, 40). An intergovernmental agreement is normally required to set out the terms and conditions of the arrangement.
	Option 5: Mutual recognition	Under mutual recognition, the rules and regulations of other jurisdictions are recognised. Mutual recognition enables goods or services to be traded across jurisdictions, and means that if the goods or services comply with the legislation in their own jurisdiction, and then are deemed to comply with the requirements of the second jurisdiction, pathways for achieving compliance are clearly established. Mutual recognition is a one of the vehicles governments can utilise to reduce the regulatory impediments to goods and services mobility across jurisdictions (Productivity Commission 2003).
	Option 6: Agreed legislation or policies	This mechanism is where governments in question agree to implement similar legislation or policies, which are then implemented by local legislation.
most coordinated	*Option 7*: Adoptive recognition	A jurisdiction recognises that the decisions of another jurisdiction meet the requirements of its own legislation regardless of whether this recognition is mutual.
	Option 8: Non-binding national standards model	A national authority makes decisions which are adopted to various extents by the respective state or territory ministers.
	Option 9: Exchange of information	Such an exchange can take many forms, including where meetings between ministers and/or public servants regularly occur to exchange information; or where best practice guidelines or demonstration projects are published with the intention that they will be adopted by other jurisdictions.
	Option 10: Independent unilateralism	Under this option each jurisdiction goes its own way – so there is no coordination at all between governments. Unlike option 1, this option means that the states and the Commonwealth all act in an uncoordinated way and pursue disparate policy objectives.

Adapted from Allen Consulting Group (2002), Farina (2004), and Opeskin (2001)

The set of mechanisms in Table 20.1 is advanced in this paper as a means to evaluate attempts to improve the consistency of OHS regulation in Australia. As will be demonstrated below, such a framework for analysis becomes very useful in examining specific attempts to harmonise regulation.

ATTEMPTS TO HARMONISE OHS REGULATION IN AUSTRALIA

Three attempts to harmonise OHS regulation are examined below. The first is the Comcare scheme which focused on providing an arena for a national system of workplace health and safety insurance schemes. The second is the national approach to establishing standards, codes of practice and guidance documents through the National Occupational Health and Safety Council (NOHSC), now called the Australian Safety and Compensation Council. The third relates to conditions attached to Australian Government payments to the states, which require firms to be accredited with the Office of the Federal Safety Commissioner. In each example the framework detailed in Table 20.1 will be used to evaluate the effectiveness of the initiative.

Comcare insurance scheme: Opting out of state-based systems

Due to the lack of harmony among the states, territories and the Commonwealth regarding workers' compensation schemes and OHS regulatory regimes, the Productivity Commission conducted an inquiry to assess possible models for *National Workers' Compensation and Occupational Health and Safety Frameworks* (Australian Government 2004a).

The report concluded that there are significant benefits to be obtained from a national approach (Australian Government 2004a, 23). They recommended that the Commonwealth 'amend the *Occupational Health and Safety (Commonwealth Employment) Act 1991*, to enable those employers who are licensed to self-insure under the Australian Government's workers' compensation scheme to elect to be covered by the Australian Government's occupational health and safety legislation' (Australian Government 2004a, 103).

Comcare initiation and challenge

While Coalition senators held that this initiative would promote competition for state OHS regimes and workers' compensation schemes and could lead to rigorous application of OHS principles and practices (Senate Committee 2006, 6-7), opposition senators argued that the standards enforced by Comcare are not as stringent as those which operate under state jurisdictions, thereby potentially lowering the standard of OHS for some corporations (Senate Committee 2006, 10). The Commonwealth Government accepted and implemented the scheme which was called Comare (Australian Government 2004b, 9).

A High Court challenge to the Comcare scheme was instigated by four states. The High Court found the licensing provisions of the Commonwealth were valid, and Victorian-based Optus, which was the first company accredited, is no longer under obligation to comply with the requirements of compulsory WorkCover insurance under the Victorian scheme (High Court of Australia 2007).

While the Commonwealth and eligible employers may be satisfied with the amendments to the SRC Act and the High Court ruling, it appears as though the states and territories may not be so content, particularly as four states mounted a court case to challenge it. In regard to firms transitioning to the federal level, the Productivity Commission Report noted that, 'Some of the smaller (OHS) schemes may ultimately become unviable on a stand-alone basis if a significant number of employers move to a national scheme' (Australian Government 2004a, 134).

The current status of Comcare licences

The High Court ruling may encourage other multi-jurisdictional, private employers to consider opting-out of state and territory workers' compensation schemes. There appear to be both administrative and financial advantages for eligible employers to move to the Comcare scheme. For example, Optus told the High Court that it expected to save $186 000 per month, or over $2m per year, on premiums by moving from Victoria's WorkCover scheme and into the Comcare scheme (High Court of Australia 2007). The key advantage of the Comcare scheme is the reduction in the amount of time and resources used in attempting to ensure compliance with separate requirements of each state and territory in which they operate.

While limited uptake of Comcare licenses has occurred to date, opting-out of state and territory workers' compensation schemes may increase, particularly now the High Court case has been resolved.

Summary: Effectiveness of Comcare self-insurance scheme

Take-up of the scheme is quite low in the construction industry, with only one major company (John Holland) making application under the scheme. Large construction firms may have waited until the High Court case was resolved until applying to participate in the scheme. Consequently, there has been very little uptake afforded by this legislation to date in the construction industry. Nevertheless, there is potential here for this to occur, particularly now that the court case has been completed.

Using the harmonisation methods outlined in Table 20.1, the Comcare initiative could be seen as independent unilateralism (See Figure 20.1) as this initiative was implemented to provide an alternative to state regulation. While it was set up to overcome workers' compensation differences, the states right to legislate in this area has not been amended.

Figure 20.1 Comcare as a Mechanism for Harmonisation

Unilateral Exercise of Power by the Commonwealth
Reference of Power to the Commonwealth
Incorporation by Reference
Complementary or Mirror Legislation
Mutual Recognition
Agreed Legislation/ Policies
Adoptive Recognition
Non-Binding National Standards Model
Exchange of Information
Independent Unilateralism

HARMONISATION THROUGH NATIONAL STANDARDS: NATIONAL OCCUPATIONAL HEALTH AND SAFETY COUNCIL

In 1985 the *National Occupational Health and Safety Commission Act 1985* (NOHSC Act) established the National Occupational Health and Safety Council (NOHSC). When NOHSC was established, two of the top priorities for the Commission were the development of a uniform legislative approach to occupational health and safety and the development of national standards (Parliament of Australia 2005, 12).

In 1991 NOHSC established standards for plant, certification of users and operators of industrial equipment, workplace hazardous substances, occupational noise, manual handling and major hazardous facilities (National Research Centre for OHS Regulation 2005, 12). Unfortunately, the standards were inconsistently adopted into regulation by the states and territories, and some were adopted in the form of codes of practice. By mid-1996, the new Howard government refocused the commission to examine the OH andS needs of small business, with a diminished emphasis on the development of national standards (Parliament of Australia 2005, 14-15). This was, in turn, reversed by the Cole Royal Commission which argued that national standards be developed for the building and construction industry, according to a timetable for completion (Cole 2003, 28).

In 2005, the Australian Safety and Compensation Council (ASCC) succeeded NOHSC. The Minister for Employment and Workplace Relations, Kevin Andrews, stated, ‘The ASCC will establish a national approach to workplace safety and workers’ compensation which currently does not exist in Australia … ASCC will be a forum for better national discussion and coordination while respecting states’ jurisdictions over workplace safety and workers compensation’ (Andrews 2005a). While NOHSC was a statutory authority, the ASCC was only an advisory committee under the executive power of the Commonwealth. This arrangement could provide the Commonwealth Government with more flexibility and less bureaucracy in regard to the ASCC, but on the other hand, means that the ASCC powers and functions are not subject to the scrutiny of the parliamentary process.

Current status of NOHSC standards as a harmonisation mechanism

The uptake by states and territories of national standards has typically been reported as quite high (ASCC 2006a, 61-63). The authors reviewed the uptake into legislation of NOHSC standards by the states and territories, and takes a different position to this – primarily due to way ‘adoption’ is defined in this paper.

As noted in Table 20.1 various levels of harmonisation are possible. Ideally, a national standard would be incorporated by reference into legislation (Option 3 in Table 20.1); that is, the standard is adopted by state legislation and thereby becomes law. This is arguably what was intended by the development of the standards in the first instance, as ASCC (2006c) notes:

> *The National OHS standards and codes of practice are not legally enforceable unless state and territory governments adopt them as regulation or codes of practice under their principal OHS Acts.*

This is reinforced by various state authorities. For example, Court (2007) recently reminded the ASCC that construction firms ‘have obligations under state OHS law, but no obligations under the national standard’. This is because the standard only becomes law if incorporated by reference into the state or territory laws.

However, as Table 20.1 demonstrates, it is possible for states to adopt a national standard at a lower level than by direct incorporation by reference in legislation. Some of these include:

- adoption of the national standard into policy, not regulation, for example as a code of practice – this could mean that the standard is not law, but provides advice on how to comply with the law
- adoption of key elements of the standard into the text of legislation, without reference to the specific standard itself – this would mean that the standard provides information which is incorporated into law
- replacement of key elements of the national standard with state codes or standards, where the standard is not incorporated into legislation, nor referred to in state legislation.

No doubt the policy intent of NOHSC was to establish national standards which would be adopted (incorporated by reference) in legislation. This paper argues that in order for a standard to become law it needs to be specifically referenced in legislation. Clearly there are examples of this occurring with NOHSC standards. However, such an uptake is somewhat patchy, with evidence that adoption has sometimes occurred at a lower level than direct incorporation by reference into legislation itself. (For a full list of the current status of the adoption of NOHSC standards please see Workplace Relations Ministers’ Council (2006)). Thus, using the definitions set out in Table 20.1, we argue that the NOHSCH standards are effectively non-binding national standards that have a mixed level of adoption into regulation (Figure 20.2).

Figure 20.2 Level of Harmonisation for NOHSC Standards

Unilateral Exercise of Power by the Commonwealth
Reference of Power to the Commonwealth
Incorporation by Reference
Complementary or Mirror Legislation
Mutual Recognition
Agreed Legislation/ Policies
Adoptive Recognition
Non-Binding National Standards Model
Exchange of Information
Independent Unilateralism

Current ASCC activity

In 2006, the Council of Australian Governments (COAG) agreed to a new reform agenda, one of which was OHS regulation. The report emphasised the need for the ASCC to reduce the time taken in developing national OHS standards, to consult with states and territories to ensure agreement on nationally consistent arrangements, and to create specific timeframes for implementation with each jurisdiction (COAG 2006, 40).

In April 2006, the Australian Government Productivity Commission report, *Rethinking Regulation* was released. The report highlighted the significance of OH andS regulation because it affects every workplace in Australia and it identified the lack of a coherent national approach to OHS (Australian Government 2006, 36-37).

In response to the two reports, the ASCC developed recommended strategies for implementing reforms to improve the development and uptake of national OHS standards, and to identify priority areas in state and territory OH andS Acts that should be harmonised (ASCC 2006b, 1). COAG endorsed a timetable and agreed that harmonisation of principal OHS Acts was essential to the uptake of national standards (COAG 2007, 4). In other words all states and the Commonwealth, through COAG, are outlining a framework for the establishment and adoption of the national standards which would develop 'core elements' of a national OHS framework (ASCC 2007b, 3). It is hoped that the latest initiatives of ASCC will improve the regulatory harmonisation of OHS regulation in Australia; however it remains to be seen what the outcome will actually be.

BUILDING AND CONSTRUCTION OCCUPATIONAL HEALTH AND SAFETY SCHEME: USING FUNDING POWERS TO ACHIEVE HARMONISATION

The *Building and Construction Industry Improvement Act 2005* provided for establishing the Australian Government Building and Construction Occupational Health and Safety Accreditation Scheme (the Scheme) that applies to construction work funded by the Australian Government, and operates under the Office of Federal Safety Commission (OFSC). The Scheme was developed to allow the government to use its purchasing power to influence change, and to champion a cooperative approach to improve OHS performance in the industry. By acting as a model client, the government aims to promote safe work, performed on time and on budget (DEWR 2007a).

In order to obtain accreditation under the Scheme, head contractors must meet agreed criteria. For example, they must have appropriate OHS policies, procedures and practices in place, and must agree to audits conducted by the federal safety officers. Additionally, they must comply with reporting requirements and accreditation-related conditions imposed by the Federal Safety Commission.

Initially, Stage 1 of the Scheme applied only to those contracts valued at \$6m or more that were directly funded by the Australian Government. Stage Two of the Scheme lowered the threshold to include head contractors for constructions projects valued at \$3m or more and directly funded by the Australian Government. For indirectly funded work, the Scheme will apply where the value of the Australian Government contribution is at least \$5m and represents at least 50 per cent of the total value of the project; or the Australian Government contribution is \$10m or more, irrespective of the proportion of Australian Government funding (DEWR 2007b). Stage 2 is particularly important to the discussions of this paper, as the requirements apply to projects conducted by state governments, but funded by the Australian Government. A discussion of federal funding arrangements is necessary to understand the changes that have occurred under Stage 2 of the Scheme.

Federal funding arrangements

State governments have three main sources of revenue – state-based taxes, other forms of state-based revenue (e.g. royalties from mining), and Australian Government funding. Over time, the amount of funding from the Australian government has steadily increased, (Costello 2007, p. 6), particularly after the introduction of the GST, and the Intergovernmental Agreement (IGA 1998). Funding provided by the Australian Government to the states and territories comes in two main forms – special purpose payments (SPP) and general purpose payments (GPP).

SPP are grants provided by the Australian Government to the states, for a particular purpose often with conditions attached (Costello 2007, 5). Major areas of SPP funding appear to be health (including disability), education and roads (Parliament of

Tasmania 2006). State governments have constitutional head of power for public works occurring within their jurisdiction. However, when the Australian Government provides financial grants to the states, it has the right to attach conditions to such grants. Specifically, the Australian Government: 'may grant financial assistance to any State on such terms and conditions as the Parliament thinks fit' (Australian Constitution, Section 96, published by the Australian Senate 2003). The High Court of Australia in the *Main Roads Case*, which is notable for its brevity, upheld the right of the Australian Government to place conditions on funding provided to the states under this section of the Constitution (High Court 1926). Some states have argued this limits their autonomy from the Commonwealth funding arrangements (Parliament of Tasmania 2006, 187).

GPP are payments provided by the Australian Government to the states and territories, who are permitted to use this money for any purpose (IGA 1998, 110). This is reiterated in state and territory budget papers. For example 'Unlike SPPs, which must be spent in accordance with purposes agreed to between the Australian Government and the State (or as prescribed by the Australian Government), General Purpose Payments (GPPs) from the Australian Government can be applied at the State's discretion' (Parliament of Tasmania 2006, 185).

The critical issue here is that, hitherto, the Australian Government has not attached OHS conditions to SPP funds. Under Stage 2 of the revised Australian Government Building and Construction Occupational Health and Safety Accreditation Scheme, construction projects indirectly funded by the Australian Government through SPP funding, will be required to comply with the Scheme. Thus OHS conditions have been attached to tied funding, and these conditions have included every project funded by the Australian Government through SPP funding, and conducted by state and territory governments.

There are some difficulties with this arrangement, however. Construction projects conducted by the states, which are funded directly or indirectly, by the Australian Government, would need to comply both with the OFSC Scheme *and* with state or territory government OHS legislation. This is certainly the opinion of Cole (2003) who felt that the application of conditions to Australian Government funding would mean that there were effectively two separate systems of regulation to every site, and that such a situation would be likely to undermine safety on the site, not improve it. This is because the conflicting and overlapping of OHS powers resulting from multiple systems would more than likely create more confusion, and not reduce it (Cole 2003).

Consequently, this initiative, as it results in duplication of requirements, rather than harmonisation of requirements, is argued to be an example of independent unilateralism (Option 10 from Table 20.1), as shown in Figure 20.3.

Figure 20.3 Level of Harmonisation for Australian Government Building and Construction Occupational Health and Safety Accreditation Scheme

Unilateral Exercise of Power by the Commonwealth
Reference of Power to the Commonwealth
Incorporation by Reference
Complementary or Mirror Legislation
Mutual Recognition
Agreed Legislation/ Policies
Adoptive Recognition
Non-Binding National Standards Model
Exchange of Information
Independent Unilateralism

DEVELOPMENT OF A VOLUNTARY CODE OF PRACTICE

As argued elsewhere (Charles et al. 2007) there is considerable utility for a voluntary code of practice (VCOP) to be developed by industry, and Cole (2003) in fact endorses such a move. The CRC for *Construction Innovation* has just published a set of guidelines for safety in the construction sector after extensive consultation with industry (*Construction Innovation* 2007). A VCOP can establish a minimum code of conduct for industry. If adopted by most construction firms, it may well form the basis for harmonisation of practice. How well the code is adopted and the reception it receives by various legislatures remains to be seen. Various states and territories are reviewing the guidelines and how these may relate to their OHS regulations. Further longitudinal research is needed to ascertain the uptake of the guidelines into a VCOP and how this might affect regulatory harmonisation in Australia.

CONCLUSION

Harmonisation is seen to provide a way of organising complex regulatory approaches. Various reports such as the Cole Commission (2003) and the Productivity Commission (Australian Government 2004a; 2004b) argued the case for increased harmonisation of OHS regulations. This paper examined three initiatives that have attempted to improve OHS harmonisation in Australia.

With the Comcare initiative, national firms can 'opt out' of state-based OHS workers compensation schemes, although uptake of this initiative has been limited to date. The recent High Court ruling which upheld the right of the government to implement the initiative, may lead to a significant increase in firms opting out, if enough construction firms perceive benefit in doing so. At the moment, however, this initiative still entails independent action by Australian jurisdictions, and is likely to remain so unless there is significant uptake by industry.

The NOHSC standards continue to hold significant promise for harmonisation. If the objective of the standards was to share information across state and territory governments, then the NOHSC standards have been successful. However, the standards need to be universally adopted into legislation in order to effectively form the basis of harmonisation. Recent COAG initiatives may lead to improved consistency of OHS regulation across the country, particularly through identifying common and core elements of OHS regulations.

The Stage 2 of the Australian Government Building and Construction Occupational Health and Safety Accreditation Scheme potentially extends the reach of the Australian Government requirements to all construction projects which are directly or indirectly funded by the Australian Government. Such a change does not encourage harmonisation directly, and in fact may, in the shorter term, increase overlap with duplicate accreditation schemes required on single construction sites.

Thus despite significant support (Cole 2003; Productivity Commission 2004), much work remains if we are to achieve increased consistency through harmonisation of OHS regulation in Australia.

An industry-sponsored and led voluntary code of practice may lead to the establishment of standardised benchmarks for OHS practice in the industry, provided it can garner the necessary critical mass within industry. Further research is needed to determine the outcome of such an initiative, particularly in how it might relate to extant state and territory legislation.

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Communication as the Catalyst for Enhanced Safety Outcomes: A multi-stakeholder perspective

Lynette Sperling
Michael Charles
Rachel Ryan
Kerry Brown

INTRODUCTION

Safety in the construction industry is a multifaceted issue and a major concern across the globe. According to Sawacha et al. (1999), the risk of a fatality in the United Kingdom construction industry is five times higher than that experienced in the same nation's manufacturing industry. Not only is there human cost to consider, but also economic costs (Mohamed 2000). For instance, the UK Health and Safety Executive estimated that, in 2005–06, there was an annual loss of 1.3 days per construction worker on account of work-related illness and/or injuries sustained in the workplace. Thus there is a clear imperative to introduce practices and strategies that reduce death and injury on-site.

Previous research suggests that one especial area of concern in the construction industry is the general inability to effectively manage occupational health and safety (OHS). It is not well understood what constitutes good communication, who are the critical parties, and which conditions facilitate communication. Communicating safety has been the responsibility of the constructor at the construction phase, as is evidenced by the legislation and safety interventions focusing on the constructor and the leadership role that they assume on-site. To facilitate an improvement in industry safety, the relationship between clients, designers and constructors (and also subcontractors and on-site personnel in general) warrants further investigation. Facets of this relationship, including the means by which effective communication can be promoted, have largely remained unexplored. According to Hua et al. (2005), previous research into construction industry communication has focused primarily on vertical communication within the project, rather than horizontal communication between the client, designer and constructor, all of whom play key roles in the overall construction process.

While many studies have underlined the importance of effective communication in achieving project success, there has been little advance concerning the operationalisation of strategies for better team communication (Thomas et al. 1999). This research will seek to determine best practice for improving client, designer and constructor multi-party communications. Moreover, the study will examine and analyse data from research conducted on 27 best practice project case studies within the Australian construction industry. The research findings provide an approach that can help in the development of an effective and more openly communicative relationship between the parties under consideration.

THE CLIENT, DESIGNER AND CONSTRUCTOR RELATIONSHIP

Depending on the contracting method employed, the project team generally consists of the client, designer and constructor. There is sometimes an overlap between these roles, but, for this paper, these will be regarded as individual entities. For many years, researchers have hypothesised that a positive correlation exists between effective communication and the success of construction projects. In view of this, Thomas et al. (1999) suggest that a lack of efficient communication within the project team presents a major challenge to project success.

Open and effective communication

Cheng et al. (2001) argue that, by ensuring a culture of effective communication at the client, designer and constructor level, an environment of open and flexible communication for all parties is created. This enhanced communication regime is not only beneficial to building the relationship between the management team, but also to the project as a whole. A lack of effective communication, while it hinders the relationships of the management team, also has further implications. Darke (2000) recognises the importance of creating an environment for effective communication and contends that the risk of insurance claims is reduced when good communication is effected. Likewise, Kumaraswamy and Chan (1998) found that a lack of effective communication between the designer and constructor leads to time delays. Furthermore, Elliot (2005) contends that a project team needs to understand the value of effective communication in order to excel in safety. The same author suggests that this is demonstrated by several of the 2005 winners of the Construction Safety Excellence Awards at the Annual Convention of Associated General Contractors of America, where considerable attention was placed on effective communication.

Hua et al. (2005) found that communication was most effective when participants took a proactive approach. This, as Zhang et al. (2004) define it, is the 'ability to take initiatives by exhibiting goal-directed behaviour'. Despite this, Hua et al. (2005) found that a proactive approach does not always guarantee effective communication. Indeed, as a communication chain becomes longer, it is more open to 'noise', i.e. forgetfulness, laziness and prejudices (Amami et al. 2000). Although often not intentional, this ‘noise’ can lead to differences between the expectations of clients, designers and constructors (Amami et al. 2000). These differences can have negative impacts on the construction process by affecting team members’ attitudes, perceptions and objectives. It is also important to note that, while team members can have good intentions regarding communication, the methods and channels used can sometimes hinder these efforts.

Development process

For communication to be truly effective, mutual understanding and collaboration between the sender and receiver must exist (Grunig 2000). A proactive approach employing a two-way symmetrical model of communication is suggested as a means to facilitate congruency between the project team. It also allows a free flow of information back and forth between parties, thereby assisting with the development of positive relationships (Martinelli 2006). For the client, designer and constructor to achieve this, all three parties must agree on chosen means of communication.

To enhance effective two-way communication flow between the client, designer and constructor, efficient communication channels must be employed. These channels should be as short as possible in order to achieve noise minimisation (Amami et al. 2000). This could be facilitated through face-to-face discussions, workshops, emails or tele/videoconferencing (Amami et al. 2000). Although email is regarded by Weinstock (2006) as a useful communication technology, the ability to convey the meaning via body language, cadence and tone are lost, with the potential for content to be misconstrued. For these reasons, Cheng et al. (2001) and Hua et al. (2005) prefer face-to-face communication. These authors hold that promoting shorter distances between communicators will lead to more efficient feedback and enhanced spontaneity. A study undertaken by Hayward (2006) found a positive correlation between groups working face to face and the achievement of greater team orientation. Thus face-to-face communication allows the development of project-specific goals and objectives.

As communication contains both implicit and explicit messages, it can inadvertently encourage or discourage safe work conditions (Gillen et al. 2004). Clarke (1999) argues that accurate inter-group perceptions of mutual trust and understanding gained from effective communication form the foundations of a positive safety culture. As a consequence, the leadership communication style needs to be effective, consistent, and unambiguous with regard to safety expectations (Biggs et al. 2005).

COLLABORATIVE APPROACH

As found in previous studies, open and efficient communication enables the client, designer and constructor to work towards shared goals. Parties working collaboratively should not only address issues regarding designing for safety, but also identify any problems requiring resolution (Workplace Health and Safety in the Building and Construction Industry 2002). One means to promote a collaborative approach is an alliance contract. This provides a framework and collaborative environment that aligns parties to project objectives (Rowlinson et al. 2006). It also enables the sharing of resources and experiences, promotes open and effective communication, and has a greater potential to expose any underlying safety threats.

Alliance contracting

An alliance contract offers clients and contractors a practical solution to overcome the recurring problems encountered in the traditional design-and-construct-style contract (Grynbaum 2004). Such contracts take the form of agreements binding the parties together with respect to targets, risk and reward mechanisms (Halman et al. 1999). The entire alliance entity is therefore at risk of failure should something go awry, a feature which essentially alters the group dynamics, motivation and cohesiveness between the alliance members compared with those of a traditional contract (Walker et al. 2002). In this way, alliance contracting can recognise conflict and ensure timely and collaborative resolution of issues. Traditional contracts place responsibility and risk on the constructor, which can lead to conflict, contractual disputes and expensive claims (Grynbaum 2004). An alliance contract, however, can distribute risk throughout the alliance team.

A limitation to this contracting method is a lack of multidisciplinary skills on the part of the client, designer and constructor, which may limit the scope of communication between them (Cheng et al. 2001). This situation can be described as a ‘silo’ mentality, i.e. the constituents do not share knowledge and keep strictly within their own functional boundaries (Ledger 2003). However, if mutual interaction, effective communication and the sharing of resources is promoted, the complementary expertise of team members can overcome these barriers (Cheng et al. 2001). Novice or unprepared team members may also pose a possible limitation to this style of contract since they might find the concept too challenging, or else may not realise the value of high-level collaboration (Walker et al. 2002). Another element for consideration is the need for highly motivated and dedicated team members.

An alliance contract thus relies on a culture of openness (Halman et al. 1999). For example, a proactive management commitment to safety culture at the client, designer and constructor level has been shown to lead to superior safety performance (Trethewy et al. 2000; Gillen et al. 2004; Clarke 1999). This openness ensures the establishment of effective communication channels and thereby facilitates mutual understanding, especially regarding the business drivers, objectives and individual interests of all the relevant parties (Halman et al. 1999). This research paper investigates the operationalisation of strategies with a view to facilitating an open and more effective communication relationship between the client, designer and constructor.

Traditional contract methods

According to Grynbaum (2004) and Cheng et al. (2001; 2004), the traditional method of infrastructure procurement can no longer be regarded as the most efficient delivery system. Since the industry is multifaceted and often divisive, much attention has been placed on contractual requirements and obligations, rather than improvement, innovation, and project success (Cheng et al., 2001; 2004). Ledger (2003) argues that, according to traditional contracts, parties are motivated to look after their own interests, rather than work towards the realisation of the project’s best interests. In this context, multi-party communication is often minimal and results in parties avoiding any possible admissions of liability, primarily to avoid potentially negative consequences (Ledger 2003). Once the relationship becomes conflictive, it can affect project outcomes.

Several authors, including Ferreira et al. (1999) and Smith et al. (1999), have criticised the 'turnkey' concept, whereby the contractor undertakes the design, commission and complete realisation of the project and turns it over to the client upon completion. According to this model, the client has very little direct involvement or communication with the project team members and may not be concerned with managerial, technical or risk components, including OHS (Sohmen 1992). Furthermore, Huang et al. (2006) emphasise the necessity of the client's active participation in all facets of the project, including preplanning, the financial support of the project's safety program, and ensuring that contractual safety requirements are met, in addition to carrying out day-to-day safety activities. Hinze (1997) and Huang (2006) argue that the involvement of owners in selecting safe contractors, designers and constructors, can positively impact on construction safety.

The actions outlined above should help to ensure that a safety culture develops on-site. Culture within an industry context, as Schein (1986) defines it, relates to shared values, norms and beliefs. Clarke (1999) suggests that the development of a positive safety culture improves the project's safety performance. An environment that engenders a safe workplace culture thereby has the greatest chance of achieving maximum success (Trethewy et al. 2000).

RESEARCH METHODOLOGY

To establish the elements of best practice communication of construction safety, the study focused on successful industry-recognised construction projects. Most projects were selected according to a best-practice framework determined by industry awards for excellence and some specific safety awards, in addition to other awards including a 'best practice in safety' selection criterion. Some Australian states and some industry subsectors, however, were not well represented in the initial investigation. Twenty-seven construction projects in the subsectors of infrastructure, commercial, rail residential and airport were identified.

An expert panel model was adopted to gather advice regarding other best practice projects. As part of this, a panel of industry experts from different professional groups within the construction industry (known as the Engineers Australia Taskforce for Construction Safety) undertook a gap analysis of the construction industry case studies, identified industry subsectors and states that were not well represented, and provided the names of projects that were considered best practice in safety performance. The selected projects were then added to the case study analysis.

The views of the client, designer and constructor on each project were ascertained by means of semi-structured interviews. This approach enabled a triangulation of data sources since respondents were asked questions at each interview pertaining to the integration of OHS principles, including industry-standard practices complying with relevant legislation, and those practices that went above and beyond industry standards. For example, this included project- or company-specific initiatives developed to integrate non-traditional stakeholders such as designers into the safety-development processes.

RESEARCH FINDINGS

Effective communication

The research revealed that effective communication, consultation and information sharing between the client, designer and constructor were vital to project success, ensuring best practice, and promoting construction safety. Communication was considered fundamental to engendering a safety culture by all client, designer and constructor representatives interviewed. Ongoing communication was perceived to encourage positive relationships between stakeholders and ensure that information was delivered along the supply chain, from clients through to subcontractors. In some cases, direct client involvement in project activities was highlighted as best practice. This concurs with Clarke's 1999 study, in which he found that accurate inter-group perceptions of mutual trust and understanding gained from effective communication form the foundations of a positive safety culture.

As identified earlier by Cheng (2001) and Hua et al. (2005), face-to-face communication between team members emerged as an important element. This supports Hayward's 2006 study, in which groups working face to face were found to achieve greater team orientation than those that do not. But the use of information technology (IT) can allow geographically dispersed participants to engage with each other (Cheng et al. 2001). IT initiatives were used on larger projects such as the Eastlink Freeway. Along with regularly scheduled meetings, construction company Thiess John Holland employed a computer-based project management tool, viz., inCITE, which tracked the project's progress and updated personnel. For projects with a smaller-sized workforce, such as the Helensvale to Nerang Railway Duplication, safety messages were personalised and communicated directly from management to subcontractors. An open-door policy was found to be especially useful in preventing communication breakdowns. Indeed, this approach allowed management team members to meet on a formal and informal level. This was clearly demonstrated by the Flinders Street Overpass project, the Geraldton Southern Transport Corridor, and the Forest Gardens residential development.

An alliance coach was appointed for the Future Port Expansion (FPE) Seawall Alliance. The coach focused on improving communication and resolving relationship issues between stakeholders. In addition, the coach held team-meeting-like gatherings and worked on communication and relationship issues, especially in promoting mutual respect among team members. The client, who appointed and financed the coach, commended the positive working relationships fostered by the alliance coach. In the Wivenhoe Alliance project, a client-appointed external facilitator assisted with working through goals and objectives. Best practice thus means that clients should be aware of, support and facilitate project safety objectives, which coheres with the work of Huang (2006) and Ledger (2003). This requires client involvement and effective communication with the constructor and/or management team throughout the construction phase.

Who drives safety?

While all parties, the client, designer and constructor, are responsible for safety decision-making and implementation, it was found that the constructor has the greatest control regarding on-site OHS. Constructors and their representatives spend the most amount of time on-site. They are also legally responsible for safety. Legislation and guidelines for all Australian states, in addition to the National Standard for Construction Work, which is led by the National Occupational Health and Safety Commission (NOHSC), sets out that the 'person with control', or employer (which, in this case is the constructor or one of their representatives), is the primary bearer of responsibility for identifying risks in the planning and construction stages and developing mitigation strategies to mitigate them (NOHSC 2005; WorkCover NSW 2001; Queensland Department of Industrial Relations 2005; WorkCover Victoria 2007). Section 7.8 of NOHSC standards specifies that the 'person with control' is the principal contractor, who is responsible for identifying risks and developing mitigation strategies and is 'responsible for the health and safety of any person who may be affected by the construction work'. This control of the worksite means that constructors also have the opportunity to develop safety systems as a result of practical experience.

Shared stakeholder responsibility for safety

The 2003 Australian Royal Commission into the Building and Construction Industry, headed by Terrence Cole, investigated claims of malpractice and misconduct in the Australian building and construction sector. The Commission found that the industry is characterised by an entrenched culture of legislative disregard, to the extent that existing workplace relations laws are clearly ineffective (Cole 2003). Cole (2003) recommended an integrated approach to accident and illness prevention through regulator enforcement, advisory provisions and teamwork between client, designer and constructor. These principles of integrated working relationship have been recommended in similar inquiries conducted in the United Kingdom (Robens 1972; Latham 1994; Egan 1998).

In addition to legislative reform and cultural and behavioural change, Cole (2003) recommended encouraging and implementing a respectful work environment where health and safety is integrated into everyday construction practices. Shared responsibility, either practically or exemplified as a philosophy across stakeholder groups, was mentioned in a number of projects as best practice. This work philosophy encompasses the facilitation of a culture of safety. According to Olive, O'Connor and Mannan (2006, 133) 'safety culture can be viewed as the overarching policies and goals set by an organisation relating to the overall safety of their facility or environment'.

This approach not only addresses safe design issues, but also identifies any safety problems requiring resolution. In the Alice Springs to Darwin Rail Link and Hallam Bypass, consultation occurred in a 'round table' structure, not as a trickle-down effect. This trickle down or 'top-down' management approach describes a type of organisational structure in which a cultural change to safety practices is driven from the top by a managerial representative or chief executive officer (CEO) (DeJoy 2005). Olive et al. (2006, 134) contend that that ownership of safety principles across all levels of an organisational is ultimately driven by management, but is most effectively enforced by management behaviour, not just messages (Olive et al. 2006, 134). This can be applied to stakeholder relationships, where safety can be driven by the client.

It is important to note that ownership and commitment to safety principles was demonstrated consistently across the 27 case studies, thereby confirming the best-practice nature of the cases selected.

Safety leadership initiatives by non-traditional stakeholders

Designers

An effective strategy was for designers to work directly with constructors and clients in order to develop strategies to design for safety, risk mitigation and reviews. Durham et al. (2002, 9) argue that 'many of the best controls for safety problems can be implemented effectively at the design and construction planning stages'. The same authors also emphasise (2002, 23) the importance of developing 'partnerships between those involved in concept and design, construction planning, construction work, maintenance and even demolition' and cited, as evidence, trials that have proved the effectiveness of safety improvements when incorporated at the design stage. Bluff (2003, 10) supports the notion of integrating OHS considerations into the 'planning and coordination' of the construction process, thus necessitating the cooperation and input of designers. The same author (2003, 10) recommended promoting effective communication between all personnel involved in the design process. An example is provided by the Eastern Freeway project. Close client consultation with the design group was also effective in the Cobram Barooga Bridge project.

Projects constructed (and, in some cases, designed) by Bovis Lend Lease and Delfin Lend Lease implemented ROAD (Risk, Opportunity and Design) systematic reviews developed by the construction company. Bovis Lend Lease facilitates the effective identification of 'known risks' in the initial design briefing and includes designers in safety decisions, thereby facilitating better communication between constructors and designers. Since ROAD seeks to eliminate or modify OHS risks in the design and delivery of structures, key stakeholders such as end users, end-user maintenance authorities, architects and core product or service representatives are informed about key roles within the design process and are asked to consider potential issues (Campion 2000). In similar fashion, design reviews and pre-established design criteria were developed for Rouse Hill Town Centre and Geraldton Southern Transport Corridor. These reviews involved all stakeholders, who worked together in an open consultation process.

Clients

Communication was a key feature in achieving client-led safety initiatives, and for driving a top-down approach. This meant communicating safety messages for the overall project direction, or directly communicating with personnel on-site. Direct client involvement, or that of a client representative, included regular participation in on-site activities such as inductions, safety meetings, inspections, and safety walks. DeJoy (1985) suggests that safety programs that facilitate two-way communication between workers and managers and involve direct participation by management in safety activities serve to reduce the administrative distance between workers and managers.

For example, in the Sydney Airport Gate 24 project, client representatives were involved with activities on-site. They maintained frequent communication with the contractor and closely monitored safety. Offices for client representatives were based on-site, which meant that communication between stakeholders (i.e. client, designer and constructor) could occur daily. Weekly meetings were held with the contractor and client representatives to discuss operations. The client held internal meetings that dealt with other projects simultaneously being undertaken, while all communication between the designers and contractors went through the client's representative. The designer and contractor spoke directly on a few matters, but the client was always informed. The client was closely involved with on-site activities for the Millennium Arts Project. This was facilitated by the client being based on-site and thereby maintaining direct interactions and communication with other stakeholders. In some cases, such as the Eastern Freeway and Melbourne Airport, the client personally inspected the site on most days.

An effective client initiative, whereby all personnel were issued with the contact numbers for client representatives to discuss safety, was initiated in the Basslink project. In some cases, client-appointed external facilitators reported directly to the client. In the Wivenhoe Alliance, the facilitator worked through safety goals and objectives and communicated openly with other stakeholders. The client personally monitored on-site activities and communicated with all stakeholders directly. Client representatives for the Millennium Arts Project, being based on-site, also become more involved with end-user (i.e. those using the site after construction was completed) considerations. The client was given statistics every month at the Project Control Group (PCG) meeting, while the constructor conducted a safety report and communicated this information to the client directly. The constructor informed the client about first-aid reports, number of lost days recorded, number of safety inductions undertaken, and number of personnel on-site.

Facilitation of shared responsibility through alliance contracts

The study revealed that the use of an alliance contract, such as that employed in the Future Port Expansion (FPE) Seawall Alliance, Wivenhoe Alliance and Eastern Freeway projects, facilitated communication between team members. This was because the alliance contract established a project delivery team rather than relying on individual parties. In the Wivenhoe Alliance, this style of contract was found to facilitate the frank and unhindered flow of communication. The FPE Seawall Alliance project exemplified an opportunity for constructability issues to be discussed at length, with a view to achieving complete satisfaction with the end product for the client and constructor. In the Eastern Freeway project, alliance contracting assisted with the early resolution of issues, with prompt and innovative alternatives suggested by all parties. This was also achieved in the FPE Seawall Alliance by drawing on the expertise of all alliance team members. The alliance contract, it emerges, constitutes a platform for maintaining a rigorous safety focus, provided that the contract specifications are endorsed and supported by the alliance team.

Information sharing

Open management systems and information sharing among stakeholders facilitated a team approach at the Lucas Heights Reactor project. Information sharing was also practised for the Melbourne Airport Runway, where each stakeholder had a different OHS monitoring system; however, the sharing of information meant that the project was treated as more of an alliance.

A custom-designed internet 'project web', which allowed different project stages to be reviewed and modified, acted as a communication tool for stakeholders of the Millennium Arts Project and Rouse Hill Town Centre. This is a standard feature for all Bovis Lend Lease projects. Indeed, multilevel planning contributed to coordinating safety plans and developing the safety goals for each project analysed. In the Alice Springs to Darwin Rail Link, safety goals were supported by a reporting structure so that, if anything went wrong, the way in which to correct the problem would be determined easily. In this case, scenario-based planning determined risk management and mitigation strategies. For the Hallam Bypass, preparation was extensive, with design meetings beginning months before construction. To ensure that a shared understanding of risk management exists, Kirchsteiger (2005) recommends a participatory approach to risk management involving all stakeholders working collaboratively with a view to characterising and assessing risks, and then integrating risk assessment practices into a risk management program.

Information was conveyed along the supply chain for the Basslink project. Monthly meetings on safety were attended by site supervisors, but not subcontractors. It was therefore imperative that project managers communicated with different OHS representatives. The company-specific 'incident and injury free' (IIF) plan developed by Lend Lease provided a flexible orientation training program that could be adapted to specific projects. This program was implemented at Hyatt Regency Coolum, Coles Myer Somerton, Rouse Hill Town Centre, and Forest Gardens.

Team building

Team building emerged as an important aspect in preparing for works in the pre-construction phase of all researched projects. Most of the projects included in the study implemented team-based preparatory measures to determine a risk management strategy. Furthermore, safety education and training development were supported by intensive training, safety certification and comprehensive inductions.

Team-building exercises such as sailing, skiing and go-cart races on rostered days off (RDOs) gave personnel the opportunity to get to know each other. This was particularly effective in the Wivenhoe Alliance project. At Lucas Heights, the philosophy of 'look after yourself and look after your buddy' was adopted to encourage team building and ensure the development of a safety culture.

Incentives

A popular method to drive safety performance was the use of incentives such as awards, dinners, BBQs, or simple acknowledgments. According to Slaughter (2000, 8), 'rewards are intrinsic to the innovation process itself, in providing personal pride and challenges to the people involved, as well as developing their professional competencies and reputation'. Applied to safety improvement, the principles of pride and recognition can effectively encourage best practice. Basslink and Tullamarine Calder Interchange (TCI) gave awards for good safety practices in an initiative that was driven by the constructor and sponsored by the client. Internal awards for safety (both small-scale and for the overall organisation) were given in the Wivenhoe Alliance and were embraced by personnel.

An incentive program for the Millennium Arts Project was integrated into team-building exercises. BBQs were a reward for good safety practices, such as avoiding time lost for injuries (LTIs). Not only did this lift morale, but also familiarised the workers with their safety representatives informally. It also aided in breaking down communication and social barriers. Likewise, the designer of the Energy Australia Stadium project thought it was important that the site safety officer use positive reinforcement. That is, workers should be told not only what they are doing wrong, but also what they are doing correctly since this encourages them to continue behaving in such a manner. This agrees with research conducted by Keller and Szilagyi (1976).

The approach employed at the Wivenhoe Alliance project involved promoting the general wellbeing of workers, in addition to providing education about the importance of a healthy lifestyle. This included the implementation of work–life balance initiatives comprising a five-day working week, and a supply of fresh food and vegetables. The latter, in particular, reinforced the notion of management being concerned about the wellbeing of its construction employees.

DISCUSSION AND CONCLUSION

This research has revealed that effective communication, consultation and information sharing between client, designer and constructor was an important contributing factor to best practice in construction safety. The research also determined that truly collaborative engagement by all parties encouraged a holistic approach to the project goals and objectives. Face-to-face interaction allowed team members to resolve issues quickly, and with a reduced chance of misunderstandings and misconstrued information. This more interactive form of communication also assisted teams in attaining a higher level of team orientation, which not only improved safety, but also other project goals.

An open-door policy was identified as a means to prevent communication breakdowns. In addition, it ensured that many issues were quickly resolved. In an alliance structure, the use of an alliance coach further enhanced communication between all parties. The research identified the need for overlap between the design and construction aspects since this would assist them in understanding the drivers of the project. This, in turn, can affect the designers' approach to the project.

In addition, the research confirms the notion that alliance contracting facilitates communication between team members. The approach ensured the creation of a project delivery team instead of individual parties with potentially conflicting interests. It also facilitated the unhindered flow of communication and avoided contractual barriers often found in traditional contracts. This arrangement also provided an opportunity for constructability issues to be discussed at length, which helped to ensure greater client satisfaction with the end product.

Top-down management commitment was found to be responsible for fostering a safety culture, especially if consistent and continued messages are conveyed to all personnel. The research thus supports the notion that a safety culture can be driven by managers, and especially the management team as a cohesive whole (Waldman and Yammarino 1999). While it was acknowledged that all parties are responsible for safety decision-making and implementation, the data clearly demonstrated that the constructor maintains the greatest control during a project's realisation, especially since the constructor has the opportunity to continually develop and challenge safety systems. The designer also needs to receive feedback, not only to ensure the success of the current project, but also to inform the designer's understanding of salient issues with regard to future projects.

Where the use of an alliance contract is not suitable for a project, as might sometimes be the case, further research could explore the possibilities of managing a design-and-construct contract via alliance-style methods. In particular, an orientation towards multi-party communication across the entire construction project, that is, from conception through to completion, could improve safety outcomes.

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CHAPTER 22

Safety Culture: A multilevel assessment tool for the construction industry

Brett Mayze
Lisa Bradley

INTRODUCTION

There are inherent risks in the building and construction industry, with contractors, subcontractors and their personnel all needing to actively manage workplace hazards to maximise worker safety and prevent injuries and deaths. The incident rate for fatalities in the Australian construction industry is almost twice the rate of other Australian industries (Australian Safety and Compensation Council (ASCC) 2007). In addition to fatalities, the incidence of injury in Australian building and construction, while declining, remains about 50 per cent higher than the all industry average (Cole 2003) with the industry recording the fourth-highest level of reported non-fatal injuries behind mining, manufacturing and transport. However, despite the size of the construction industry (employing about nine per cent of all employed persons in Australia (ASCC 2007)), and the significance of these safety concerns, organisational behaviour literature has typically not focused on safety for this industry within Australia or internationally. Occupational health and safety remains one of the least studied phenomena in organisational behaviour, with estimates suggesting it represents less than one per cent of the total amount of published research (e.g. Campbell, Daft and Hulin 1982; Zacharatos, Barling and Iverson 2005).

A MODEL OF SAFETY PERFORMANCE

Current research into the measurement of workplace safety often does not incorporate the complex relationships that impact on individuals in the workplace. The present paper outlines a model (refer to Figure 22.1) that incorporates the individual, the influence of supervisors, and the workplace on a range of important safety outcomes. The proposed model draws on a framework provided by Neal and Griffin (2004) which examined the work environment and individual antecedents of safety outcomes. The model is expanded to incorporate the worksite level and additional antecedents important to safety performance. A brief overview of the components of the model and reason for their inclusion precedes the derivation of the measures used to assess the model. The aim of this study was to test some of the model's newly developed measures. Initial evidence from this study indicates that the measures capture those aspects of the model tested and that the model is showing interesting relationships between the variables.

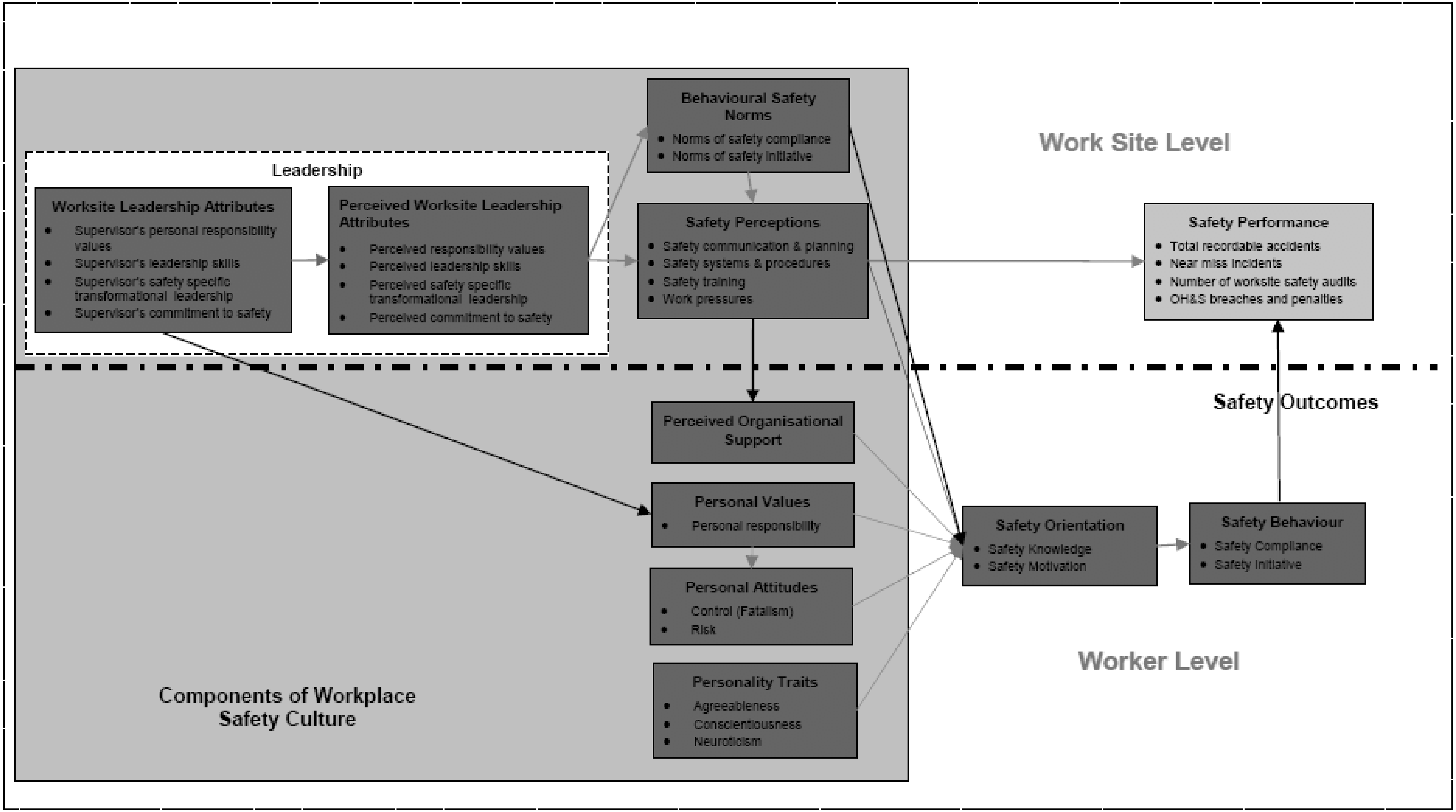
ANTECEDENTS OF SAFETY: WORKSITE

Safety culture

The term 'safety culture' is generally used to explain how safety is placed as a priority, which is reflected in decisions and policies and filters down through these into every aspect of operational performance. However, Cooper (2000, 119) notes that 'a literature search reveals that very few models of organisational safety culture exist,' Likewise Watson, Scott, Bishop and Turnbeaugh (2005) further suggest that the concept of safety culture is lacking a reliable and valid approach to its theoretical and conceptual definition. While the few existing models of safety culture have often implied influence across multiple organisational levels, the majority have aggregated their findings to a single level of analysis or concentrated on within-level measures. Many studies have recognised the potential group effects on an individual's health and safety, but there is little empirical research that has actually investigated cross-level affects (Hofmann and Tetrick 2003).

Mearns and Flin (1999) suggest that safety cultures, like the determinants of safety values and norms, are relatively enduring. Furthermore given the centrality of values and norms to the concept of culture, the present model defines safety culture by safety values and safety norms. However, Ajzen (1991) reported that situational factors that intercede between safety values and safety behaviour are likely to influence the relationship. The most strongly held beliefs cannot be translated into behaviour without an environment or climate that enables the behaviour (Ajzen 1991). As such, safety climate is often considered a distinct yet subordinate of the broader concept of safety culture and presents a sensible starting point for the factors that may potentially contribute or directly relate to a safety focused culture (Guldenmund 2000; Schneider 1990; Zohar 2003).

Figure 22.1 Multilevel Model of Safety in the Construction Industry



Safety climate

Safety climate represents a combination of what organisational members perceive is happening within the organisation and how they feel about that (Schein 1992). Safety climate plays an important role in the realisation of desired safety behaviours and performance (Griffin and Neal 2000; Zohar 1980). However, climate is an emergent property, characterising groups of individuals. Operationally, it is assessed by aggregating individual perceptions to the required unit of analysis (organisation, worksite, team/crew), and using the mean to represent the climate for that entity (Reichers and Schneider 1990). However, the aggregation of individual perceptions averages out individual and subgroup variation, and has often been used with inconsistent frames of reference across studies. This aggregation of psychological constructs has been posed by Clarke (2006) as a possible explanation of the failure to find a strong influence of safety climate on accident involvement. The various studies into safety climate and culture have seemingly failed to consistently distinguish between measures of safety perceptions (commonly safety climate studies) and measures of safety attitudes (commonly safety culture studies) (Clarke 2006). Furthermore, Clarke (2006) suggests that there are additional disregarded factors which will influence the effect of attitudes on behaviour, and suggests that including normative safety beliefs will add to the power of safety attitudes in explaining an individual's safety behaviours at work.

SAFETY PERFORMANCE

As opposed to self-report, accident and injury data have often been employed as a criterion measure (Griffin and Neal 2000; Mearns, Whitaker and Flin 2003; Silva, Lima and Baptista 2004; Zohar 2000), and Clarke (1998) suggests that a reduction in accident and incident rates provides the best measure of a positive safety culture. Yet, accident data as a measure of safety performance has often been criticised (e.g. McKenna and Glendon 1995) as, amongst other shortcomings, it doesn't provide a means to evaluate risk exposure and is often insensitive as incidents are so rare (Glendon and Litherland 2001). More recently, however, proactive safety measures such as the numbers of safety audits and inspections conducted, the frequency of communication events, and the percentage of workers receiving OHS training, are being increasingly applied at the organisational level (NOHSC 2005). At a worksite level the incorporation of these proactive indices with traditional safety performance measures will be employed to help assess the model.

Accordingly, the current study includes measures of both subjective perceptions of worksite safety practices and worksite behavioural safety norms as well as objective measures of worksite level safety performance. However, measures of leadership have been omitted from this study.

ANTECEDENT OF SAFETY: INDIVIDUAL

While safety culture implies an organisation-wide influence on individual behaviour, individual behaviour has a reciprocal effect on organisational culture (Schein 1992). To gain a complete picture of influences on safety outcomes, individual antecedents are also included in the model to provide greater understanding of the dynamics that govern the exchange between the individual employee and the workplace.

Perceived organisational support

Eisenberger, Huntington, Hutchison, and Sowa (1986) suggested that employees form a global belief concerning the extent to which the organisation values their contributions and cares about their wellbeing. They called this 'perceived organisational support' (POS). High levels of POS are thought to create obligations within individuals to repay the organisation. The interrelationship between perceived organisational support and safety is illustrated in how perceived safety violations can undermine trust in the employment relationship. There does not appear to be previous research that has explored the link between POS and safety performance.

Personal safety values

It is important to consider both individual values and group values in their influence on safety outcomes. Thygerson (1992) notes that accident prevention is highly correlated to one's sense of values. A person facing a novel situation, such as commencing work on a new job site, or undertaking new tasks associated with a job, will often experience higher unintentional injury rates (Thygerson 1992). Similarly Crowe (1995) reported that individual safety values are a better predictor than the combination of gender, class standing, and demographic region in determining an individual's safety practices.

Personality

Factor analyses of the relationships between personality and risk taking suggest that personality profiles can be used to predict risk orientation (Nicholson et al. 2005). Wagenaar (1992) reports that occupational accidents are often characterised by a lack of conscious risk taking. Therefore it would follow that personality should predict both individual safety compliance and participation; however only a handful of studies have examined this relationship. A meta review by Clarke and Robertson (2005), which included a criterion measure of accident data and at least one personality measure from the Five Factor Model of Personality (FFM), concluded that regardless of context, individuals low in agreeableness and low in conscientiousness are more likely to be involved in accidents; also that personality measures of conscientiousness, agreeableness and neuroticism were valid and generalisable predictors of accident involvement (Clarke and Robertson 2005).

Safety orientation

Campbell et al. (1993) propose that there are only three determinants of individual performance: knowledge, skill, and motivation. Safety performance, therefore, must be determined by knowledge and skills necessary for particular behaviours and by the motivation of individuals to perform the behaviours (Neal and Griffin 2004). Personal-safety orientation, a latent variable determined by safety knowledge and safety motivation (Zacharatos et al. 2005), has been found to mediate the relationship between perceptions of safety and safety behaviour (Neal et al. 2000).

SAFETY BEHAVIOUR

It has been suggested that behavioural data are superior to accident statistics as they focus on unsafe behaviour prior to incidents occurring (Reber, Wallin and Duhon 1989; Zohar and Luria 2003). Individual safety behaviours relevant to the workplace can be conceptualised in the same way as other work behaviours that constitute work performance. In this way, safety behaviour in the workplace can be divided into two major components: task behaviour and contextual behaviour (Borman and Motowidlo 1993; Griffin and Neal 2000).

Task or safety compliance behaviour, describes the core safety activities that need to be carried out by individuals to maintain workplace safety (Neal and Griffin 2002; Simard and Marchand 1994; Williams, Turner and Parker 2000). These behaviours may include, for example, wearing personal protective equipment and ensuring an adherence to current and accurate work method statements.

In contrast, contextual or safety initiative, refers to behaviours in which workers are not simply working within safety standards, but go beyond compliance and act proactively to improve safety in their environment. (Simard and Marchand 1994; Williams et al. 2000). Neal and Griffin (2002) define safety initiative behaviours as participating in voluntary safety activities or innovation for safety improvement.

Supplementing the previous worksite level measures the individual antecedents discussed (perceived organisational support, personal safety values, personality, individual safety orientation and safety behaviour) have also been identified as important in the organisational safety literature and while integral to the model, are tested in the current study.

METHOD

The survey was developed to assess an individual's own attitudes, values, and behaviours related to workplace safety and their perceptions about safety-related worksite group norms and practices. To investigate the relationships between these variables the survey instrument needed to clearly delineate between belief-based constructs. Such a survey was not directly available from the literature, and the development of appropriately distinct measures was the primary aim of this study.

Participants

Surveys were distributed on three construction sites across Australia. The majority of the respondents were male (92 males, 5 females), and were 17 to 64 years old (mean age 38.5 years). The education levels varied with 27 per cent of respondents having completed up to Year 10, 15 per cent completing up to Year 12, 30 per cent had completed a trade and 16 per cent had completed a certificate, and the remaining respondents had completed a variety of other qualifications. Average role tenure was 12.3 years, organisation tenure was 4 years, and construction industry tenure was 13.6 years. The respondents were predominantly subcontractors (60%), while 40 per cent were direct employees of the organisation.

Measures

The worker survey assessed the components outlined below.

Behavioural norms of safety compliance and behavioural norms of safety initiative

This was measured using three items each adapted and extended from the safety norms of co-workers scale by Watson et al. (2005) (alpha = .76).

Worksite safety perceptions

Measures included extended items assessing communication and planning (5 items), as well as safety training (4 items), systems and procedures (3 items) from Neal, Griffin and Hart (2000) with alpha coefficients of .93, and a fourth dimension of work pressures from Seo (2005) with an alpha coefficient of .88.

Perceived organisational support

Assessment involved using the eight-item measure of the Survey of Perceived Organisational Support that has a Cronbach's alpha of .90 (Eisenberger et al. 1997).

Personal safety values

Personal safety values were assesed using a develop measure consisting of seven items based on work by Crowe (1995) and Maierhofer and Griffin (2002).

Personal attitudes towards risk and behavioural control

Attitudes towards risk were assessed using four items adapted from Dedobbeleer and Beland (1991) and Watson, Scott, Bishop and Turnbeaugh (2005). While attitudes towards behavioural control were assessed using four items adapted from Dedobbeleer and Beland (1991) and Williamson et al. (1997), these were developed using subject matter experts for wording and practical relevance in accordance with the theory of planned behaviour using the framework provided by Ajzen (2002).

Personality

Specifically agreeableness, conscientiousness, and neuroticism were assessed using Saucier's (1994) Mini-Markers. Each of the personality variables was assessed using eight items. The Mini-Marker has been used widely in a range of settings and has demonstrated strong correlations with the NEO–Five-Factor Inventory (Mooradian and Nezlek 1996).

Safety orientation

Safety orientation was assessed by the two measures of safety knowledge and safety motivation. Safety knowledge assessed the extent to which employees felt knowledgeable about safety and was assessed with four items from Neal et al. (2000). Safety motivation assesses effort and interest in personal safety at work and was measured using four items (Neal et al. 2000).

Safety behaviour

Safety behaviour was assessed using measures of safety compliance and safety initiative as described by Neal et al. (2000). Seven items from both Neal et al. (2000) and Williams et al. (2000) were combined to measure safety compliance with some items adapted for the construction setting. Safety initiative was measured with eight items adapted from Turner and Parker (2004).

Safety performance

Incident, injury and safety data were collated for the worksites being surveyed and presented as six different indices:

1. Total Recordable Incident Frequency Rate (TRIFR): The number of total recorded unsafe incidents on-site. This figure includes personal injury and incidents (e.g. lost time injuries, fatalities, medical treatment injuries, alternate work injuries, first aid injuries) property damage and environmental events, presented per one million hours worked on-site
2. Total Near Miss Frequency Rate (TNMFR): The number of recorded near misses per one million hours worked on-site.
3. Frequency of Communications Events: The number of hours worked between each worksite communication event (such as toolbox talks, pre-starts) over the six months prior to the survey.
4. Frequency of Worksite Inspections: The number of hours worked between each worksite safety inspection over the six months prior to the survey.
5. Audits Conducted: The total number of worksite safety audits conducted on-site over the six months prior to the survey.
6. Hazards Reported: The total number of worksite safety hazards reported and recorded on-site over the six months prior to the survey.

Procedure

Batches of surveys were sent to safety managers on each worksite. These managers handed out the surveys personally during team meetings and canvassed site personnel to participate. Safety managers were available for survey-related questions, though the questionnaires were self-explanatory. Upon completion, individual surveys were sealed in a reply-paid return enveloped and either returned to the safety manager or placed directly into the mail.

RESULTS

Survey participation

From the 188 surveys distributed, the overall response rate for the study was 55%. However, the response rates varied across worksites with 50 per cent response from worksite 1 (N=20), 49 per cent from worksite 2: (N=52), and 78 per cent from worksite 3 (N=32).

Scales scores

Inspection of the means, standard deviation, skewness and kurtosis scores reveals some potential ceiling effects in some measures. These are expected values in the population and the impact of these are likely to be lower with a larger sample size (Tabachnick and Fidell 1996, 73)

The previously developed measures all had alpha coefficients that were similar to previous findings and all demonstrated acceptable internal consistency of the items. For the newly developed items, all except one measure also produced good internal consistency. Attitudes towards risk control had an alpha coefficient of .59 indicating that the items were not assessing the same construct. Inspection of the correlations reveals that some of the measures are strongly correlated.

Factor analysis

An exploratory factor analysis was undertaken to establish whether the attitude, behaviour, norm and value measures were distinguishable from each other in assessing differing aspects of safety. The factor analysis results are encouraging with a small sample.

The first factor had all seven safety value items loading on it, along with three cross-loaded safety initiate behaviour items. Factors 2 and 3 captured the safety compliance behaviour and safety initiative behaviours measures respectively. Factor 4 encapsulated both the safety norm items for initiative and compliance. The two types of norms loaded onto the same factor, despite being strongly correlated (r=.649, p<.01) in subsequent regression results, produce a pattern of results consistent with the predicted model. The items for attitudes towards worksite risk loaded on their own factor, factor 5, while factor 6 captured the majority of the attitude to risk control items, though one item cross-loaded on the attitude to worksite risk factor. Factor 7 has an interesting array of items loading on it, with two of these providing unique loadings and the other three all cross-loaded.

Mediated regression

A mediated regression was performed for each of the outcome measures (self-report safety compliance behaviour and self-reported safety initiative behaviour). Norms, attitudes, values, and personality were entered into the regression in the first step, followed by the mediators of safety knowledge and safety motivation on the second.

The results for the regression of the independent variables onto safety compliance behaviour mediated by safety knowledge and safety motivation appear in Table 22.1. The value of personal safety responsibility and the personality trait of conscientiousness were fully mediated by safety orientation (safety knowledge and safety motivation). Safety compliance norms were direct predictors of safety compliance behaviour. The model predicted 70 per cent of the variance in safety compliance behaviours (F=15.95, p<.05, df =98).

Table 22.1 Regression of Independent Variables onto Self-reported Safety Compliance Behaviour Mediated by Safety Knowledge and Safety Motivation

	Step 1 *Beta*	Step 2 *Beta*
Step 1		
Safety compliance norm	.175	.161*
Safety initiative norm	-.031	-.004
Communication and planning	-.062	-.014
Safety training	-.077	-.071
Safety systems and procedures	.186	.103
Work pressures	.100	.076
Perceived organisational support	.106	.065
Value of personal safety responsibility	.222*	-.047
Agreeableness	.182	.075
Conscientiousness	.220*	-.001
Neuroticism	.081	.033
Attitudes to worksite risk	-.041	.064
Attitudes to risk control	.070	.008
Step 2		
Safety knowledge		.182*
Safety motivation		.597*
Adjusted R^2	.385	.696
F	5.727**	15.95**
Df	98	98

* p<.05, ** p<.01

The second mediated regression examined the dependent variable of safety initiative behaviour (see Table 22.2). Again the value of personal safety responsibility and the personality trait of conscientiousness were mediated by safety orientation (safety knowledge and safety motivation). Neuroticism (which was negatively associated with the mediators) was also fully mediated in its relationship with safety initiative behaviour. Safety training had a direct negative relationship with safety initiative behaviour, indicating that greater safety training was associated in less frequent participation in safety initiative behaviour. Attitudes to risk control and safety initiative norms also had a direct, but positive link to safety initiative behaviour.

Table 22.2 Regression of IVs onto Self-reported Safety Initiative Behaviour Mediated by Safety Knowledge and Safety Motivation

	Step 1 *Beta*	Step 2 *Beta*
Step 1		
Safety compliance norm	.118	.093
Safety initiative norm	.230	.242*
Communication and planning	.139	.202
Safety training	-.250*	-.259*
Safety systems and procedures	.137	.069
Work pressures	.129	.114
Perceived organisational support	-.025	-.045
Value of personal safety responsibility	.199*	.029
Agreeableness	.107	.039
Conscientiousness	.339**	.177
Neuroticism	-.224*	-.198
Attitudes to worksite risk	-.080	-.017
Attitudes to risk control	.258**	.217**
Step 2		
Safety knowledge		.231*
Safety motivation		.237*
Adjusted R^2	.403	.484
F	6.10	7.13
Df	98	98

* *p*<.05, ** *p*<.01

WORKSITE SAFETY INFORMATION

Worksite safety data were also collected from safety records held in the organisation for six months prior to the survey completion (refer to Table 22.3). When the three worksites are compared, the site with the lowest total reportable injury frequency rate, total near miss frequency rate, least work pressure and that reported fewer workplace hazards, also rated the most positively perceived safety systems and procedures, communication and planning, and the highest levels of support from the organisation, personal safety responsibility values, and safety motivation.

Table 22.3 Worksite Safety Information

	Total injury frequency rate (Hrs)	Total near miss frequency rate (Hrs)	Frequency of communications events (Hrs)	Frequency of worksite inspections (Hrs)	Audits conducted	Hazards reported
Worksite 1	62.6	20.9	231.5	5324.9	3	62
Worksite 2	191.2	233.2	93.9	152.4	28	154
Worksite 3	73.6	73.6	135.2	1181.7	13	76

WORKSITE COMPARISONS

The ANOVAs tested for significant differences between worksites for the measures tested in the study. Results indicate that perceived organisational support, work pressures, and safety initiative norms were significantly different between the three worksites. Table 22.4 provides the worksite means for these measures.

Table 22.4 Mean Worker Self-reports Aggregated by Worksite

	Perceived organisational support	Work pressures	Safety initiative norm
Worksite 1	3.71	2.84	3.75
Worksite 2	3.19	3.14	3.90
Worksite 3	3.32	3.05	3.38

DISCUSSION

The sample size for this study was not sufficient to conduct a full test of the research model. However, the main aim of the study was to assess the reliability and test the newly developed items and those modified for the construction industry. This was achieved and the ability of the attitude, value and normative measures to predict the behavioural measures in this small sample provides a guide to the predictive validity of the measures.

Though the sample size was not sufficient to conduct a confirmatory factor analysis, the factor loadings from an exploratory factor analysis suggest that the items are distinguishable and present to the respondents in a manner consistent with their inclusion on their respective scales. A few exceptions can be noted with some cross-loadings and appropriate adjustments to be made to augment some measures. The safety initiative behaviour measure had the highest number of cross-loaded items, all of which loaded on the value measure. This suggests that these items may not sufficiently allow respondents to determine how important the initiative behaviour is versus how often it is performed. Also the cross-loading of attitudes towards risk control leads to the conclusion that there may be two points of references being used in responding to the items, self and other. Additional items need to be developed that are more focused to improve these measures in future research.

Both the compliance and initiative norms loaded on the same factor, suggesting that these tap into the same measure (social norms in this case) indicating that these measures don't distinguish between compliance and initiative. This result may be attributable to the small sample size, previously discussed as a concern in conducting this factor analysis, although it is curious. It could be that some of the items identified as initiative are considered compliant practices within the subject organisation. However, further analysis demonstrated that the measure of safety initiative norms significantly differed across the three sample worksites, and that regression analysis found that compliance norm predicted compliance behaviour whereas initiative norm predicted initiative. Furthermore, closer inspection of the items that loaded on factor 7 suggest that these measured behaviours or practices are considered organisationally desirable or carry some expectation of observance rather than behaviours that are considered conforming or innovative.

The development of the measures displayed sound reliability with high levels of internal consistency. The alpha coefficients ranged from 0.80 to 0.92. Exceptions to these results were for the measures of neuroticism (0.70), safety compliance norms (0.77) and attitudes towards risk control (0.59). Apart from neuroticism these other two measures require refinement. The measures also had good discriminant validity as shown in the factor analysis, and predictive validity. New measures were also tested for face and content validity with safety managers. Based on these findings adjustments to the measures for future studies should include the addition of items to the existing scales for safety initiative behaviour, attitudes to workplace risk, and the compliance and initiative norms. The findings suggest the proposed measures differentiate between belief-based constructs, to allow independent assessment of respondent's values, attitudes, perceptions, and norms. Furthermore the measures assessed explained a significant portion of the variance in an individual's safety behaviours and observation suggest on first impressions that they also proportionally trend with actual site safety performance.

CONCLUSION

Enabling organisations in the construction industry to proactively intervene and prevent an accident, rather than simply reacting to safety statistics after the event, represents a major advance in risk management practices. Results suggest that the refinement of the measures used to assess the research model in the current study will enable organisations to identify their own specific levers to most effectively drive their unique safety culture.

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The Use of Lead Indicators in Safety Culture Research: Measuring construction industry safety performance

Don Dingsdag
Herbert Biggs

INTRODUCTION

This paper investigates the potential of the development and applicability of measuring safety performance in the Australian construction industry based on a newly devised 'tool', Safety Effectiveness Indicators (SEIs). Its development emanates from a recently commenced research project funded by the CRC for *Construction Innovation* in partnership with Leighton Contractors, John Holland Group, Thiess Contractors and the Office of the Federal Safety Commissioner (OFSC). Nationally the construction industry has far more injuries and ill-health impacts than the Australian average, and pays one of the highest workers' compensation premium rates in Australia. Similarly, notwithstanding improvement in their rates, fatalities are too high. Yet, other than lost time injuries (LTIs) or similar 'negative' 'lag' performance indicators, reliable, comparable and standardised performance indicators are not available. An evaluation below of Positive Performance Indicators (PPIs) as an OHS performance measuring tool, based on a brief overview of its limited uptake in Australian industry, suggests that it does not reliably measure OHS performance. Similarly, other 'positive' or 'lead' indicators, which owing to word length limitations are not discussed in this paper, have parallel shortcomings. However, based on current workers' compensation claims and incidence of injury and illness there is a clearly demonstrable need to accurately measure safety performance on construction sites in order to improve industry performance. Likewise, in the pre-construction design and scoping phase, in the post-construction facility management stage of completed projects as well as in the repair, maintenance, minor alteration and addition (RMAA) functions, there is a need for reliable safety performance measurement. In part, these issues of safety performance measurability were addressed by Biggs et al. (2006), who while conducting research for *A Construction Safety Competency Framework* (Dingsdag et al. 2006a; 2006b) devised a matrix of safety cultural competencies determined by identified safe behaviours and safety management tasks (SMTs) for the Australian construction industry.

The research objectives for the current research project are to examine how safety cultural competencies and their associated safe behaviours, as well as leadership attributes and effective communication, can be proactively assessed predicated on whether they have a measurable impact on safety performance. It is suggested that, based on their current application in the construction industry, PPIs do not have the capacity to actually measure safety performance although some do recognise safe behaviours, leadership and communication as measurable characteristics of safety culture. Rather, as discussed below, PPIs tend to measure OHS processes, but not safety performance *per se*. In Australia the unsuitability of PPIs gradually became clear to industry, including the construction industry, after 1994 when the then National Occupational Health and Safety Commission (NOHSC) (also known alternatively as WorkSafe Australia) held two initial workshops/symposium to determine the viability of PPIs as an alternative to measuring OHS performance based on lag, or so–called negative indicators, such as LTIs. The difficulty of the measurability of safety performance by most known existing performance indicators is a recurring theme for this paper and the broader research framework of the current and former project. Arguably one of the most practical guiding principles of the measurability of safety performance is given in the Australian/New Zealand Standard, AS/NZS 4804: 2001 *Occupational health and safety management systems: General guidelines on principles, systems and supporting techniques* (AS/NZS 4804) which defines safety performance as:

> *The measurable results of the occupational health and safety management system related to the organisation's control of health and safety risks, based on its OHS policy, objectives and targets. Performance measurement includes measurement of OHS management activities and results.*

Perhaps ultimately, the most informative, yet simple, guidance for the efficacy of any performance indicator emanates from the UK HSE which prefaces one of the key sections of *A Guide to Measuring Safety Performance* by asking 'Why measure performance?' (HSE 2001, p. 6). This simple question is possibly best responded to by Peter Drucker' s often quoted, maxim, 'You can't manage what you can't measure,' which may seem trite, yet its straightforward exhortation seems to offer invaluable advice when attempting to measure safety performance effectively.

PPIS AND THEIR IMPACT ON SAFETY PERFORMANCE

During the currency of the research project that produced *A Construction Safety Competency Framework*, aside from identifying essential leadership attributes, communication and desired safe behaviours as necessary elements of safety culture, Dingsdag, Biggs, Sheahan and Cipolla (2006a) identified the measurement of safety effectiveness as a requirement for measuring the influence of these elements of safety culture on safety performance. However, aside from positing that these have a positive influence on safety performance, there is little validated evidence that the positive safety actions they generate actually influence safety performance positively. Other than anecdotal evidence from industry that safety culture impacts positively on safety performance and a plethora of academic literature that enthusiastically supports the implementation of safety culture, its benefits are largely premised on an article of faith: It is not unusual to hear experienced OHS professionals claim that they know it works, but that their claims are based on intuition, not on measurable criteria. Further, currently, there are no standard national or international PPIs or any other lead indicators measuring safety culture or safety performance that are accepted by the construction industry (nor any other industry) notwithstanding that the application of PPIs was enthusiastically advocated in 1994 by the then WorkSafe/NOHSC at a national symposium attended by all industry sectors' representatives (see, for example, NOHSC 1994b; 15-27).

A series of subsequent workshops and papers commissioned by NOHSC resulted in a consensus that, based on an industry-wide framework, individual organisations should develop PPIs to achieve improved OHS performance. Unfortunately no guidance was established relative to the development, application and valid measurement of PPIs. Significantly for this research, even though safety culture change was identified during the symposium, the use of safe behaviours as performance indicators was considered, but not developed sufficiently. Essentially, the identified positive performance indicators were mainly (but not exclusively) linked to non-behavioural processes and typically measured numbers of OHS-oriented activities and did not provide an indication of these activities' measurability. Examples, as espoused by NOHSC (1994b, 39) included:

- effectiveness of training programs
- effectiveness of OHS structures
- effectiveness of OHS representatives
- return to work rate.

This endorsement of the development of PPIs was a reaction to the perceived inability of traditional 'outcome' safety performance indicators, LTIs, or lag indicators, to measure success. They were condemned as being exclusively quantitative, negative, largely measuring failure; e.g. for lost time injury frequency rates (LTIFRs), the raw number of injuries sustained in an organisation per year and their frequency was obtained by dividing the number of injuries by (a notional) one million hours worked per annum. An inherent flaw resides in the assumption that all organisations work a million hours per year, which is not universally the case in the Australian construction industry for all but the largest contractors: small companies which only operate in the cottage sector, for example, employing only a few workers can perhaps attain only 10000 hours p.a. and are severely disadvantaged by the LTIFR generated as a result. Obviously, industry comparability is not possible. On the other hand, the capacity of PPIs to show improvement in safety performance, rather than negative outcomes, was explored at length by NOHSC, and their implementation was strongly endorsed largely predicated on the mistaken assumption that their success lay in their attributes, which unlike lag indicators, were qualitative and 'proactive.' The process of what PPIs should measure and how to devise standardised PPIs was also fully discussed eventually to the detriment of their implementation. Andrea Shaw, one of the NOHSC 1994 symposium's facilitators suggested that PPIs may not be sufficiently precise. Further, concerns were raised that PPIs may not be able to be generalised because there was no standardised application of PPIs (see NOHSC 1994a; NOHSCb). Briefly, common limitations of PPIs identified were that PPIs may:

- not directly reflect actual success in preventing injury and/or disease
- not be easily measured
- be difficult to compare for benchmarking or comparative purposes
- be time consuming to collect and collate
- be subject to random variation
- encourage under- or over-reporting depending on how they are measured …

… and that:

- the relationship between PPIs and LTIs was arbitrary
- they only measure the number of events and do not provide any indication or measure of effectiveness of each measured event.

It is the last limitation that has particular relevance for the issues raised in this paper. Another issue that militated against the uptake of PPIs was that for legislative purposes, such as recording and reporting injuries, mainly LTIs and the like are required under the nine disparate Australian OHS jurisdictions. Generally their format is guided by Australian Standard 1885.1-1990, known as the *Measurement of Occupational Health and Safety Performance: Describing and reporting occupational injuries and disease* or alternatively as the former NOHSC's *National Standard for Workplace Injury and Disease Recording*, which are both non-enforceable at law, but nationally and internationally recognised as an authoritative conformance document. Other than a cursory mention of PPIs in AS/NZS 4804: 2001 there is no equivalent standard for PPIs. The application of PPIs is and was strongly denounced in the performance measurement literature, most notably by Dr Edward Emmett, Chief Executive, WorkSafe Australia (NOHSC 1994a) who officiated at the 1994 symposium. On the other hand, the robust denunciation of lag indicators at the same symposium is still current in the construction industry notwithstanding that no reliable, comparable and standardised lead performance indicators have emerged.

In 1999 NOHSC issued an extensive report on the development of PPIs for the construction industry entitled *OHS Performance Measurement in the Construction Industry*. Based on several industry case studies a tripartite working group of industry, government and the union movement examined the possibility of implementing PPIs to measure safety performance in the construction industry. As with its 1994 strategy, NOHSC sought to develop a set of broad (and vague) PPIs that measured performance across the industry. Based on case studies of the various construction industry sectors the following PPIs were found to be commonly used, and support those identified by NOHSC (1999, 44, 45):

- Number of JSAs conducted
- Number of hazard inspections conducted
- Number of toolbox talks conducted
- Number of OHS inductions conducted
- Number of OHS meetings completed
- Number of OHS training exercises held
- Number of OHS audits conducted
- Number of OHS bulletins issued
- Number of OHS non-compliance reports issued
- Whether OHS procedures for critical works have been submitted by subcontractors (rated either yes or no)
- Whether there is evidence that surveillance of subcontractors is carried out (rated either yes or no)
- The frequency of on-site inspections
- The time taken to fix problems in accordance with the allocated timeframe
- General attitude to safety on-site (subjectively assessed by the OHS coordinator)
- Quality of records and documents related to OHS (subjectively assessed by the OHS coordinator)
- Commitment to safety overall (subjectively assessed by the OHS coordinator)
- The consistency of project managers in relation to OHS as a measure of the quality of OHS management in contractors (used informally and subjectively assessed by the OHS coordinator)
- Workers' rating of supervisors or project management's commitment to OHS
- Percentage of injuries incurred for major hazards
- Percentage of substandard conditions identified and corrected as a result of safety audits
- Results of independent (by people in the same company, but from different (sites)) and external audits; measured as number, regularity, quality outcomes and action taken to resolve non-conformances
- Time taken to get hazards under control once they have been identified
- Assessment of the availability and standard of PPE
- Number of hazard reports and feedback from toolbox meetings.

As well as suffering the common limitations of PPIs identified at the 1994 NOHSC workshops/symposium, it is readily observable that those PPIs that merely measure a number of activities without follow-up ('close out') actions, do not directly impact on safety performance. In fact, evidence gathered from industry focus groups held for the current research project strongly endorses what has been known for some time: that, typically other than collecting and collating these indicators, no follow-up action may occur. Hence it's entirely possible that historically there was no impact on safety performance at all, let alone that they may '…only measure the number of events and do not provide any indication or measure of effectiveness of each measured event' (NOHSC 1994a; 1994b).

THE DEVELOPMENT OF SEIS

As a consequence of the vagueness and broadness of PPIs and their measurement, what is undertaken for this research is the investigation of the development of a guidance framework for performance measurement that can be applied by individual organisations based on an industry standardised set of performance indicators suited to their particular organisational objectives and environment. At this stage of the research process we propose to develop a mechanism which may incorporate lead indicators that have demonstrated capacity to measure their impact on safety performance and combine those with measures of safe behaviours and safety cultural competencies. Simply stated, this research project seeks to create a mechanism to standardise and customise the measurement of safety effectiveness with valid and user-friendly industry-supported indicators that measure the effectiveness of specific proactive safety activities each company undertakes.

Even though since the 1994 NOHSC symposium and workshops, lag indicators have been repeatedly denounced in some academic literature and government reports (e.g. NOHSC 1999) as being negative and reactive, and by some academics (e.g. NOHSC 1994b) and practitioners as merely measuring failure; it may well be that LTIs, LTIFRs and a raft of other lag indicators give the most accurate measurement of performance or, in some instances, the lack of performance (refer to Table 23.1). At this stage of the current research project it is envisaged to examine a range of lag indicators as dependent variables with proposed lead indicators (which have not yet been fully definitively identified) as independent variables. The proposed methodology, based on a range of suggested lag indicators and lead indicators, will be industry-trialled and modified according to industry feedback.

Table 23.1 Table of Suggested Lag Indicators

Acronym	Rates
FAIFR	first aid injury frequency rate
FIFR	fatality incidence frequency rate
LTIFR	lost time injury frequency rate
MTIR	medically treated injury rate
NMTIR	non-medically treated injury rate
NDOR	notifiable dangerous occurrence rate
NII	non-injury incident or near miss/near hit
RTWR	return to work rate
WCCR	workers' compensation claim rate
WCPR	workers' compensation premium rate

Data from the two-year national research project (mentioned above) that investigated the motivators of safety culture and safety behaviours in the construction industry has provided a database (Dingsdag et al. 2006b) which identifies measurable safety behaviours informing the future formulation of SEIs. Based on approximately 70 interviews with managing directors, other senior management, construction site managers, union officials and semi-structured focus groups consisting of line and senior management of Australia's 11 largest principal contractors, Dingsdag et al. (2006b) identified the 39 SMTs outlined above that are considered critical to enhancing safety performance by the industry. Two survey instruments consisting of a management and worker questionnaire were administered nationally to the participating construction companies (for worker survey see Dingsdag, Biggs and Sheahan 2008). All of the findings were validated through interviews with senior officials of the ACTU, the principal construction sector union, the CFMEU, and senior managers of each of the OHS regulators in every state and territory. After the qualitative and quantitative data were collated and analysed, the results were taken back to each participating organisation for comment, suggestions for change and/or validation. To create SEIs was outside the scope of the research project, but the standardised measurement of safety actions and associated safety behaviours is seen by industry as a necessary complement to the 39 SMTs. Further, notwithstanding the above opinion that other than anecdotal evidence from industry, safety culture impacts positively on safety performance, the research project's investigation of the motivators of safety culture and safety behaviours in the construction industry data suggested that measurable safety behaviours have the capacity to formulate SEIs (Dingsdag et al. 2006). Other recently conducted research, notably Choudhry, Fang and Mohamed (2007), strongly endorse the measurability of safety culture elements. Further, this important article provided a useful (but incomplete) typology of the major safety culture/safety climate methodologies of which some also incorporate suggested (but largely inconclusive) methods of measuring safety culture actions.

However, the success of measuring safety culture/safety climate is complex, notwithstanding its strong endorsement in the literature. As mentioned above and discussed more fully below, according to Guldenmund (2007), safety culture/safety climate may not be able to be measured accurately at all. Further, other than the reasons examined above and below, at an industry level measurability of safety performance and safety culture is negated by the fragmented nature of the Australian construction industry which in the private sector consists of fewer than 30 very large principal contractor organisations and a similar number of 'second-tier' large principal contractors. Typically these organisations rely on a substantial component of large contractors employing up to 100 or more employees who in turn employ subcontractors, which may consist of two or three to fewer than 20 employees. It is also common to engage subcontractors who are the proprietor/only employee. Conversely, in some construction trades, such as in formwork, there are very large subcontractors employing 100 employees or more. Perhaps the distinction between contractor and subcontractor is notional other than in the contractual basis under which they are engaged. Additionally, construction workers may also be recruited from labour hire companies. In this manner the Australian construction industry employs approximately 900 000 people of which, according to industry informants, in NSW, up to 98 percent of the workforce is employed making principal contractors very small employers indeed relative to the total numbers in the industry.

Further, projects may last from a few months to a few years after which the project team moves on to another project and the safety culture and its safety performance dissipates. In addition, the industry is further fragmented, by the nature of the work undertaken, which includes the erection of commercial and residential highrise buildings, the cottage industry, building refurbishment and maintenance, facility management, road and bridge work, tunnelling, rail infrastructure, energy infrastructure including electricity transmission lines, pipelines of various types as well as the development of open-cut mines. Quite clearly, the industry is not uniform in terms of the work performed and organisational size, and hence organisational resources. In addition, each part of construction work has its own particularised context relative to health and safety hazards, associated risks, safety performance and performance measurement. Notwithstanding this variability, indicators should be based on the particular OHS risk exposure generated by the types of work and projects undertaken, yet they must be uniformly applicable and comparable across industry.

Consequently, in order to improve the industry's safety performance, other than the universally accepted lag indicators, other standardised performance indicators must be developed. In 2002 NOHSC held another workshop whose report also reflects the lack of standardised construction industry PPIs and the difficulty of their measurement (NOHSC 2002). Interestingly, during the currency of the 1994 NOHSC workshops, a common emerging theme was that PPIs should be flexible and particularised to conform to individual projects' requirements. From the data gleaned from the industry focus groups held so far for the current research project, it is gradually emerging that owing to the industry's reliance on commonly used standardised OHS procedures, lead indicators must also be standardised and be able to be applied uniformly to every sector of the construction industry.

Standardisation of OHS procedures in the industry is widely understood, although not necessarily consistently applied. 'Tools' such as hazard identification/risk assessments, even though there are variants, observe the same common principles; for example, (a) to proactively identify hazards, and (b) to identify, assess and evaluate the associated risks (for example as expounded in part in the globally accepted AS/NZS 4360: 2004 Risk Management). Similarly, the implementation of the appropriate control measures based on the universally accepted Hierarchy of Controls should be constantly applied across the entire industry. The premise for this unilateral direction is simple, yet based on irreducible principles of risk assessment, that, no matter how particularised the hazards of each construction industry sector may be, risk exposure must be undeviatingly minimised, or preferably eliminated if possible, by these principles. For example, even though the cottage sector, based on its construction processes, has almost completely divergent hazards from the tunneling sector's particularised hazards, the hazard identification, risk assessment and control processes are identical: hence, lead indicators should be consistently applicable.

Suggestions emerging from the industry consultation conducted for the current research project so far indicate that there are also common processes that were identified in *A Construction Safety Competency Framework* drawing on its 39 safety management tasks (SMTs). In particular, SMT1, Carry Out Project Risk Assessments, has been identified as having universal applicability and standardised measurability across all projects based on its process steps:

- Gather project information required to undertake the risk assessment (scope of work, contract requirements, legislative requirements)
- Select and form a risk assessment team (consisting of representatives from principal contractors, contractors and subcontractors)
- Conduct project risk assessment
- Identify risk controls (resources, people and procedural actions required), and ensure actions are completed (closed out).
- Communicate and review project risk assessment
- Review and control implementation progress.

Currently the project team is considering the scope and nature of the SEI(s) that may be able capture these steps quantitatively, or indeed whether it will be a quantitative measure. The current fluid stage of development is to develop a set of qualitative values for each SEI based on a sliding (quantitative) scale. However, some form of readily accessible and easily applicable enumeration may have to inform the qualitative aspects of the SEIs. This approach is appealing for several reasons: (a) the application of metrics is common practice in the industry so that the construction process itself is accurate and the product is not defective, as is the reliance on scoring/measuring safety performance quantitatively, (b) it is well understood, and (c) the reason for the ease of use is predicated on the industry principle that immediacy of measuring safety effectiveness on-site is imperative and must be usable by all on-site; otherwise the impetus will be lost and its essential linkage to measuring safety performance based on lag indicators will lose its significance as well.

Another way of characterising the on-site measurement of safety effectiveness may be that it represents the microcosm of the macro/global coordinating functions of capturing site data, correlating it with other site data and linking it to the appropriate global organisational lag indicators.

MEASURING SAFETY CULTURE

As indicated in the above abstract, in addition to there being no reliable safety effectiveness indicators that accurately measure safe behaviours, nor the positive safety actions they generate, nor their impact on safety performance, another major obstacle is that there is no known consistent and reliable measure of safety culture. Typically, as outlined briefly above, during the course of the current research project and the previous project alluded to above (Dingsdag, Biggs and Sheahan 2006a) industry respondents claimed they 'knew' that their site safety culture had a positive, but immeasurable, impact on safety performance. When prompted to say what the visible attributes of a vibrant safety culture might be, the most consistent response was 'good housekeeping.' The rationale proffered being that, if housekeeping were attended to regularly, the more essential safe behaviours and related actions, such as conducting regular proactive risk assessments, would also be more likely to be conducted properly. So far, other constant safety culture attributes indicated were:

- **'Good' toolbox talks**, i.e. those that were planned and based on two-way communication rather than a diatribe delivered without meaningful input. What was seen as essential in this regard was that participants' suggestions or concerns were listened to and, more importantly, 'closed out.'
- **Planned alignment of the disparate phases of the construction process**; for example, ensuring that the steel fabrication phase was completed in tradesman-like fashion and on time before the concrete pour began. The rationale is that, when each construction phase is systematically completed, contractors and subcontractors start on time without having to rush their task and, more importantly, without cutting corners, because that is when essential OHS procedures are likely to suffer.
- **Holding pre-construction/design phase meetings** with contractors and subcontractors where site- or task-specific safety management plans and safe work method statements (SWMSs) were prepared, based on meaningful input because of the positive impact these have on safety performance during the construction phase.

A 'lessons learnt' overview of safety culture and the related task and safety performance, undertaken either at the 'close out' stage of the project or about 60 per cent through the project, were also seen as having positive impact on the safety of current and subsequent projects. The latter suggestions were premised on the 'hard' or functional aspects of safety culture; the 'softer' attributes suggested were under the rubrics of visible and engaged leadership and collaboration, for example:

- regular site walk-arounds by senior management and/or board members
- all management regularly seen on-site (wearing the correct PPE)
- work done collaboratively (based on consultation)
- listening to each other
- the need to treat people as people and to have respect for the individual
- commitment from workers and from management built on mutual trust
- explanations given of why actions suggested at toolbox talks/pre-start meetings were undertaken or not.

Relative to the measurability of safety culture investigated in the literature Choudhry et al. (2007, 1000) make the observation that,

> *Traditionally, organizational culture is measured through the application of qualitative methods, such as observations and interviews. Nevertheless, the three main dimensions (psychological, situational and behavioral) can be measured through a combination of qualitative and quantitative methods (Cooper 2000). The situational aspects of safety culture can be seen in the structure of the organization; policies, working procedures, management systems, etc. The behavioral aspects of safety culture can be measured through peer observations, self-reporting and outcome measures. The identified safe behaviors are placed on observational checklists, and trained observers regularly take observations which are then translated into 'percentage of safe scores' to provide feedback to those being observed. The psychological dimension is most commonly examined by safety climate questionnaires devised to measure people's perceptions of safety.*

However, the examples of the models they claim do measure the essential elements of safety culture are all human-resource-intensive and some may also be capital intensive:

> *For example Kennedy and Kirwan (1998) … developed the Safety Culture and Operability (SCHAZOP) approach that focuses on the many aspects of safety management practices. It deals with day-to-day activities, including safety management, real roles and the personnel fulfilling these roles. One drawback of the SCHAZOP approach is that it is very resource intensive.*

(Choudhry et al. 2007, 1001).

Similarly, according to Choudhry et al. 2007, 1001):

> *Cox and Cheyne (2000) incorporated behavioral indicators in their 'Safety Assessment Toolkit' along with climate questionnaire and semi-structured interview schedule. Cox et al. (2004) conclude that behavioral safety is effective in increasing employees' confidence to challenge unsafe practices, as well as highlighting examples of best practice. Behavioral safety process (BSP) supports cultural realignment towards a 'safety first' culture. They indicate that the BSP is an effective motivational tool that assists in both individual behavior and attitude change. Although measurement of safety culture depends on how it is defined (which in turn reflects the adopted perspective), ethnographic approaches are often costly and time consuming. Additionally, they tend to produce discovery data rather than hard data that can be incorporated into a management action plan.*

In other words, BSP is effective, but resource-intensive, and it may well be that, similar to PPIs, they may produce 'discovery data', or what was characterised above as mainly measuring process rather than 'hard data' defined as actions above. Further, the misgivings about the usefulness of the data produced by Choudhry et al. (2007) align with the concerns expressed above about the capacity of PPIs to influence safety performance significantly if at all.

Guldenmund adds another dimension to the accurate measurability of safety culture and/or safety climate. He provides a trenchant critique of 40 per cent of the 27 sources listed and characterised by Choudhry et al. (2007, 997-998). Refreshingly Guldenmund (2007, 727) also criticises his previous work. He writes:

> *In my 2000 paper (Guldenmund 2000) I proposed four principal 'attitude objects' with regard to safety climate – hardware/physical environment, software, people and risk – these partly being taken from Cox and Cox (1991). However, this classification is too coarse and unspecific to be of any use.*

This comment follows from Guldenmund's generic critique of questionnaires which interesting flies in the face of the data obtained from the initial 12 industry focus groups held so far during which questionnaires were identified by several participating construction companies as providing reliable and replicatable data. It is important to remember in this context that Guldenmund's paper is devoted to the generic application of safety culture/safety climate survey instruments, not those specific to the construction industry: yet, the methodological issues raised relate equally well to those that apply to the construction industry.

The opening paragraph of Guldenmund's paper abstract goes to the heart of generic safety culture/safety climate research so far: it also strikes at the heart of the research problematic for the current research, that is,

> *Questionnaires have not been particularly successful in exposing the core of an organizational safety culture. This is clear both from the factors found and the relations between these and safety indicators. The factors primarily seem to denote an overall evaluation of management, which does not say much about cultural basic assumptions. In addition, methodology requires that levels of theory and measurement are properly recognised and distinguished. That is, measurements made at one level cannot be employed at other levels just like that unless certain conditions are met*

(Guldenmund 2007, 723).

First, Guldenmund addresses the unknowable aspects of how and how well safety culture influences safety performance. This methodological hurdle was encountered during the past and current research undertaken by this project team. Those obstacles are briefly addressed above. Second, if Guldenmund's position on safety culture/safety climate holds, then the relationship between what he labels safety indicators, and the current research, Safety Effectiveness Indicators, and the efficacy of safety culture makes the research challenge for the current project even more complex than at first the project team might have predicted. Guldenmund (2007, 727) asks:

> *So, what kind of information do we collect with questionnaires? Although we intend to uncover an underlying trait called culture, the questionnaires invite respondents to espouse rationalisations, aspirations, cognitions or attitudes at best, that is, the very thing called espoused values by Schein (1992). Obviously, one could still argue that behind all these espoused values the 'true' shared values, if any, hide, but it takes a lot of deciphering and a creative analyst to uncover these. Hence, we are stuck with a set of factors and scores on them but we do not know what they really mean or imply. We maybe have an answer to the what question but we certainly do not know why. Basically, we are back where we started from with trying to figure out why this company shows these artefacts and expresses these espoused values. Or, put in another way, survey research does not yield processed climate or culture results but rather provides another source of raw data to extract an organisational culture from.*

Guldenmund poses a highly relevant question for the current research project; that is, what kind of information do we collect; how is it measured and how can the data be correlated with safety performance? Yet, he also provides a solution to this dilemma. To this end Guldenmund proposes a nine-process model that encompasses the entirety of the safety management system of an organisation. It has a more than reasonable fit with the way in which larger construction organisations (principal contractors and the larger contractors/subcontractors) are organised. It is predicated on three levels: organisational, group and individual across the nine processes of risks, hardware design and layout, maintenance, procedures, manpower planning, competence, commitment, communication, and monitoring and change. Each of these has resonance with the SEIs identified so far for the current project although they may have somewhat slightly different designations.

Further, Guldenmund's three levels (2007) of organisational, group and individual have commonalities with the concerns relayed during the currency of the previous, and current research project by industry focus groups; for example, the remoteness of senior management (organisational level) was a recurrent theme. Similarly, the importance of on-site (group level issues) were raised. Guldenmund (2007) addresses common 'barriers encountered/used by the work group to control the risks they face during the execution of their primary tasks.' We used the example above of ensuring that the steel fabrication phase was completed in tradesman-like fashion and on time before the concrete pour began so that contractors and subcontractors start on time without having to rush their task and, more importantly, without cutting corners in safety. Similarly the project research has identified most of Guldenmund's individual elements (2007). Presence of rules, procedures and work instructions for a particular task and their level of detail relates directly to the development of SWMSs and/or JSAs (job safety analyses). After further consultation with industry it may well be that Guldenmund's seminal paper (2007) provides the key to developing SEIs that have the capacity to improve safety culture.

CONCLUSION

The challenge for the current project is to develop reliable, comparable and constant indicators that measure safety performance without the drawbacks commonly attributed to PPIs: in other words, they must be easily measured and be able to be compared for benchmarking purposes within sections of an organisation and across industries without being subject to random variation. For the construction industry specifically, they must be able to be implemented uniformly from project site to project site notwithstanding the disparate sectors of the industry, the variability of the work undertaken and the diverse risk contexts these generate. Further, they must be simple to implement so that they are not capital- and human-resource-intensive: They must not be so complex that they are time consuming to administer and collate and they must measure effectiveness instead of simply measuring a number of events which have no demonstrated effect on safety performance.

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Development of a Practical Guide to Safety Leadership: Industry-based applications

Herbert Biggs
Don Dingsdag
Colette Roos

INTRODUCTION

Developing safety culture and improving safety performance are current challenges for the Australian construction industry. Although there have been improvements in OHS performance over the past 20 years, the injury and fatality rate in the Australian construction industry remains a matter of concern (ASCC 2006). The notion of safety culture has been identified as a useful concept to help understand what safety behaviour is expected in industry (Choudhry, Fang and Mohamed 2007; Cox et al. 1998; Glendon and Stanton 2000). Improving safety culture is an important step toward embedding safety awareness and compliance in everyday practices in industry (Guldenmund 2000; Farrington-Darby et al. 2005). Current research has identified that positive safety culture is correlated with positive improvements to traditional lag indicators such as injury and time off work (Dodsworth et al. 2007; Silva, Lima and Baptista 2004). The problem for industry is how to create and maintain a positive safety culture in different organisations.

Recent investigations into construction site safety culture (Biggs et al. 2006; Dingsdag et al. 2006) have provided a means through which the industry could address this issue. Previous research, with significant input from industry, developed the Construction Safety Competency Framework (Dingsdag et al. 2006) which identified 39 safety management tasks and 11 safety-critical positions which are crucial to understanding which safety position in an organisation is responsible for what safety task. Specific safety positions were ranked with either a 1 or a 2 indicating the level of proficiency and understanding, respectively, that the position occupant needed to demonstrate on each of the safety tasks, a score of 1 indicated that a full understanding was required, while a score of 2 indicated that working knowledge was necessary. The safety-critical positions within the industry that have a significant impact on safety culture were mapped, and the behaviours and competencies required to successfully drive a positive site safety culture were identified. Essentially, the competency framework identified, in detail, what process should be followed when completing particular tasks; the knowledge, skill and behaviour required to complete the task effectively; and what cultural outcomes should be achieved if the task is completed effectively (Biggs, Dingsdag and Sheahan 2006). The framework also provided some initial recommendations to industry on training, mentoring and employee motivation. The competency framework proved to be a useful tool in developing safety culture, but feedback from industry indicated that further resources were necessary for industry personnel to be able to adopt the recommendations put forward in the framework.

This chapter reports on a project to continue development of the *Construction Safety Competency Framework* by formulating comprehensive implementation guides for the safety management tasks and safety-critical positions identified in the framework. Developmental issues, industry liaison processes, and stakeholder ownership issues are discussed as well as future implications for skill acquisition of safety-critical tasks, and recruitment and professional development concerns. The anticipated outcomes have the potential to enhance current safety skill and behaviour acquisitions in first-tier construction companies and greatly assist the strategic development, planning, and implementation of these skills and behaviours in second-tier construction companies and associated contractors.

RESEARCH METHOD

In order to develop a useful implementation guide for the framework, it was important to firstly identify the sections of information that would help industry to begin to implement the framework in a systematic and efficient way. It was also important to highlight the fact that the framework should be customised to meet the needs and level of safety competency already within the organisation. To this end, preliminary development of the guides commenced, a brief 'how-to-implement' document was conceived, and industry participation was sought. Following feedback from industry and corporate partners, several modifications to the original development of the guides were made to the final version. The original concepts are presented below, followed by information gained from industry partners and finally the presentation of the final implementation guides is described.

Developmental issues

Initial decisions were made about the audiences, the presentation of the implementation guides and the type of information the guides were potentially to contain, prior to seeking industry comment. Beginning with the audiences, of the 11 safety-critical positions that were identified in the framework, four superordinate categories, or framework implementation audiences, were created. These categories aimed to collapse the 11 positions into more workable categories for the presentation of the information. It was thought that not all companies would employ staff to fill each of the 11 individual positions identified in the competency framework, especially in smaller organisations. For parsimony, the four categories were: senior managers (inclusive of CEOs and senior managers), safety professionals (inclusive of national safety managers, regional safety managers and state safety managers), engineers and project managers (inclusive of engineers, project managers, and construction and operations supervisors), and construction site managers (inclusive of site managers, foremen and site OHS advisors).

In presenting the information in the guides, the four audiences were targeted in brochure and folder format, and to gain a more useable and readable document, it was decided to highlight different sections of the skills matrix in each brochure for easy reference. Therefore, each of the four audiences' tasks which scored a 1 or a 2 were collated and presented as an example of what safety-critical tasks might be the responsibility of which safety-critical roles. A 'safety snapshot' was also included highlighting how to customise the competency framework to suit each organisation's needs. The 'safety snapshot' would enable an organisation to take a snapshot of how their current occupational health and safety concerns are being met, and include sets of ideas on how they can positively progress meeting these concerns.

In addition, it was decided to seek industry feedback on the information medium for specific elements in the preliminary guides. For example, it was thought that the construction line managers represented staff 'on the ground' and they may use a plasticised flipchart-type brochure which could be carried in the pocket. Additionally, CD-Roms were planned to be included in each guide, which would include web links and other useful information for industry professionals. The practicality of the CD-Roms would also be investigated in the focus groups.

Overall, the intention was that the guides would contain information gleaned from the original framework document, and added information about how to use the guides, with emphasis on the customisability of the framework.

Industry liaison process

Industry feedback was sought to determine if the ideas on audience, presentation and information were able to aid industry to adopt the competency framework into part of their day-to-day accountabilities. Several first-tier and some second-tier companies were contacted and invited to take part in evaluating the draft implementation guides. Draft guides were sent to industry professionals and face-to-face focus groups followed.

Focus groups

Ten focus groups were held across Eastern Australia with people in a range of different positions from both first-tier and second-tier organisations. The focus group discussions lasted approximately one and a half hours and were structured around the appropriateness of the implementation guides, including the audiences, useability, usefulness, and the media used. The information gained from these focus groups was instrumental in helping to identify strengths and weaknesses in the initial guide concepts.

For example, in terms of audience, most first-tier companies did have staff in most or all of the original 11 roles, including some organisations who had identified more than the original 11 for their organisations. However, feedback from second-tier companies indicated that they only have staff in the four super ordinate roles (i.e. senior manager, safety professional, project designer and construction line manager). This and other positive feedback about the audience groupings helped to strengthen the rationale for the super ordinate categories of safety-critical roles; however as will be seen in the final document, the focus on the presentation of the guides based around the four categories of safety-critical roles was de-emphasised. This was primarily due to indications that the safety implementation would most likely come from an internal central source such as the HR safety manager rather than be immediately disseminated to individual employees or employee groups.

Other main points of discussion indicated that most industry representatives did not think that construction site managers would carry the plasticised flipchart in their pockets, altering the focus from something the site managers would carry with them, to something the site managers could have implemented into their day-to-day working practices. The CD-Rom also caused a significant amount of comment from the industry professionals. Interestingly, some companies did not have CD/DVD readers in their computers for security reasons. In addition, a perusal of industry intranet sites indicated that the industry already has a great deal of quality information and web links developed for their intranet. Therefore, it was deemed unnecessary to provide a detailed list of sources of information since, firstly, employees might not be able to access it; secondly, it would be reiterating information that employees already had access to; and, thirdly, the information provided would be outdated very quickly and would need continual updating and there were no identified resources to assist this process.

The focus groups were also very useful in detailing the types of information organisations would like to see in 'how-to-implement' tip-sheets and flowcharts. Discussions mainly centred on an initial mapping procedure to help give the organisation an idea of where they presently were in regard to achieving a safety culture whereby each safety management task had an employee responsible for ensuring that the task could be completed and monitored effectively. It was determined that the guides would provide a brief instruction and a workbook for enabling the organisations to gain a snapshot as to where they were currently in the safety culture environment.

Interestingly, many first-tier organisations, with sufficient resources, has already begun to map and implement the tasks and positions included in the competency framework, while several second-tier organisations were struggling with the complexity and detail in implementing the framework with significantly less resources.

Following the initial focus group which indicated that the organisation had been attempting to implement the framework, it was decided to solicit case studies from organisations who were already working down that pathway. Therefore, several first-tier organisations were approached and agreed to provide examples or case studies as to how they initially tackled the task of beginning to map and implement the competency framework within their organisations. In keeping with the notion of customising the competency framework to suit pre-existing safety matrices and internal structure within organisations, each company began the implementation in different ways. It is believed that the 'tip sheet' and 'industry case studies' will vastly improve the understanding and accessibility of the framework, particularly for second-tier organisations where such information fulfils both an informatics and mentoring function.

The importance of the focus groups with industry professionals cannot be underestimated. Not only do they provide valuable and knowledgeable feedback about the usefulness of the information to industry, but the participants also become stakeholders with ownership of the finished product. Their input helps shape the finished product and therefore the authors can be more confident that their product will be both accepted and valid for industry use.

In summary, it was decided to deemphasise the format of the four audiences and focus on the steps involved in customising the framework within differing organisations.

FINAL FRAMEWORK IMPLEMENTATION GUIDE

The final guide looks quite different to the original guide sent to industry for comment. Although the premise of aiding companies to customise the framework to suit their individual needs stays intact, the presentation of the guides has changed. The focus on presenting the guides based around the four audiences has been altered. The presentation focus now is on the steps necessary to customise the framework and therefore draws more heavily on an operational flowchart contained in the original document. This flowchart identified eight steps to implementation, including understanding safety culture, identify safety-critical positions, customise the task and position matrix, plan, adapt the competency specifications, use a step-wise approach, implement, and show continuous improvement. The final guide includes a substantial unpacking of these flowchart steps, defining them, identifying why each step is important, and detailing how the company can implement this step in their organisation. Furthermore, each step contains action 'tickboxes' to complete, and are illustrated using one or more case study excerpts from industry activity.

The guide contains two workbook-style components which can be used to start to implement the framework in a workshop, pen-and-paper style. Firstly, the action lists from each of the eight framework flowchart steps are consolidated into one action document to help prompt organisational personnel and identify subsequent steps. Secondly, several questions and a blank matrix were included that will help organisations perform a current status health check on their company. The questions help identify whether an organisation (a) already has a safety management task in their organisational documentation, (b) already has a role responsible for a safety management task, and (c) already has a training program teaching particular safety management tasks. Following this exercise, the organisation can begin to complete the 'blank matrix', a matrix from the original competency framework with the safety-critical positions list removed so that companies can identify, in the context of their own organisation, which position is responsible for which task.

The full case studies from organisations that have already begun to adopt elements of the framework are also presented in entirety including 'key learning' approaches for each. These case studies and key learnings cover adoption areas such as customising the framework, recruitment and selection, continuing education, and effective communication and can act as a catalyst for organisations wishing to customise their own solutions across their critical safety positions using a number of the 39 identified safety management tasks.

Additionally there is a CD containing the information provided in the guide in accessible electronic format. No additional website links or other additional information is provided, based on feedback from the focus groups.

A hard and electronic copy of the original 'Construction site safety competency framework' document is also included as a resource.

AREAS OF USE

The full usefulness of the framework and the implementation guides will be seen as companies embrace the need for a consistent and thorough means to identify the safety strengths and weaknesses they presently have in their organisations. Once companies move forward to identify the safety-critical positions in their organisations and map the responsibilities inherent in those positions to specific safety management tasks, they can begin the job of evaluating and monitoring the critical safety tasks and behaviours of employees in those safety roles, and thus improve safety culture. There are many ways to evaluate, monitor and manage those roles to ensure employees are committed to achieving a positive safety culture. For example, steps can be made in performance management, recruitment and selection, and professional development. Some brief examples follow (see Biggs, Dingsdag and Sheahan 2006).

Performance management

After identifying that the employees hold the required competencies, it is then important to promote the desired behaviours. This could be done by linking behaviours to existing performance management and appropriate reward systems. For instance, an employee may be motivated to increase their safety communication by a management requirement that they show evidence of this behaviour in order to receive public recognition or even a satisfactory performance review. Incorporating safety competency and demonstrated safety performance improvement in performance appraisals reinforces organisational values while also giving incentive to individuals to focus on safety as part of their everyday actions.

Recruitment and selection

Selecting new employees who have the competencies required to successfully maintain and develop an appropriate safety culture is one method an organisation can use to improve safety. For example, a construction company seeking an engineer may assess candidates for communication, leadership styles, and attitudes and beliefs about safety. By structuring the assessment process around key competencies it is possible for organisations to exclude people who are most likely to have a negative impact on safety culture. The skill and safety competency level of existing employees is also an issue. Hence, a robust training system based on adult learning principles also needs to be in place.

Professional development

A set of safety competencies should make clear to the organisation the difference between an employee's current behavioural competencies and the behaviour that is required. After conducting a traditional training needs analysis, the organisation should develop a training plan to develop the skills, abilities and behaviours required by employees to improve safety culture.

Additionally, by standardising and integrating core safety culture competencies into the organisational safety management and HRM system, it is possible to mitigate the behavioural skills loss when employees shift to new projects either with the organisation or with another construction company. The greater the uptake of standardised safety culture competencies by individual organisations, the more uniform safety practice will be across the industry.

First-tier and second-tier implications

The project investigations have made it very clear there is a substantial gulf between first-tier and second-tier construction companies in the development and expansion of critical staff positions matched to safety management tasks. While second-tier companies that were interviewed identified with the super ordinate four safety-critical positions (i.e. senior management, safety professional, project designer and construction line management), the identification of these categories was relegated to a smaller focus in the final document. However the important notion that companies need to customise the competency framework for their organisation in terms of number of safety-critical positions ranging from four (in second-tier organisations) to 11 or more (in larger organisations) was stressed on several fronts.

Almost universally first-tier companies have developed systems to recruit for, train for, and perform for, improving safety outcomes. There is no doubt that substantial savings to the industry overall could be made by some rationalisation and sharing of these systems and procedures across the sector as a whole. The authors have seen some examples of that occurring and expect that such common use will be a feature of future efforts to gain equivalency, and easier systems to facilitate competency assessment in a human resource environment of significantly shifting workforces across organisations and projects.

The second-tier companies are somewhat more challenged. With fewer resources and fewer specialised safety-critical positions, they are not generally able to adopt immediate and ongoing strategies to implement the entire 39 safety management tasks of the framework in a short timeframe. It is thought that the Practical Guide to Safety Leadership would be of greater practicality to second-tier organisations in that they could commence (or advance) the customised development of their own way of handling the 39 safety tasks, by selecting those of greater priority and adopting them initially, and then proceeding to adopt more SMTs as priorities and resources allow – a process undertaken at all times within the competency framework broadly accepted by first-tier companies and the Office of the Federal Safety Commissioner.

FUTURE PROGRESS

Following an industry launch of the Practical Guide to Safety Leadership, a series of industry workshops is planned for key cities across Australia which will facilitate the use of the Practical Guides in organisations. The workshops will be structured using workbooks developed by the current authors and industry experts, and participants will have the opportunity during the sessions to develop and retain their own implementation plans.

The combination of a discussion of the framework intentions, a review of how other organisations are currently implementing it, and a practical exercise to develop a customised implementation plan for each workshop participant organisation should provide an ideal and practical learning opportunity for framework adoption.

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Part 6
Facilities Management

FM Exemplar Project: Sydney Opera House

Stephen Ballesty

INTRODUCTION

The Facilities Management (FM) Exemplar Project: Sydney Opera House was a research project initiated by the FM Action Agenda in April 2005 and completed in November 2006. The FM Action Agenda's strategic plan entitled *Managing the Built Environment* provided a reform framework for the public and private sector alike, and together with FMA Australia and allied industry bodies, set the direction to achieve the vision of a more 'productive and sustainable built environment through inmproved innovation, education and standards.'

The FM Exemplar Project was supported by the Australian Government and conducted as a CRC for *Construction Innovation* project with a team of 25 individuals from 10 other supporting organisations. The team was led by Rider Levett Bucknall, and included representatives from Brisbane City Council, CSIRO, Queensland Department of Public Works, QUT, Rider Levett Bucknall, RMIT, Sydney Opera House, Transfield Services, University of Sydney, and Woods Bagot.

The FM Exemplar Project, centred on one of Australia's most recognisable icons, focused on three key FM research streams of digital modelling, services procurement and performance benchmarking. Another distinguishing feature of the project that sets it apart from previous research was the project's objective of linking each of these three streams together to produce an integrated FM framework. To achieve this, firstly the three research themes were investigated as follows:

- **Digital modelling research**: aiming to develop a digital model based on the 3D digital building models to assist in the integration and automation of FM information.
- **Services procurement research**: aiming to develop a performance-based procurement framework for FM service delivery. Service requirements were defined in terms of performance objectives, assessment techniques and decision-making strategies.
- **Performance benchmarking research**: aiming to develop an FM benchmarking framework that comprised performance measures, methods and procedures, and deliver benchmarks which enable facilities/organisations to identify best practice and improvement strategies.

Further, the FM Exemplar Project considered Sydney Opera House's business objectives and functional requirements holistically and in the context of the 2005-06 total asset management plan to formulate an integrated FM solution. The project showcased ways to improve FM performance and promote best practice to better measure and manage the economic, social and environmental impacts of FM across industry, business and the community.

DIGITAL MODELLING

The FM Exemplar Project has developed an appropriate Building Information Model (BIM) strategy and investigated the potential information systems to enable a future integrated platform to support FM activities and processes for this Australian icon. BIM offers many advantages for the FM industry particularly as an integrated data source which is model-driven and provides data consistency and system functionality.

Using this approach, several advantages can be envisioned: consistency in the data, intelligence in the model, multiple representations, an integrated source of information for existing software applications, integrated queries for data mining, etc. The standardised BIM acts as main data structure which can be extended with other data sources as each element (wall, furniture, room, grouping elements) has a unique identifier. This unique identifier can be used to correlate different datasets opening up query capabilities across different datasets.

The industry foundation classes (IFC) (an open building exchange standard) provides comprehensive support for FM functions, and offers new management, collaboration and procurement relationships based on sharing of data. The major advantages of using an open standard are: information can be read and manipulated by any compliant software, reduced user 'lock in' to proprietary solutions, and third party software can be the 'best of breed' to suit the process and scope at hand. Standardised BIM solutions consider the wider implications of information exchange outside the scope of any particular vendor, information can be archived as ASCII files for archival purposes, and data quality can be enhanced as the now single source of users' information has improved accuracy, correctness, currency, completeness and relevance.

The current availability of FM applications based on BIM is in its infancy but focused systems are already in operation internationally and show excellent prospects for implementation systems at Sydney Opera House. To support the FM processes using the IFC, guidelines and modelling practices have been formalised in the form of a Sydney Opera House specification. This specification describes how Sydney Opera House-specific information and conventions can be incorporated in the BIM. Tests with partial BIM data demonstrated that the creation of a complete Sydney Opera House BIM is realistic, but subject to resolution of compliance and detailed functional support by participating software applications.

The FM Exemplar Project has demonstrated successfully that IFC-based exchange is possible with several common BIM-based applications through the creation of a new partial model of the building. Data exchanged has been reasonably geometrically accurate, notwithstanding that Sydney Opera House's structure represents some of the most complex building elements and supports rich information describing the types of objects, with their properties and relationships.

Furthermore, the use of the IFC model offers even more advantages as it addresses the importance of interoperability between software systems. The adoption of digital modelling systems does not only manage primary data more effectively but also offers practical systems for detailed monitoring and analysis of facility performance that underpin innovative and more cost-effective management of complex facilities.

The FM Exemplar Project research was the basis for the CRC for *Construction Innovation*'s publication in April 2007 of *Adopting BIM for facilities management.*

SERVICES PROCUREMENT

The services procurement research focused on procuring building maintenance and cleaning services, especially in-house versus outsourcing methods, and collaborative tendering in the context of the user's requirements, organisational culture and service provision reliability and risk sharing. A multi-criteria assessment approach is being investigated to support decision-making strategies and guidelines for selection of appropriate FM procurement routes.

The FM Exemplar Project centred on the Sydney Opera House to produce an initial procurement systems review. This review analysed the strategic objectives and operational requirements to formulate Sydney Opera House 'demand statements' as evaluation criteria in the service procurement process. The subsequent procurement approach considers the elements contributing to the criteria for decision-making in the service procurement process.

The services procurement research concentrated on procurement strategies and innovative methods using a case study approach, and outputs included:

- Documented FM innovations and experiences at Sydney Opera House, and a proposal for a decision-making framework and guidelines for selection of FM procurement routes to provide a useful model for the FM community.
- An integrated performance framework to link maintenance service functions to high-level organisational objectives and strategies.
- Procurement methods and contract outcomes focusing on building maintenance and cleaning services.
- Multi-dimensional assessment of service providers and general decision-making strategies and guidelines for selecting FM procurement routes.

Whilst the current case study approach emphasises the experience of Sydney Opera House, a study of procurement strategies and methods from published research and FM good practice will supply facilities managers with alternative procurement routes.

Further research on the procurement theme will develop a final decision-making model for the procurement of FM services, drawn from the evaluation of the case study outcomes, as well as further investigation of FM good practice and findings from other published research.

PERFORMANCE BENCHMARKING

Performance benchmarking focused on the strategic asset management of facilities similar to the Sydney Opera House, with a bias towards performing art centres. In identifying the success factors for the functional areas of FM and delivering a benchmarking framework and recommendations on implementation of best practice, the FM Exemplar Project conducted a two-stage survey of iconic facilities.

These surveys and the research findings provided a basis to develop high-level key performance indicators (KPIs) against organisational objectives in order to better monitor, control and improve FM performance. Participation from international comparators of iconic status was sought as part of the study. Collaboration between services procurement and performance benchmarking research included sharing of the survey data and use of KPIs to support innovative procurement strategies.

A key finding was that benchmarking is a crucial decision-making tool for organisations and processes; however, the application FM benchmarking is not widespread or consistent. Further, the responses provided insights into scope, methods and frequency of facilities assessments and the nature of stakeholders on which perceptions of quality are based. While anecdotally the performance drivers for iconic facilities have been seen as unique, the research suggests that they have considerable elements in common with typical FM practices.

Analysis of the benchmarking data from The first stage survey has identified that the highest-order items which should be considered core to a FM benchmarking framework would include:

- condition: building structure and services, public spaces, internal fittings and finishes
- energy management: rate of consumption and management
- accessibility: security provision and information for visitors
- contractor's performance: quality of service, safety, timeliness and compliance.

The second stage survey focused on more detailed information, particularly regarding condition assessment and energy management, in order to evaluate the resourcing, data collection and reporting cycles.

Further survey responses have also identified the high-level status drivers (by ranking) as:

1. functionality
2. landmark status
3. operational efficiency
4. cultural heritage.

Measurement metrics and KPIs should be tempered by the corporate objectives and culture. For iconic facilities, and specifically performing arts centres, this may require reference to the mission of vision or such issues as the 'six areas of key performance for arts centres – recognition for excellence, value for money, pride in a key symbol, 'the experience', artistic and industry development, and access and equity'.

Further research on the FM Exemplar Project outputs would assist in developing a broader FM benchmarking framework which could have applications to other facility types and benefit the FM industry and the community at large.

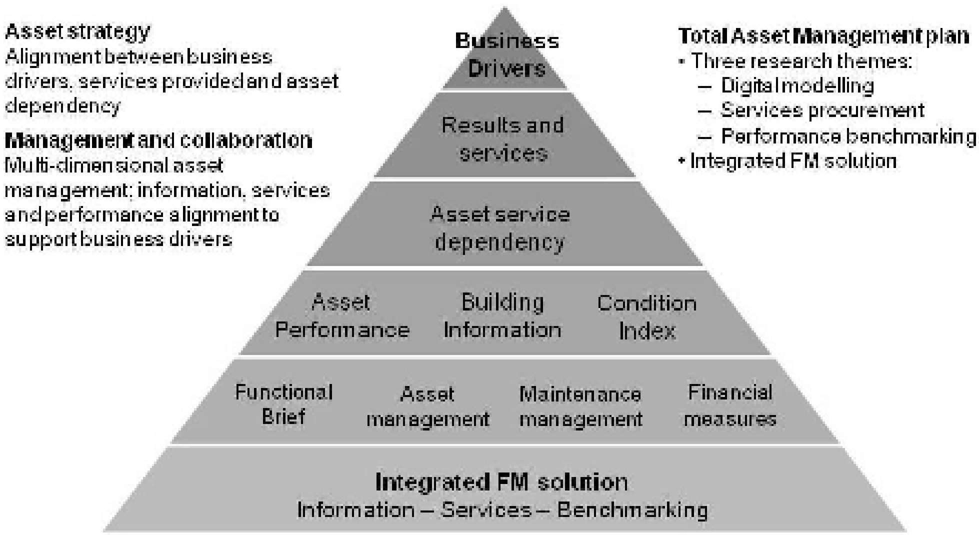
INTEGRATED FM SOLUTION

The digital modelling, services procurement and performance benchmarking research streams present different dimensions of the FM equation. Collaboration across these three research themes is considered crucial in improving the performance of FM and its ability to support an organisations' corporate objectives. This research in part aimed to develop an integrated FM solution that supports the Sydney Opera House's total asset management plan (TAM Plan) through an integrated model that utilises information, service, performance and business alignment.

This integration report reviews the three research streams and their relationship with the higher-level Sydney Opera House Asset Strategy and TAM Plan developed by Rider Levett Bucknall in 2005–06 to demonstrate the need for alignment of FM information, services and performance to support overall business

The defining aspect to the FM Exemplar Project is the collaboration between the three research themes and the prospect of real progress towards an integrated FM solution, as depicted in Figure 25.1.

Figure 25.1 FM Exemplar Project as an Integrated FM Solution



OUTCOMES

The final report of the FM Exemplar Project: Sydney Opera House, integrating the digital modelling, services procurement and performance benchmarking research streams, titled *FMas a Business Enabler* was published in February 2007. This was followed by a second publication in April 2007 focused on the digital modelling outputs, and titled *Adopting BIM for Facilities Management.*

In the final report, *FM as a Business Enabler*, our research outcomes were aligned within the broader context of Sydney Opera House's total asset management plan in support of their business enterprise. The need for alignment of services, performance criteria and supporting information with an organisation's business goals and objectives was a key finding of the research project and that:

- data is 'king' in pursuing FM excellence and supporting total asset management
- digital modelling and building information modelling standards using industry foundation classes (IFC) with open system architecture for interoperability must be endorsed
- effective services procurement, inhouse or outsourced, requires alignment of FM deliverables with organisational culture
- performance benchmarking should support organisational objectives in order to better monitor, control and improve FM performance and its contribution to the business enterprise
- an integrated FM solution should, as a minimum, consider information, services and benchmarking with KPIs and metrics reflecting the business drivers.

It was shown that digital modelling technology could be used as an effective tool for assisting in this process. Other findings of the research included the value of ensuring that contractors understood the facility's organisational culture and the need to use performance benchmarking to develop effective KPIs that integrated with organisational objectives.

RECOGNITION

Sydney Opera House was added to UNESCO World Heritage Listing on 28 June 2007 as a facility of global significance. In turn the FM Exemplar Project recognises the importance of *FM as a Business Enabler* as a means of achieving a more productive and sustainable built environment.

In May 2007 at FMA Australia's *Ideaction* conference gala dinner in Sydney, the CRC for *Construction Innovation* received the Facility Management Association of Australia's Rider Hunt Terotech Industry Achievement Award for excellence in facility management strategy and practice for their work on the FM Exemplar Project: Sydney Opera House.

The digital modelling component of the FM Exemplar Project research also featured in two recent Arup-sponsored international awards – the Jury's Choice category of the American Institute of Architects (AIA) Technology in Architectural Practice (TAP) 2007 Building Information Model (BIM) awards, and the Bentley Awards for Excellence 2007 award for BIM in multiple disciplines. Recently, *Adopting BIM for Facilities Management* was awarded the Association of Consulting Engineers Australia (ACEA)'s 2007 Project of the Year.

CONCLUSION

The FM Exemplar Project represents an excellent opportunity to use the iconic nature of Sydney Opera House to answer some unique FM challenges, and to support the FM Action Agenda in promoting the benefits of improved information, service delivery and performance for the benefit of the FM industry, stakeholders and ultimately the community.

Despite its title, *FMas a Business Enabler* does not provide a panacea but it does distil a range of issues and provides direction on achieving an integrated FM solution. Indeed the importance of this study is not just what it means to Sydney Opera House, but the idea that if FM can contribute to such an iconic and complex facility, then the case for FM's value proposition for generic and standard facilities is compelling.

ACKNOWLEDGEMENTS

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An Exploration of BIM Opportunities at the Sydney Opera House

Robin Drogemuller
Paul Akhurst
Richard Hough
Stuart Bull

INTRODUCTION

The Sydney Opera House (SOH) is one of the most heavily used performing arts centres in the world, delivering over 1500 performances and 1000 other events each year. The facility management (FM) systems play a key role in maintaining a satisfactory operating environment for all of the functions within the SOH. As with almost all existing facilities, the FM systems do not contain all of the available information on the SOH, nor do they capture all of the potentially useful information from FM processes in an integrated, reusable way.

The well known, curved profile of the SOH, with its pure geometric forms, masks a complex structure, containing equipment and activities that are just as complex. The complex comprises 7 performance spaces, 37 plant rooms, 12 lifts and over 1500 rooms in total.

The FM team from the SOH have been working on building 'as constructed' and 'as maintained' data for the complex over a number of years. The aims and proposed extent of this work has changed over the years as the capability of computer systems has improved. This work is under way using the team of Arup (structural), Utzon Architects, JPW Architects and Steensen Varming (building services), together with other specialist consultants working in particular areas, such as laser scanning. For a facility as large and complex as the SOH this is a major undertaking in itself.

Recent initiatives at the Sydney Opera House have included:

- a program of consolidating the existing documentation on the building and surrounds, and filling in gaps
- a maintenance management software system used for both internal and contracted Fm activities
- proposals for a series of major refurbishment projects including the proposed opera theatre renewal.

The Sydney Opera House FM Exemplar Project used some of the available information to provide a demonstration of what functions FM systems may provide in the near future. The Exemplar Project grew out of a discussion arising from the *Construction 2020* (Hampson and Brandon 2004) series of seminars. The presentations at the seminars were perceived to be focusing on the design and construction of buildings, but there was little information on how the concepts of building information modelling (BIM) and interoperability would assist in the maintenance and refurbishment of buildings during their operational life. In subsequent discussions between Paul Akhurst, Director of Facilities, Sydney Opera House, and the CRC for *Construction Innovation* personnel, a project scope was developed. Additional funding support was obtained through the Australian Government's Facility Management Action Agenda.

The aim of this paper is to describe the processes involved in building a complex BIM model for the SOH (which has won a number of awards) and to give a brief overview on how the BIM data might be integrated with the existing asset management system to provide advanced FM functions.

FM WITHIN THE FACILITY LIFECYCLE

A wide definition of facility management is used within this paper where it is taken to cover all of the activities involved in maintaining the building from initial handover by the contractor. Consequently the normal day-to-day maintenance activities, minor refurbishment (such as repainting and replacement of finishes) through to major refurbishments, such as the proposed major refurbishment to the Opera Theatre, are all in scope. Standard FM systems can record operations on and changes to components and systems within a building, but they are not set up to exploit full 'as-built' data for the building, or to provide an 'as-is' representation of the building for use in a major refurbishment. The ideal situation would be to have a fully detailed 3D model of the 'as-built' building on handover which is used as the basis for creating and tracking FM operations and can then provide 'as-is' data for use in planning major changes to the building's structure or systems. The aim of the Exemplar Project was to understand the implications of this goal and to demonstrate the feasibility for selected systems.

For a facility that will be as long-lasting as the SOH, there are projects to be managed under the general umbrella of 'FM' that are of a larger scale than the more routine aspects of inspection, maintenance and upgrade of building services systems and fixtures and fittings. Such larger projects have recently included the opening up and integration of the western foyers, and improvements to disabled access and to toilet facilities. One project stands out for its size and potential impact: the proposed refurbishment of the Opera Theatre, including auditorium, stage and scenery handling facilities.

To maximise the value and use of the BIM tool, it is important that it can be deployed for these larger projects. In FM terms, the benefits that follow include:

- consultant design teams can develop refurbishment proposals directly within the framework of the 'existing conditions' 3D CAD model
- works contractors can then use the model for visualisation during tendering, and potentially for quantities estimation, and then for 4D visualisation and programming during the works
- contractors' as-built documentation can then be uploaded to update the evolving model.

The current asset management systems at the Sydney Opera House are not significantly different to those used in many other buildings. They competently support budgeting and order management and link in to the financial management systems. They are linked to a TRIM document management tool that stores PDF files of the drawings and an SQL database that stores the rating data on presentation of the building. The MAINPAC module handles the building maintenance functions, such as job sheets, time taken to complete tasks and performance measures. HARDCAT is the financial asset register, monitoring the value of an asset at any given time. The TAM Manager records all major and scheduled works budgets, commitments and actual expenditure.

Examination of a number of asset management systems in a previous *Constructin Innovation* project has indicated that it is often difficult to 'mine' the data entered into such systems in order to identify long-term trends. This is mainly due to human issues rather than shortcomings in the systems themselves. This can be due to users not completing all of the fields for a particular event or useful information being buried within long text fields, such as 'Paint walls with acrylic paint'. Obviously, appropriate management practices would reduce these types of problems.

BUSINESS CASE FOR BIM FOR FM

The management of the Sydney Opera House have found that a number of key issues affect FM activities at the SOH through their response to normal business needs:

- The building structure is complex, and building service systems – already the major cost of ongoing maintenance – are undergoing technology change, with new computer-based services becoming increasingly important.
- The current 'documentation' of the facility comprises several independent systems, some overlapping, and is not ideal to service current and future FM requirements.
- As with all performing arts centres the condition and serviceability of key public areas and the functionality of performance spaces requires periodic review.
- Many business functions such as space or event management require up-to-date information about the facility that could be more efficiently delivered.
- Major building upgrades are being considered that will put considerable strain on existing facilities portfolio services, and their capacity to manage them effectively.
- Increasing use of external service providers to deliver maintenance requires accurate information for contract specifications and a common (internal) database for maintenance records across all providers.

There were several catalysts that led to the decision by the Sydney Opera House Trust to begin transferring historical records into a 3D CAD model, including:

- **Consolidation opportunity**. Hardcopy drawings and drawings scanned to CDs were known to be held in various locations, particularly by participants in the original design and documentation process, by consultants involved in subsequent interior modifications, by the SOH itself, and in archives of state agencies.
- **Design management opportunity**. Funds had been committed by the NSW State Government for commencement of upgrade projects to enhance facilities and operations, including refurbishment of the Utzon Room, construction of the western colonnade, improvements to disabled access, and integration of the western foyers. Plans for substantial enhancements to the Opera Theatre auditorium, including orchestra pit enlargement and stage and scenery handling upgrades, were also being developed in parallel. A 3D CAD model of existing conditions promised a valuable base for insertion and 'virtual testing' of refurbishment proposals, small or large.
- **Opportunity for management of building services maintenance and operations**. As noted previously, the scale and complexity of building services provide an excellent argument for conversion over time to a more automated management process with a 3D graphical interface and direct links to recording for operational and maintenance purposes.
- **Contract management**. A coordinated 3D model with linked database promises improved coordination and consistency of documentation among the large number of contractors participating in modification and upgrade works on-site over a given period.
- **Potential future opportunities**. A well-developed 3D CAD model offers a range of other opportunities depending on the level of detail to be provided. These could include virtual tours of the facility, virtual trials by the performance companies of scenery installation and reconfiguration, even virtual rehearsals where lighting, acoustic, and environmental (thermal, ventilation) parameters can be simulated, as experienced at a particular seating location.

BUILDING A BIM

The construction of the model

The software chosen to get the project under way was Bentley's 3D suite of BIM tools, Bentley Structure, Bentley Architecture and Bentley HVAC, formally known as Microstation Triforma, because it happened to be the software in use by both of the project architects (Utzon Architects, and JPW Architects), and the structural consultant (Arup), for the refurbishment projects noted above.

A substantial effort went into assembling the available record drawings, both structural and architectural, and into discovering information considered to be the most current, given the large number of interventions over the years. This often led to site visits to resolve geometric uncertainties, and where that was not sufficient, to requests for on-site surveys.

The model is 'live' in that the most detail is provided in those areas proposed for refurbishment, so that the Opera Theatre for instance is treated in more detail than the Concert Hall at this stage.

Importantly, historical data sources were not abandoned in the process, but were retained by cross-referencing from elements in the 3D model to the relevant drawings or survey data on which they were based. This allows future users to revisit sources and to review how any apparent conflicts amongst source data were resolved.

While record drawings existed for the auditorium ceiling, a multiple station laser-based site survey carried out by Hard and Forrester, was used in preference, to obtain a more accurate 'as-built' surface. This in turn offered improved knowledge of the clearances between ceiling structure and the soffit of the concrete shells above, one of the critical aspects of the building's geometry. It must be noted that this laser-based survey was used to a level of one metre above FFL due to the seating that remained *in situ* and obstructed the laser. Traditional survey methods were then used to complete the lower wall and floor areas.

Other surfaces researched and documented by the architects for addition to the structural 'base model', were the precast concrete cladding panels, both floor- and wall-mounted, based again on record drawings and on-site inspections. Regarding the building services systems, only the larger duct runs for supply and exhaust air and associated plant were captured in the initial stage, in areas of particular design interest, such as loft, flytower and areas beneath the balconies. Building services consultant Steensen Varming provided Bentley HVAC Building Services 3D modelling of such existing conditions for integration into the growing model.

In terms of the procedures for transfer and overlay of files created by each of the three design firms contributing to the model, it was initally set up as simple exercise via email every few days. Later on, when more consultants and sub-consultants became involved, and real construction work began on some of the early projects, information was formally issued via a web-based FTP system called Aconex.

Modelling of the highly complex shell rib elements, primary arch support structure and long-span concourse beams within Bentley Structural proved straightforward, due to the large amount of accurate historical documentation still available for these elements.

The shells are all created from spheres of the same radius but with the centre points at different elevations. This allowed a single typical tapering rib of the longest length, 191 feet, for the largest shell on the Concert Hall, to be created, arrayed around the sphere surface and trimmed to suit the height of each shell. A similar exercise was done in creating the continuously changing profile of the long-span post-tensioned concourse beams.

Testing the model

While it was convenient for the contributors to the model to share the same software during its creation, it was not intended that its future use should be restricted to that software. For example, to capture and integrate documentation of new works by design consultants and contractors, some flexibility of software would be needed, albeit within minimum compatability requirements specified by the SOH as client.

To check the robustness of the model for interchange between CAD packages, an experiment was carried out to transfer the entire model from Bentley Structural to Graphisoft's Archicad, then back to Bentley Structural, and to check if full functionality could be retained through the exchanges. The experiment was carried out as part of the Sydney Opera House FM Exemplar Research Project within the CRC for *Construction Innovation*, with IFC2x3 as the information exchange schema to effect the transfers, and with Woods Bagot Architects, one of the research project participants, acting as the Archicad host.

The full structural/architectural model after merging of the 165 reference files into a single model was some 55MB in Bentley Structural, which became 263MB within Graphisoft's Archicad, significantly larger but still manageable in terms of manipulation. This included the Archicad database.

The full exchange was eventually completed with near perfect functionality from Bentley Structural into Graphisoft's Archicad. Improved interoperability is now available with the release of newer versions of Graphisoft's Archicad version 11 and Bentley Structural XM edition. Experiments have also been carried out with IFC exchanges to Autodesk's Revit Structure 4 and 2008; these proved fairly successful in terms of geometric representations but less successful in translating the information within the objects.

Given that the lifetime of most buildings is likely to exceed the life of many software companies, long-term use of BIM will be best served by the use of open standards and an upgrade and maintenance strategy for both the software systems used to access and manipulate data, and also the data itself. The information (data) standards for FM will improve over time as commercially available software becomes more powerful and the information needs of facility managers become better understood.

INTEROPERABILITY WITH ANALYSIS ENGINES

BIM as a design tool

BIM can extend 'upstream' in the documentation process to include modelling of design options as early as 'scheme stage'. Although current CAD and analysis tools are not yet well adapted to the frequent and radical design reconfigurations that can occur in early design stages, this drawback is less pronounced in design for refurbishment, where at least the existing building can be safely modelled in full detail to provide the framework for the proposed intervention.

The 'Design Manager' represents a file transfer program based on a chosen schema, and the plug-ins are purpose written according to a specified protocol, so they can provide access to a wide range of analysis (and CAD) packages via APIs. The plug-ins need to be more or less elaborate depending on the size and sophistication of the Design Manager, which may not only provide the file transfer function, but can also add value to the files being transferred, by filtering them for simple optimisation outcomes, thus minimising the need for separate satellite optimisation routines linked directly to the analysis engines themselves.

Application to the SOH Opera Theatre refurbishment design project

Arup has been researching the application of BIM to early stages of the design process, with RMIT University's Spatial Information and Architecture Laboratory. An opportunity to apply the intent of the figure occurred during scheme design stage for the refurbishment of the Opera Theatre, using the 3D CAD model of the existing building as the framework onto which a range of options for modifications to the auditorium could be overlayed. The options could then be checked against a wide range of architectural criteria, and also against particular technical criteria, such as structural feasibility (extent and implications of internal demolition and reconstruction), acoustic outcomes (including volume and reverberation), and smoke management in fire mode (using CFD modelling).

Regarding structural analysis, automatic links had already been established via in-house VB programming between Bentley Structural models and structural analysis packages GSA and Strand 7, for the extensive structural design work carried out on 'Watercube', the Beijing National Aquatics Centre (Hough et al. 2007). Linking between the CAD model, the Odeon package for acoustic analysis and the FDS package for CFD analysis were partially successful. Differing types of mesh are required by such analysis packages. For example CFD modelling can require a solid block type of mesh whereas acoustic models typically require a 'watertight' single-surface type of construction. Exports of Bentley Structural and Architecture models provided a starting point for creation of these environmental models but significant revisions were required outside of the BIM links for completion of these analysis models. Challenges included reducing the density of surface facets and triangulation and ensuring joints between surface elements were closed 'watertight' for the acoustic and lighting analyses.

LINKS TO FM DATABASES

Beyond its use as a framework for modelling of major refurbishment projects, the detailed BIM of the existing building offered itself as the graphic interface for an automated FM tool, covering operations, maintenance and upgrading of building services systems, and any other systems requiring inspection and maintenance, such as furniture, fixtures and fittings.

The development of links to other databases illustrates the versatility of the BIM concept and the benefits that will be realised from the introduction of interoperable (BuildingSmart) standards for software. At present data requires a secondary translation process before it can be moved from one system to another, which is time consuming and can introduce reconciliation errors. As an interim measure the FM team has been developing its own 'language' so that there is consistency between the various databases (for example 'purchase order' is always abbreviated to PO and not P0). Similarly the original room numbering system is being re-established and reinforced so that each room has a unique identify whilst allowing variable generic and colloquial room names that will change over time.

There are of course countless ways of linking the CAD model to individual serviced components within the building. Some components will be too small or too well embedded within their sub-system to warrant their explicit graphical representation in the 3D model. Handbasins in washrooms for example, can be easily referenced by a specifier plus room identification.

Given Bentley's basis of model organisation by geometric objects rather than by intelligent associative objects, such as in Archicad or by contained volumes (rooms), door openings were chosen as the key descriptor of a space. They offered the unique advantage over rooms in that each door has been uniquely numbered since original construction, per standard SOH practice. The door location and number remain (virtually) unchanged, regardless of the physical rearrangement of doors, wall openings and rooms, which has of course been considerable during the life of the facility so far. Door numbers are only ever 'retired', never reused. When a new door opening is created it is given a new number.

Trial links were created between the CAD model and existing facilities records, to demonstrate the potential of a fully developed interface. So far these links comprise of the door opening in walls being invisibly tagged and linked to cells within the SOH master door schedule., which indicates fire compartmentation, designation of space and functional use of that space. This linking mechanism makes it possible to locate a door number in the external FM database and consequently access the database, which holds all the information about the wall containing that door, as well as compartmentation of the space and all relevant asset and facility management information.

The link is bi-directional, either working from the BIM model to the FM database or from the FM database to the BIM model. Future links can provide a direct connection to FM/asset management software packages.

The benefit of this integrated process is that the client can use the BIM model for documentation as well as building management, therefore creating a powerful 'interactive window' between the physical model and the building information datasets.

The method used for creating the links between the BIM object and the master door spreadsheet was by designing a custom interface within Bentley Structural using VBA scripting. This customisation would allow a search to be run to identify dynamically linked tags, placed in the door opening, and linked to a specific cell in the spreadsheet defining the historical door notation. With this dynamic link ability, the cell within the master door schedule can search within the Bentley Structural model, identify the relevant door opening, open Bentley Structural and display the location of the opening in the model.

Other examples of the BIM providing a graphical organising function to assist facilities management processes, include its use in the inspection, updating, and recording of schedules of fire-rated walls within the building, and its proposed use in the inspection and recording of sealant condition between tiles and between tile lids, on the clad surface of the roof shells.

PROVIDING FM INFORMATION FROM BIM

The software deliverables from the Exemplar Project used the DesignView (CRC for *Construction Innovation* 2007) software platform that was developed in previous *Construction Innovation* projects. Only a few factors of interest to the FM team were explicitly modelled as the deliverables were intended as proof of concept rather than 'production' systems. One significant measure for the SOH is the building presentation index (BPI). This is a measure of the visual presentation of key public areas, as part of a priority asset management initiative. The spaces shown in the plan are below the podium level. The plan-based display of the results gives a good overview of the results in the context of the surrounding spaces without expecting the user to know all of the room (space) names or numbers or the adjacency relationships between them.

Another key parameter for the SOH is energy usage. The data is stored in the existing SOH databases and can be accessed for display. Queries can also search on multiple parameters. For examples, all spaces that are used for rehearsals with an energy usage greater than 7000 could be identified.

CONCLUSION AND FUTURE WORK

The Sydney Opera House is an exceptional building in many ways. However, the facility management requirements there are not significantly different to many other buildings. The fact that it is proving cost-effective for the Sydney Opera House Trust to build a BIM for their existing facility indicates that this would be something that other facilities with complex requirements or significant refurbishment programs should consider. Of course, the ideal situation is for a BIM to be produced during the design of a building but this is only now becoming possible with the new generation of CAD and analysis software that is becoming available in our industry. Creation of a BIM for an existing facility will be a retrospective exercise and the cost-benefit will need to be assessed for each facility.

The implementation of the software deliverables across a range of FM parameters has demonstrated that BIM data can be integrated with 'traditional' FM databases. The BIM node would be best implemented as a 'model server', where the current state of the entire facility is available for access by all of the other modules. This would be updated as necessary through the day-to-day operations of the total FM system The model server could then act as a central resource to improve the management of the entire facility.

ACKNOWLEDGMENTS

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CHAPTER 27

Diagnostic Process Based on Fuzzy Logic for the Management of Bridges Exposed to Aggressive Environments

Srikanth Venkatesan
Sujeeva Setunge
Tom Molyneaux
John Fenwick

INTRODUCTION

Management of bridge infrastructure is a significant issue in many countries. For example, Carse (2005) identified that most bridge structures in Queensland, Australia, required significant repairs around the halfway mark of their design life with probably one per cent or less reaching their 100-year design life. Furthermore it was found that bridges exposed to aggressive environments such as coastal regions, or acidic/alkaline soil environments deteriorated faster. A research project funded by the CRC for *Construction Innovation* and supported by Queensland Department of Main Roads (QDMR), and the Brisbane City Council (BCC) had been undertaken by the authors in 2005–2006 to look into this situation. A diagnostic software tool was developed that can identify the major distress mechanisms (such as chloride-induced corrosion, alkali-silica reaction) affecting concrete bridges. The tool developed is significant since the first step in the diagnostic process is the evaluation of the type and severity of distress in the bridge concerned. To fit with the current conference theme of 'Clients benefiting from innovation', it is shown in this research paper that the approach developed in previous research projects can be convoluted into a generic model. This is achieved by testing the methodology on timber bridges.

The next section of the paper presents the results from previous research efforts. The details of case study 'Timber Bridges in Queensland, Australia' is presented. The analysis of the case study bridges using fuzzy logic is presented and the methodology is convoluted into a generic modelling approach, Finally, conclusions and future research directions are presented.

PREVIOUS RESEARCH

About 30 case study bridges affected by various distress mechanisms such as alkali-silica reaction (ASR), chloride-induced corrosion, delayed ettringite formation, plastic shrinkage, plastic settlement and basic corrosion were analysed. For a brief description and technical details of these mechanisms readers can refer to the *Bridge Inspection Manual* of the Queensland Government Department of Main Roads. A mind-map technique was adopted to identify the principal variables that influence the distress mechanisms listed below:

- Type of element (e.g. pier, pile cap, deck)
- Type of construction (e.g. prestressed, reinforced concrete, hollow spun)
- Material type (e.g. cast-in-situ, precast)
- Environmental conditions (e.g. salt water, inland, coastal)
- Climate (mean annual temperature, rainfall, humidity)
- Position of the element (e.g. above water level, submerged, tidal zone)
- Grade of concrete (e.g. 20 Mpa, 40 Mpa)
- Clear cover to reinforcement (expressed in mm, e.g. 50 mm, 75 mm)
- Type of coarse aggregate (e.g. aggregates with opaline quartz influence ASR)
- Type of fine aggregate (e.g. quarry sources having ASR-sensitive chemicals)
- Type of cement (e.g. cements without fly ash contents can influence ASR)
- Crack characteristics (such as width, pattern, appearance and growth are indicators of the distress mechanisms)
- Other defects (such as spalling, staining, macro-cell formations are indicators of the severity and extent of the mechanism).

Experts use the information available on the above variables to arrive at genuine conclusions or recommend lab tests to confirm their assessment. It can be noted that there are subvariables for each of the main variables i.e. there are about 60 different types of elements, at least five different types of construction, different material types and so on. Schematically this can be represented using the cause–effect diagram concept as shown in Figure 27.1.

Figure 27.1 Cause–effect Diagram of Distress Mechanisms Affecting Concrete Bridges

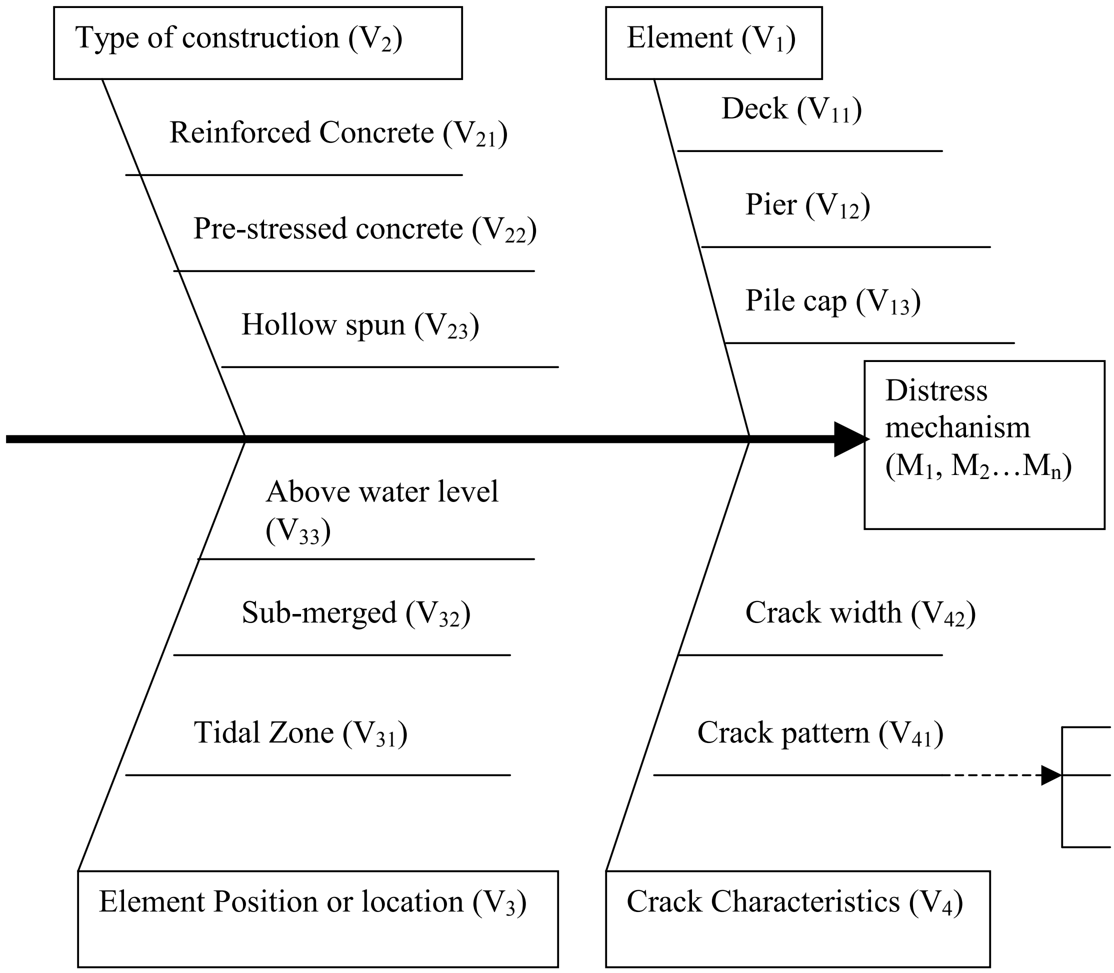


Figure 27.1 presents a sample of main variables and subvariables. A sub-tree for crack pattern has been indicated which is to include patterns like vertical cracking, map cracking, and horizontal cracking, A complete list of the variables required to identify distress mechanisms in bridges has been published in Venkatesan et al. (2006b).

Based on Figure 27.1, a fuzzy rule having multiple antecedents can be developed as a combination of (V_{1i} ^ V_{2i} ^ ….V_{ni}) M_n, τ_γ (1) $\rightarrow$ where V is the variable, M is the mechanism, ^ is the operator symbol and τ_γ is the degree of confidence with $\gamma = 0$, 0.5 and 1 to denote low, medium and high confidence levels. In the case of the variables 'V' having additional levels such as the ones described for 'Crack pattern' an additional subscript is added. For convenience (of using in the software) these variables can be identified by using unique codes (e.g. reinforced concrete construction can be coded as 'RCC' or just 'RC'). It is to be noted that the user may not have information for all the variables defining a rule base. For example the user may have no information on the grade of concrete and clear cover. Sometimes these pieces of information are strictly required to evaluate the mechanism (as in the case of chloride-induced corrosion) and may not be really required in the evaluation (as in the case of ASR). Therefore we define an additional variable α_j such that $\alpha_j = 0$, 0.5 and 1 meaning it is compulsorily required in the evaluation (1) not compulsory in the evaluation (0) and qualitative which is neither compulsory nor non-compulsory. In cases where the information is non-compulsory but qualitative, these values provide additional information towards the truth-qualified fuzzy rule; in other words this increases the degree of confidence. It must be noted that the rule bases have to use an 'either-or' type of evaluation for some of the variables. For example, poor concrete grade and inadequate concrete cover are susceptible to chloride ingress. Some combinations of these variables can be: good or high strength concrete grade and low cover; poor concrete grade and adequate cover: in these situations the decision has to be based on the combined evaluation of grade of concrete and clear cover. As in most cases, a typical rule might apply to a number of material types used in the construction. Thus the software can be programmed to accept any one of the variables out of a group. That is a variable might take up fuzzy prepositions within that hierarchical rule. All these can be easily programmed.

From the foregoing discussion (and expanding Equation 1), a typical rule base can take the form shown below:
V_{1i} (element; $\alpha_j = 1$) ^ V_{2i} (construction; $\alpha_j = 1$)^ V_{3i} (material type; $\alpha_j = 0$) ^ V_{41i} (crack pattern; $\alpha_j = 1$) ^ V_{51i} (crack appearance; $\alpha_j = 0$)^…. M_1 (ASR),τ_μ(high confidence) (2)

Assigning a code for each of the variables in the software, will result in
PILE(1) ^ PSC(1) ^ CIS (0) ^(CRA_PAT = VER+LLR) ^(CRA_APR = DARK) = ASR (HIGH) (3)

Here, the element is pile (noted as PILE) of prestressed construction (PSC) of cast-in-situ material (CIS) with a vertical crack (VER) along the line of least resistance (LLR) with a possible dark appearance (DARK) and ^ is an operator symbol used in fuzzy logic. Complete rule bases of this form have been input into the software BridgeDIST.

Reasoning engine

The reasoning engine developed using fuzzy logic technique has been presented in Venkatesan et al. 2006b. This discussion is not within the scope of this paper.

DESCRIPTION OF CASE STUDY BRIDGES

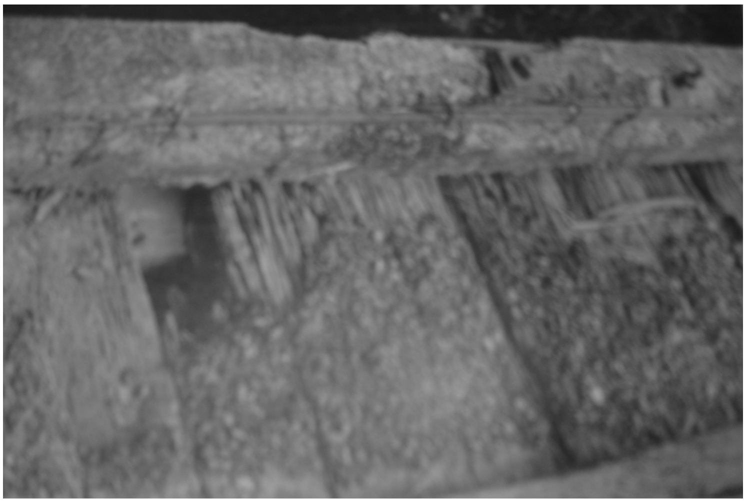
In this section, timber bridges in Queensland have been chosen as case study bridges as opposed to the concrete bridges presented in the previous section. For privacy reasons, these are named as Bridge 1, Bridge 2 etc.

Bridge 1

Bridge 1 is in Queensland, Australia. This particular bridge is a three-span timber bridge built in 1960. Figure 27.2 presents the general view of the bridge along deck side and Figure 27.3 presents the portion of the weathered and rotted timber deck.

Figure 27.2 General View of Bridge 1, Queensland

Figure 27.3 Weathered and Rotted Timber Deck of Bridge 1



These two figures depict the poor condition of the timber decks. The bituminous wearing surface near the kerb is observed to be badly pot-holed perhaps due to the deck flexibility and flood stripping. It is noted that this bridge can be submerged up to 8m during major stream flow.

Bridge 2

Figure 27.4 presents a general view of Bridge 2 in Queensland. This timber bridge has been widened and the original timber decking replaced with transverse steel trough decking. As can be noted from Figure 27.5, considerable distress is evident in the deck. The poor performance of the decking can be attributed to flexible superstructure due to longer spans and wider spacing of girders.

Figure 27.4 Bridge 2, General View

Figure 27.5 Bridge 2, Badly Cracked Wearing Surface Over One of the Piers

It is noted that the above case study bridges have highlighted the problems associated with timber decking. Experience has shown that the other significant member that is susceptible to the failure of timber bridges is the piles. The authors are also aware of bridges in which the structures were affected by termite attack, fungal attack, timber splitting and rotting of timber. Some of the visual symptoms are rotten pockets, soft spots, decay signs, termite galleries, nests and longitudinal cracking in piles and timber deck members. Using this information, a cause–effect diagram is developed to demonstrate the generic nature of fuzzy logic approach.

ANALYSIS OF CASE STUDY BRIDGES USING FUZZY LOGIC

From the above section, distress observed in timber bridges can be identified as.

- termite attack
- fungal attack
- timber splitting
- rotting
- weathering.

The types of elements observed to have distress are:

- deck
- piles
- bituminous surface
- kerb.

It is to be noted that the decks and piles may generally be classified as elements in superstructure and substructure. furthermore distress may be observed on the deck girders or underside members or at the ends of deck planks. Similarly distress may be found on piles that are well submerged into the ground/well above the water level or ground level, and in a region close to water level or ground level. Thus in hindsight 'element position' is another sub-variable that needs to be considered.

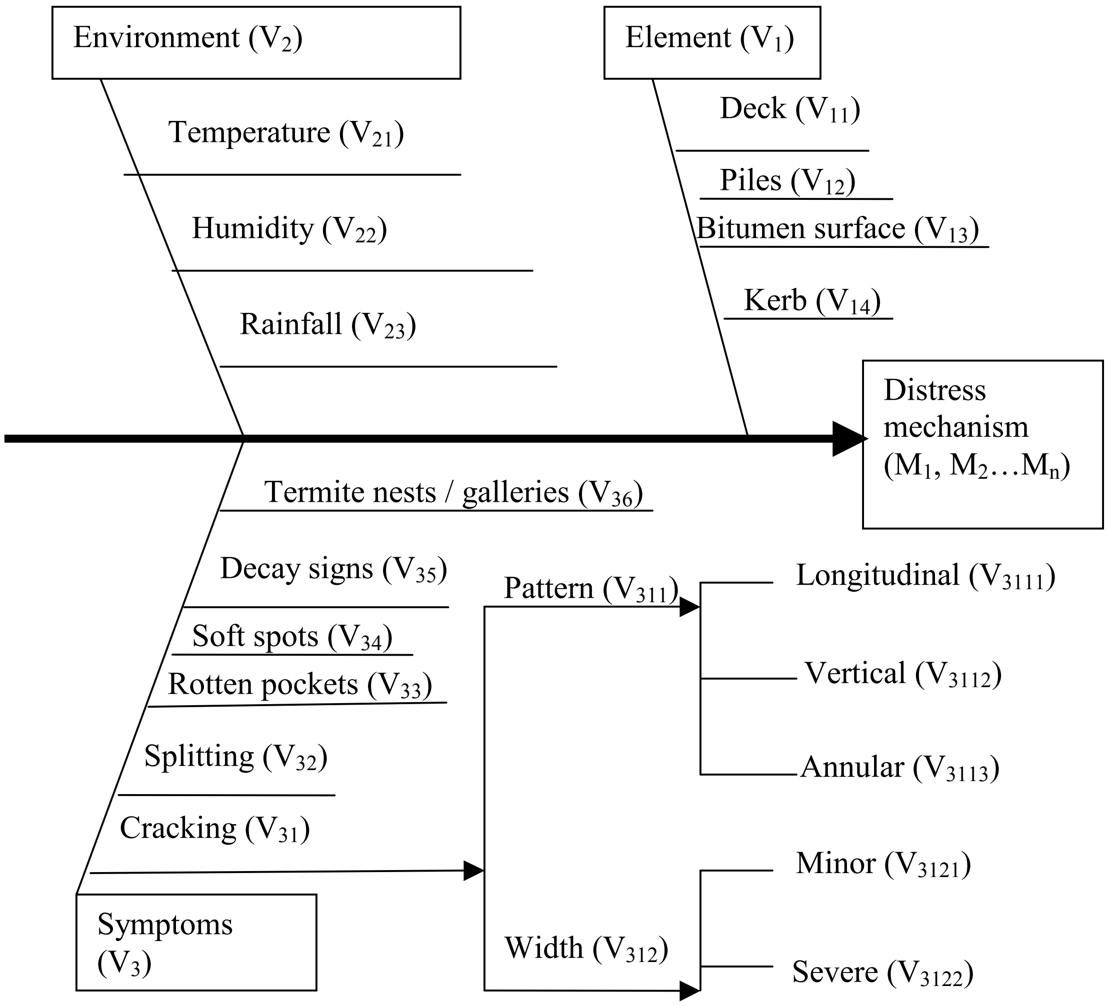
The visual symptoms associated with the above descriptions can be identified as:

- cracking
- splitting
- rotten pockets
- soft spots
- decay signs
- termite nests or galleries
- discoloured appearance.

It is to be noted that cracking is again a broad classification and a series of sub-classifications may be required to differentiate between the cracking observed in weathered decks (random–minor cracks) to severe cracking observed in piles/deck elements. It is very important to note that the presence of termites may not have any visual appearance but may be detected in soft pots. The soft spots again may be an indicator of fungal attack, moisture attack or termite attack. In addition, the environmental conditions and the location of the bridge are external factors that can influence the level of distress observed. Thus additional levels of visual and external identifications will be needed towards developing a complete model. However, the intention of this paper is to present the generic approach and for this purpose the above variables provide a reasonable starting point.

From the foregoing discussion, distress mechanisms can be labelled as M_n where M_n is a set = {termite attack, fungal attack, timber splitting, rotting and weathering} n varies from 1 to 5 in this case; main variables V_1 can be grouped as V_{1n} where V_{11} = deck, V_{12} = piles, V_{13} = bitumen surface and V_{14} = kerb. External factors like environmental conditions can be considered as a main variable V_2 where in average temperature, humidity, rainfall can be considered as subvariables V_{21}, V_{22}, V_{23}. Similar provision can be made for site location. Importantly the symptoms observed is a main variable say V_3 which consists of V_{31} = cracking, V_{32} = splitting, V_{33} = rotten pockets, V_{34} = soft spots, V_{35} = decay signs, V_{36} = termite nests/galleries V_{37} = discoloured appearance. Cracking can be further subdivided into its patterns V_{311} = longitudinal V_{3111}, vertical V_{3112}, and annular V_{3113} and into its width V_{312}-minor width V_{3121}, severe width V_{3122} so on. Similarly, splitting can be further subdivided into parallel to grain, perpendicular to grain and annular (if required). Schematically this is represented in Figure 27.6.

Figure 27.6 Cause–Effect Diagram of Distress Mechanisms Affecting Timber Bridges (Typical Application)



Having developed the cause–effect diagram using the above procedure it is now possible to use the fuzzy logic statement in defining the mechanism using the following equation: $(V_{1i} \wedge V_{2i} \wedge \ldots V_{ni})\ M_n,\ \tau_{\gamma} \rightarrow$ (2) where V is the variable, M is the mechanism, ^ is the operator symbol and τ_γ is the degree of confidence with $\gamma = 0$, 0.5 and 1 to denote low, medium and high confidence levels. The degree of confidence is required as the mere presence of symptoms alone cannot be interpreted as the bridge having a higher degree of distress. Equation 2 can be interpreted as a typical rule wherein an element of a known type with definitive symptoms together with known environmental conditions can be considered to have a known distress type with a certain degree of confidence. Again it can be shown that fuzzy logic technique developed by the authors (Venkatesan et al. 2006b) can be adopted in defining the confidence levels. Due to length restrictions of this paper, these details are not provided here. It is to be noted that equations 1 and 2 are very much the same and thus the generic approach in modelling distress mechanisms using fuzzy logic has been demonstrated. Furthermore, the compilation of such rule bases into a software tool alleviates the need of experts' opinion each time, and thus the knowledge of the experts is captured using this approach.

CONCLUSIONS, OUTCOMES AND FURTHER RESEARCH

In this research paper an innovative methodology adopted in previous research (funded by the CRC for *Construction Innovation*) has been demonstrated as a generic modelling tool, i.e. fuzzy logic technique adopted in a previous research effort for determining major distress mechanisms in concrete bridges has been shown to be applicable for timber bridges. By this demonstration, it is now possible to adopt this approach in determining the severity of distress in timber bridges. The impetus gained from this research provides credence to the fact that this modelling technique can be applied in many other fields; hence the theme of 'Clients benefiting from innovation' has been amply demonstrated. In developing the complete diagnostic software tool for timber bridges that encompasses the procedures described here, further work in the form of additional case studies and software development is required.

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Effective Condition Monitoring and Assessment for More Sophisticated Asset Management Systems

Abdulkader Sharabah
Sujeeva Setunge
Ralph Godau
Chris Karagiannis

INTRODUCTION

A major challenge faced by authorities managing infrastructure assets is determining the amount and the type of data required to be collected to arrive at a reasonable predictive model to ascertain the remaining life of the existing infrastructure stock. Prior to developing a data collection regime, it is important to establish the asset management model to use the data. There are several infrastructure management approaches reported in literature. These can be summarised as:

- approximate methods where condition of different elements were rated A, B, C and D or 1, 2, 3, 4, 5 through condition inspections; deterministic lifecycle analysis is conducted assuming the time period of progression of deterioration to be fixed in one state (Hovde 1998)
- same as above with modifications for different exposure conditions and usage through fixed factors calibrated with data (ISO factorial approach, Bamforth 2004; Tepley 1999)
- reliability-based methods using the discrete Markov chain for deterioration modelling
- reliability-based methods using continuous Markov process (Maheswaran et al. 2005)
- predicting lifecycle of assets considering an integration of three drivers such as market drivers, physical deterioration and functional obsolescence.

Out of the above, the most common approach used by the industry is a deterministic method based on condition data and fixed deterioration curves. However, these approximate methods lack the ability to account for uncertainties, which is essential to manage risk of maintaining assets to provide the required level of service delivery. Also, a large amount of condition data is needed to establish a deterministic deterioration model for a given infrastructure asset.

A research program at RMIT, funded by the CRC for *Construction Innovation* (Sharabah et al. 2007) has developed a sophisticated asset management model based on the Markov chain for building assets owned by public authorities. The model includes an innovative building weighting method which can be used to quantify the condition of a given asset type in monetary terms.

In considering the application of the asset management model developed at RMIT University at the Brimbank City Council in Victoria, significant efforts have been then made to establish a realistic and financially feasible data collection regime to feed into the asset management system. A brief overview of the proposed asset management model and the data collection methods proposed are presented here. In the first stage, the data collections plans included all the buildings owned by the council.

PROPOSED ASSET MANAGEMENT MODEL

Conceptual framework

In reliability-based deterioration modelling the attributes of a model randomly change over time. A Markov chain is a probability model, which has a finite-state, for describing a certain type of stochastic process that moves in a sequence of phases through discrete points in time according to fixed probabilities. The process is stochastic because it changes over time in an uncertain manner. In this chain the future states are dependent only on the present state and independent from any state before the present states. A Markov chain consists of transition matrix and initial distribution. Transition matrix consist of a set of finite set of states S (1,1,3….n) and a propriety pi j to pass from state i to state j in one time step t. Time can be treated as either discrete (called discrete-time Markov chain) or continuous (called continuous-time Markov chain). In a Markov chain the states are continuous and similarly the time could be either discrete (called discrete-time Markov process) or continuous (called continuous-time Markov process).

The first step for using Markov chain modelling is evaluating the condition of building elements. This is to assess their physical, operational and maintenance conditions. For any building element a condition rating scheme comprises four ratings A, B, C and D, where *A* represents a new or nearly new element not requiring any maintenance action, and *D* represents a condition which indicates that the element has to be replaced (refer to Table 28.1 (after Figure 28.2)).

Figure 28.1 Condition Rating Scheme

A	Excellent	The element is as-new
B	Satisfactory	The element is sound, minor damage, minor maintenance required
C	Unsatisfactory	Major damage. Major maintenance required.
D	Failing	Serious damage. Element should be replaced

Although the deterioration processes evolve over continuous time, for simplicity, discrete time steps could represent these processes (such as the time of the building inspection). Hence in this paper, a discrete-time Markov chain will be considered as a model for predicting the lifecycle for a building element.

Discrete-time Markov chain

A discrete-time Markov chain is a finite-state stochastic process in which the defining random variables are observed at discrete points in time. This chain satisfies the Markov property which means that given that the present state is known, the future probabilistic behavior of the process depends only on the present state regardless of the past. If an element is in state 'i', there is a fixed probability, pij, of it going into state j after the next time step. pij is called a transition probability. The matrix *P* whose ijth entry is *Pij*, is called the transition matrix . The transition matrix consist of a set of finite set of state *S* (1,1,3….n) and a propriety pij to pass from state i to state j in one time step t. In a Markov chain Pij should satisfy two conditions:

$$\sum_j Pij \le 1$$

$$pij \ge 0$$

This means that if an element is in state i, there is a (pii) probability that this element will stay in state i, and (1- pii) will move to next state j.

- Present state at time t is i: $X_t = i$
- Next state at time t + 1 is j: $X_{t+1} = j$
- Conditional probability statement of Markovian property: $\Pr\{X_{t+1} = j \mid X_0 = k_0, X_1 = k_1,\ldots,X_t = i\} = \Pr\{X_{t+1} = j \mid X_t = i\}$
- Discrete time means $t \in T = \{0, 1, 2, \ldots\}$.

The probability of an element being in a given state at a given point in time can then be depicted by the set of curves shown in Figure 28.2.

Figure 28.2 Cumulative Space

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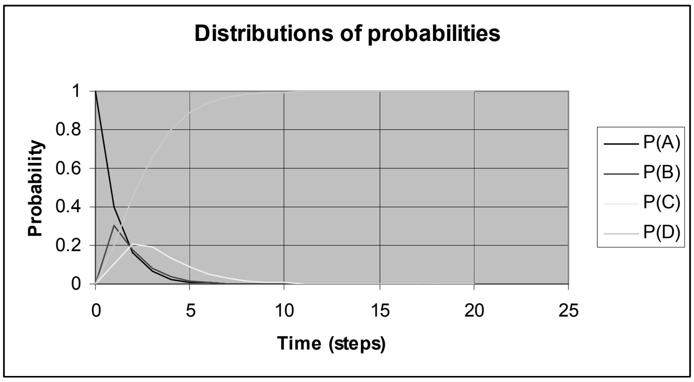


An initial distribution 'v' is a single-row matrix representing the number of elements in each state. In a Markov chain after one time step the new distribution will be the result of multiplying initial distribution v by the transition matrix P. Distribution after 1 step: vP. The distribution one step later, obtained by again multiplying by P, is given by $(vP)P = vP^2$. Therefore distribution after 2 steps = vP^2. Similarly, the distribution after n steps can be obtained by vP^n. P^2 is the two-step transition matrix for the system. Similarly, P^3 is the three-step transition matrix, and P^n is the n-step transition matrix. This means that the ijth entry in P^n is the probability that the system will pass from state i to state j in n steps.

Prediction of the future cost

To predict the future cost for any element there are two kinds of cost:

1. inspection cost
2. element replacement cost or element repair cost when the element makes a transition from one state to another – inspection cost is represented by the m-dimensional column vector: $\mathbf{C}^S = \left(c_1^S, c_2^S, \ldots, c_m^S\right)^T$

Each component is the cost associated with state i.

The cost of a transition is embodied in the m × m matrix: $\mathbf{C}^{\mathrm{R}} = \left(c_{ij}^{\mathrm{R}}\right)$

Each component specifies the cost of going from state i to state j in a single step.

Expected cost of being in state i, (Jensen and Bard 2003) is given by: $c_i = c_i^{\mathrm{S}} + \sum_{j=1}^{m} c_{ij}^{\mathrm{R}} p_{a\,ij}$

P_{aij} is the probability of maintenance action.

Absorbing states

An absorbing state is a state from which there is a zero probability of exiting. An absorbing state is a state j with pjj = 1. In other words, without any maintenance action, an element which reached condition D will stay in that condition forever. Calculating the expected number of steps to absorption (elements pass from different states to end up in state D) can help to obtain an overall view about the estimated lifecycle for that element. To calculate the absorbing states:

Let 0, 1, . . . , k be transient states and
k + 1, . . . , m – 1 be absorbing states.

Let q_{ij} = probability of being absorbed in state j given that we start in transient state i. Then for each j we have the following relationship:

$q_{ij} = p_{ij} + \sum p_{ir}q_{rj}$, i = 0, 1, . . . , k.

For fixed j (absorbing state) we have k + 1 linear equations in k + 1 unknowns, q_{rj} , i = 0, 1, . . . , k.

Long-term behaviour of the Markov chain

If there are recurrent actions taken to repair or replace the element in any state it leads to a steady state probability, which helps to set a stable maintenance plan and expenditure. Calculation of steady state probability can be given by, Let π = (π1, π2, . . . , πm) is the m-dimensional row vector of steady-state probabilities for the state space S = {1,…,m}. To find steady-state probabilities, solve linear system: $\pi = \pi P$, S_j = 1,m $\pi_j = 1$, $\pi_j \geq 0$, j = 1,…,m.

Building weights

Zhang (2006) has divided building network (N) into each individual building (b) then divided the building into its constituting system (s) which is dependent on its components(c). Finally he divided the component to elements (e). He suggested that the overall performance of a building network is eventually depending on the performance of all the buildings elements. For each element there is a composite measure (w) of key factors (distress, structural capacity, safety (Hudson et al. 1997). Then he multiplied these weights by assigning value for these factors 'v'. The result will provide conditions index for this element CI_t^{bsce}.

$CI_t^{bsce} = \Sigma$ W*V

The overall building network weight is

$$CI_t^N = \sum_{b=1}^{m}\sum_{s=1}^{mb}\sum_{c=1}^{mbs}\sum_{e=1}^{mbsc} W_b W_{bs} W_{bsc} W_{bsce} CI_t^{bsce}$$

According to Zhang (2006) there are four allowable management actions that could be taken for each element in any state (a1 = replacement, a2 = major repairing, a3 = minor repairing, a4 no action).

DATA COLLECTION REQUIREMENTS

Sharabah et al. (2007) presents the application of the proposed concepts using some hypothetical data. This exercise has given the research team an understanding of the nature of the required data. The data collection approach is discussed below.

Facilities hierarchy

The first step of buildings condition assessment is to identify the hierarchy of the buildings depending on the building's function. The function decides strategic importance and takes into account the key principles which impact in determining the functional level of service as part of providing a sustainable range of facilities to the community.

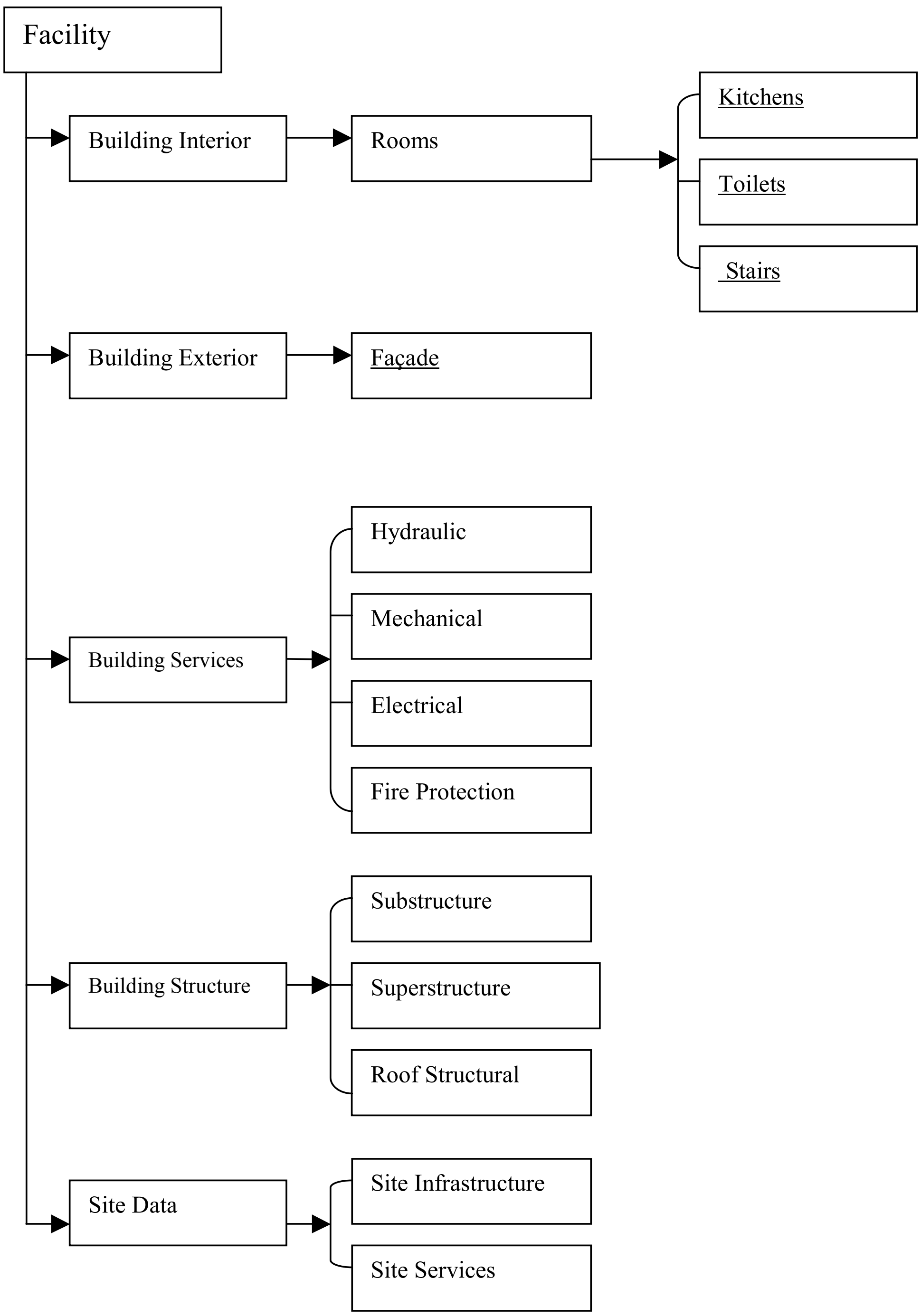
As a case study, Brimbank City Council's Facility Asset Management Plan (FAMP) has developed a facilities hierarchy for its buildings and placed all facilities into the classifications outlined in Table 28.1.

Table 28.1 Priorities of Building Categories

High priority	Medium priority	Low priority
Childcare centres	Community centres	Playgroups
Preschools	Neighbourhood houses	Residences
MCHC	Senior citizens centres	Public halls
Family centres	Arts centres	Emergency youth housing
Planned activity groups	Works operations	Public toilets
Leisure centres	Municipal offices	Commercial facilities
Libraries	Youth centres	Other (sheds/hothouses/vacant buildings etc)
Playgrounds at facilities	Meals on wheels food dispatch	Heritage facilities
	Sports pavilions	Highball stadiums
	Sports clubrooms	

At the next stage a hierarchy for the asset class has to be established (refer to Figure 28.3). This has been done in consultation with other councils and a review of literature.

Figure 28.3 Building Hierarchy



Guidelines for condition assessment

All constructed council buildings consist of a number of elements that can be identified and measured. In assessing actual condition it is important to identify and focus on those elements of the council's buildings most important to business needs. When the key council building elements have been identified, they should be assessed against a limited number of clear criteria. These may vary according to the function of the council's buildings.

1. Condition of element: What is the element condition?

Assessment according to the consequence and risks:

- health and safety: is there a health and/or safety risk?
- security: is there a security risk?
- functioning: does it function satisfactorily?
- amenity: is the level of amenity acceptable?

2. The defects that could be found in these elements

- major defect groups
- severity of the defects
- priority to repair these defects
- quantity of the defect and the cost to repair or renew and which trade can repair these defects.

The criteria may not all be relevant to every element. The criteria chosen should lend themselves to consistent interpretation and ready and economical assessment.

CONDITION SURVEYS

The surveys describe all elements of the property, and not just those where work is necessary. In deciding how to gather the information, consideration should be given to how it is going to be presented and used.

- Items that need repairing or replacing are put into a system where they can be priced, sorted, aggregated, compared and so on.
- Items in good condition, where no work is required, can be simply described in text.

Direct inspection can range from superficial to detailed physical examination. When direct inspection of the council's buildings or one of its key elements is not practicable, physical measurement and non-destructive testing can be used for elements of the council's buildings that cannot be reliably assessed by direct inspection.

The surveys cover all council's buildings and external areas on the site. Each block should be kept separate in the survey report and referenced. Where a building includes one or more extensions of different ages, or types, it may be appropriate to treat the extensions as separate blocks, even though they are part of the same building.

Interior spaces

This section is intended to capture all interior information on a room-by-room basis. Three basic types of forms are included: a form for a general room with standard amenities (e.g. general office area, common rooms, meeting rooms), two forms customised for special use spaces including kitchens and toilets.

Building envelope/structure

Several forms work together to assess the complete architectural and structural exterior features and systems. In addition, changes in materials or structural systems may require a separate form be generated. Use as many forms as is necessary.

Mechanical

This section covers general mechanical systems found in various areas of a building. It gathers significant information on the heating, cooling and ventilation systems supplying the building's spaces.

Electrical

This section covers electrical systems in similar fashion as for mechanical systems.

Site data

This section provides for the evaluation of general site conditions as well as areas and equipment which support outdoor activities.

Level of detail

The checklists, as shown, are very limited in their provision of comment areas. Comments should be added and used as required to explain conditions and/or cover subjects that are not included in the evaluation form.

Inspectors will identify and assess materials, defects and overall condition, on a scale rating from D (failing) to A (excellent). In addition they will assess the overall consequence of the defect on 'business', 'human' and 'environment' which will help to analyse the information and decide on priorities.

Survey scales

Table 28.2 Asset Grading Condition

A	Excellent	The element is as new and can be expected to perform adequately to its full normal life.
B	Satisfactory	The element is sound, operationally safe, and exhibits only minor deterioration.
C	Unsatisfactory	The element is operational but major repair or replacement will be needed soon, that is within one to three years.
D	Failing	The element runs a serious risk of imminent breakdown.

Table 28.3 Consequence Grading Criteria

1	No disruption to the business. No harm to human and/or no harm to the environment
2	Minimal disruption to the business. Minor injuries to human and/or minimal damage to the environment
3	Moderate disruption to the business. Recoverable injuries to human and/or reversible damage to the environment
4	Business disruption. Temporary disability to human and/or recoverable damage to the environment
5	Business disruption. Permanent disability or fatalities. huge impact to the environment.

Table 28.4 Severity Defects Grading Criteria (Severity Level)

Grade 1	Minor defect (minor maintenance required)
Grade 2	Major defect (major maintenance required)
Grade 3	Sever defect (item needs to be replaced)

Table 28.5 Priority to Repair

Level 1	(0 - 30 days) urgent
Level 2	(1 – 12 months)
Level 3	(13 - 24 months)
Level 4	(2 – 5 years)
Level 5	(5 – 10 years)

Table 28.6 Trade

C	Carpenter
E	Electrician
Pb	Plumber
P	Painter

Table 28.7 Cost to Repair or Renew

Severity (1-3)	Priority (1-5)	Trade	Condition	Consequence
1: Minor defect	Level 1 (0 - 30 days)	C: carpenter	A: excellent	1: no disruption
2: Major defect	Level 2 (1 – 12 months)	E: electrician	B: satisfactory	2: minimal disruption
3: Sever defect	Level 3 (13 – 24 months)	Pb: plumber	C: unsatisfactory	3: moderate disruption
	Level 4 (2 – 5 years)	P: painter	D: failing	4: temporary disruption
	Level 5 (5 – 10 years)			5: long-term disruption.

An estimate should be made at the time of assessment of the cost of repairing or renewing a defective element. These costs should be for bringing the element up to 'grade A' condition. It may be that alternative solutions to straightforward repair or renewal might offer better value for money, e.g. the scope for wider-scale refurbishment, adaptation, or rationalisation.

Minor day-to-day maintenance

Minor day-to-day maintenance (e.g. replacement of locks, broken glass, tap washers) and minor routine works (e.g. inspection, testing, cleaning, servicing, adjusting, overhauling) should be excluded from this survey, but inspectors should create a maintenance request to repair these kinds of day-to-day maintenance. Then they should enter a work request to confirm.

DATA ANALYSIS

Preliminary analysis by Brimbank City Council

The most critical factors in analysing the information and deciding on priorities are:

- council's buildings category: how important is this council building?
- condition impacts: how serious is this risk?

Once the condition of premises has been assessed, priorities should be allocated according to the seriousness of the condition revealed and the urgency associated with any breaches of legislation. In addition risk should be used as a driver for optimising the performance of a council's buildings. Risks that the building services systems posed to an organisation and stakeholders can be assessed by using a risk matrix: Impact of risk = Condition of the council building X consequence.

Table 28.8 Severe–high–medium–low-risk Matrix

Consequence / Condition	1	2	3	4	5
A	Low	Low	Low	Low	Low
B	Low	Low	Medium	Medium	Medium
C	Medium	Medium	Medium	High	Severe
D	Medium	High	High	Severe	Severe

The following priority grades are recommended in the context of a five-year planning period:

- **Priority 1 (severe risk, less than 1yr)**: urgent work that will prevent immediate closure of premises and/or remove an immediate high risk to the health and safety of occupants and/or remedy a serious breach of legislation.
- **Priority 2 (high risk, 2yr)**: essential work required within two years that will prevent serious deterioration of the fabric or services and/or reduce a medium risk to the health and safety of occupants and/or remedy a less serious breach of legislation.
- **Priority 3 (medium risk, 3–5yr)**: desirable work required within three to five years that will prevent deterioration of the fabric or services and/or reduce a low risk to the health and safety of occupants and/or remedy a minor breach of legislation.
- **Priority 4 (low risk, more than 5 yr)**: long-term work required outside the five year planning period that will prevent deterioration of the fabric or services.

The cost of rectification and the financial year in which funding can be made available are also important factors to be considered, particularly in the case of works that can safely be deferred. A schedule for action needs to be considered for each case. However, broad conclusions can be drawn on appropriate timeframes for action by looking at the council's buildings categories against each element's condition priority.

Developing input data for the Markov model

With the planned data collection regime, information will be available in the form of condition grade vs. age for a given building category and building element. These data will be used to calculate the transition matrix for each type of building element. Building weights and cost elements will be calculated using the approach previously discussed. The data analysis process is currently being developed to be user-friendly with the assistance of an experienced computer programmer.

Once the data have been analysed, the model proposed previously will be used to predict the long-term performance of council buildings. This will be compared with the ranking established by the traditional process. Also it is anticipated that the model will later be calibrated using data from the Queensland Department of Public works.

SUMMARY AND CONCLUSIONS

The paper presented an innovative reliability-based asset management model and a condition monitoring plan to collect data for the validation of the proposed model. The condition monitoring plan developed would serve the dual purpose of ranking the council buildings using a traditional risk-ranking approach as well as using the more sophisticated Markov process. The proposed condition monitoring plan included following elements:

- a facilities hierarchy for buildings
- categorisation of buildings according to the functionality and priority
- guidelines for assessment
- survey scales
- priority ranking method.

The principal outcome of the proposed project is contribution to knowledge through the use of Markov modelling to predict the deterioration process of building elements. The model is probability-based which is essential if one is to incorporate the uncertainties involved in performance prediction, represented by a set of condition transition matrices. The deterioration process can be represented by transition probability matrices. Based on observations on building conditions, the transition probability matrices can be modified to express the deterioration process more accurately. This research will explore and apply the Markov process for developing an asset management system. Simulation of the probable development in the deterioration of all building elements will enable determination of the probable date of replacement. It will help to assess the global development in maintenance and refurbishment costs for entire buildings. It will allow planning of future maintenance and refurbishment by listing the probable elements to be replaced in the future. This will lead to many applications in civil infrastructure asset management.

ACKNOWLEDGMENTS

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Part 7
Industry Development

Knowledge and the Boundaries of the Firm: Implications for the construction industry

Peter Galvin
Stephane Tywoniak
Janet Sutherland

INTRODUCTION

Organisational structure is synonymous with a firm's knowledge – both today and in respect of a firm's future knowledge stocks. For some, this may seem obvious, yet for most scholars (and practitioners) this is not the case, as structure – particularly where the boundaries of the firm lie and what they look like – rarely makes it into any knowledge management discussion. Yet what a firm does today, be it broad in its activities or highly focused to the point of being a virtual organisation, is both a reflection of its existing capabilities/routines (which are based around knowledge) as well as determining its likely learning and transformational opportunities into the future. In addition, the permeability of any organisational boundary and the existence of any mechanism to maximise the inflows of new knowledge are fundamental to developing new or reconfiguring existing capabilities. This paper therefore addresses how knowledge and structure are inextricably linked and, through the use of a case study, illustrates how a public sector organisation has significantly rebuilt its capabilities by rethinking its organisational boundaries, both in terms of location and basic characteristics.

The determination of organisational boundaries is a classic theme with theories being developed on the basis of tasks and activities (Katz and Kahn 1966; Lawrence and Lorsch 1967; Thompson 1967), to theories of economic organisation focused on property rights and transaction costs (Alchian and Demsetz 1972; Grossman and Hart 1986; Jensen and Meckling 1976; Williamson 1975), and strategic theories of resources, capabilities and knowledge (Barney 1995; Foss 2002; McGee 2003; Teece, Pisano and Shuen 1997). While these different theories each provide a different lens through which to see how organisations structure themselves to create their boundaries, these theories tend to be weak in linking organisational boundaries to value creation (or competitive advantage). Furthermore, these theories say little about the nature of organisational boundaries beyond their basic location. To counter this perceived weakness, we draw primarily upon the knowledge-based view of the firm which proffers an alternative explanation regarding organisational boundaries and the need for organisational alliances. The knowledge literature simultaneously provides an opportunity to investigate the nature of organisational boundaries in the context of alliances and knowledge transfer.

Positing that organisational structure in terms of firm boundaries (location and permeability) fundamentally drive an organisation's ability to engage in learning and knowledge transfer, we use a case study of Main Roads Western Australia (WA) to illustrate how rethinking their structural boundaries and the nature of these boundaries allowed for a rebuilding of key organisational capabilities.

TRADITIONAL THEORIES OF ORGANISATIONAL BOUNDARIES

Early organisational theory (March 2007) conceived organisations as semi-open systems in interaction with their environments (Katz and Kahn 1966) where organisational design is contingent on environmental conditions (Lawrence and Lorsch 1967). Firm boundaries can be linked to the existence of unused managerial services (Penrose 1959) which stimulates organisational growth and enables economies of scale and scope (Chandler 1962). However, organisational growth itself also generates bureaucratic costs of administration and control (Pugh et al. 1968), leading to diseconomies of complexity. The balancing effects of economies of scale and scope and diseconomies of complexity generate a self-regulating mechanism which automatically determines an optimal organisational size (Blau and Schoenherr 1971). This maximum size of the organisation thus determines how many activities and departments can be located within the boundaries of the organisation.

Theories of economic organisation are driven by considerations of 'first-order economising' (Williamson 1991a) which involves the governance of asset residual rights, incentive structures, and transaction costs. According to Coase (1937) the boundaries of the firm are not determined by considerations of process interdependencies and production system efficiency, but by the relative costs of market transactions relative to entrepreneurial coordination within the organisation. Williamson (1975; 1991a) develops this line of theorisation by proposing that economic governance covers more than the market/firm (hierarchy) dichotomy to encompass hybrid forms, depending on the degree of asset specificity, the risk of opportunistic behaviour between contractants, and the frequency of transactions. Thus organisational boundaries depend on the ability of managers to draw up contracts covering the contingencies of their transactions: high asset specificity and high exposure to opportunistic behaviour lead to the internalisation of the activity within the boundaries of the firm.

Agency theory (Jensen and Meckling 1976) takes Coase's arguments in a slightly different direction. Instead of opposing managerial 'fiat' (Williamson 1975) and market contracting, agency theory conceives of the firm as a nexus of contracts, within and beyond its boundaries. In this perspective, organisational boundaries are not drawn based on the costs of transacting, but according to the costs of monitoring the execution of contracts. Thus, in the perspective of agency theory, the boundaries of the firm are determined by agency costs and the ability of principals to monitor the behaviour of their agents.

The limitations of these theories have been widely noted: they assume quasi-substantive rationality on the part of principals and agents (Tsang 2006), they are predicated upon situations of market equilibrium and thus are ill-equipped to account for the evolution of structures over time (Rumelt et al. 1994), they embody assumptions about human behaviour that are extreme and not borne by empirical evidence (Bromiley 2005; Tsang 2006) and it is argued that they to lead to self-fulfilling prophecies (Ghoshal and Moran 1996). Perhaps most significantly, these theories tend to treat what is completed internally versus what is undertaken via market-based contracts as absolute. Bradach and Eccles (1989) therefore suggest that it necessary to consider the whole organisational structure rather than just individual transactions one at a time. In this respect, the knowledge-based perspective with its ability to easily account for alliances and its focus on the knowledge underpinning routines central to an organisation's operations, provides a useful approach for furthering this field.

KNOWLEDGE-BASED VIEW OF THE FIRM

Firms are far more than transactional vehicles: they provide the basis for generating, sharing and applying knowledge (Kogut and Zander 1996) – something that is not well accounted for within the economic theories concerning organisational boundaries. In this sense, knowledge and resource-driven theories of the firm provide not only an alternative perspective for understanding firm boundaries, but they do not divorce the boundaries-of-the-firm question from the value-creation question (whereas transaction cost economics and agency theory are best utilised at the corporate strategy rather than the business strategy level).

The knowledge-based view or theory of the firm (KBV) has emerged from the resource-based view of the firm and views competitive advantage as a function of effective acquisition and utilisation of knowledge (Grant 1996; Spender 1996). Inherent within KBV is the need to take a dynamic perspective with respect of knowledge, and thus the continual acquisition and deployment of knowledge through mechanisms such as learning become a central feature of research in this area. KBV also specifically develops a rationale for the existence of strategic alliances as there is never a perfect congruence between the activity boundaries of the firm and the knowledge boundaries of the firm. Given the failure of these boundaries to align, opportunities exist for alliances or other forms of intermediate or hybrid organisational structures. These organisational arrangements are not only important in terms of understanding the structural boundaries of organisations, but the alliances can themselves be a central part of the learning process which underpins much of the thinking by KBV scholars.

In these alliances (or hybrid forms), firms have pulled back their corporate boundaries through outsourcing and divestment of core activities. As a result, they have increasingly cooperated with other organisations to engage in activities and access resources, including knowledge, outside their own boundaries (Grant and Baden-Fuller 2004). Essentially such firms are using contractual structures, especially strategic alliances, to replicate the vertical integration which previously existed internally (Williamson 1991b). KBV, however, does not address how the knowledge actually flows between organisations and instead implicitly treats knowledge like other tradeable assets without delving into the practical complexities of transferring knowledge across organisational boundaries (Grant 1996; Grant and Baden-Fuller 2004).

PERMEABLE BOUNDARIES AND KNOWLEDGE ACQUISITION

To date, we have reviewed the principal theories concerning organisational boundaries. We posit that organisational boundaries are important for determining firm-level competitiveness because the location of the boundaries will determine the likely future knowledge boundaries as well as the potential for learning. Perhaps more importantly, it is the nature of the boundary that also fundamentally affects knowledge transfer and therefore we suggest that the whole question of firms' boundaries needs to move towards an integration of organisational boundaries and value creation. In this respect, the knowledge-based view of the firm and related knowledge-driven theory concerning competitive advantage provide the best opportunity for moving this field forward in terms of the way that knowledge generation, sharing and application directly affects both organisational structures and competitive advantage.

On the basis of our review of the literature, we posit that the exact location of organisational boundaries are not as important as the nature of these boundaries – and in this respect we propose that the permeability of the boundary is a critical dimension. Jacobides and Billinger (2006) introduce the notion of permeable organisational boundaries to explain how markets and hierarchies can be used simultaneously for the same activity as permeability allows for inputs and outputs, and most importantly knowledge, of movement relatively freely into and out of the organisation. And Hamel (1991) used the analogy of a collaborative membrane to describe the permeability of the boundary of the firm. The extent to which the membrane is permeable and the direction(s) in which it is permeable determine the capacity of knowledge flow and thus relative learning (Hamel 1991). By sharing skills and knowledge, firms engage in learning – something that fundamentally affects where future organisational boundaries may lie.

The ideal scenario is that organisations with specialised or complementary knowledge learn from each other via a two-way flow of knowledge through permeable organisational boundaries. This is itself unlikely to be enough, as knowledge transfer is rare when an explicit and clearly communicated learning motive is lacking (Hamel 1991; Inkpen 2005). That is, inter-partner learning must be by design and not default, i.e. an explicit strategic intention (Davenport and Prusak 1998; Dixon 2000; Inkpen 2005). While Helleloid and Simonin (1994) believe that learning can occur as an unintended consequence of inter-firm collaboration, Hamel (1991) found that in the absence of a clearly articulated learning agenda, individual businesses appeared unlikely to devote resources to the task of learning and that they could expect skills substitution or surrender. Thus permeability in itself is important, but true benefits are most likely to accrue when the knowledge is being actively pushed or pulled across the organisational boundaries.

THE RATIONALE FOR HYBRID PUBLIC–PRIVATE ALLIANCES

As the knowledge boundaries and activity boundaries of the firm often fail to align, opportunities exist for alliances or other forms of intermediate organisational structures (Grant and Baden-Fuller 1995; 2004). Hybrid structures are not a new phenomenon and have existed since the early 20th century. The sense that hybrids are a new phenomenon may be garnered from a rise in popularity since the 1970s, as well as a shift in motives for their establishment, such as higher levels of knowledge exchange and technology transfer between partners (Inkpen and Crossan 1995; Mowery et al. 1996), the adoption of new ways of structuring boundaries and internal organisation (Foss 2002), and for the efficiency, flexibility and responsiveness they offer (Lorenzoni and Baden-Fuller 1995). With the emergence of New Public Management, large government departments (English 2005; English and Skellern 2005; Pollitt and Bouckaert 2000) have pulled back their activity boundaries through outsourcing and divestment of core activities. As a result, they have increasingly cooperated with other organisations, mainly private enterprise, to engage in activities and access resources (Hood 1995; Lapsley 1999; Seal 1999), including knowledge, outside their own boundaries. This mirrors trends in large industrial organisations where new organisational forms are emerging as firms roll back their boundaries through downsizing, divestment, refocusing and outsourcing (Grant and Baden-Fuller 1995). Essentially government is using contractual structures, such as strategic alliances, to replicate the vertical integration which previously existed internally (Williamson 1991b).

Achieving effective knowledge transfer in public–private alliances, in the current public sector environment, requires a shift in thinking which recognises the need to share a culture that goes beyond the organisational boundaries (Badaracco 1991b; Rowlinson and Cheung 2002). It also requires a move away from the adversarial nature of contracting relationships which use dispute resolution mechanisms as a fall-back position. These partnerships enable the organisations to benefit from integration and specialisation in a manner that is most likely more difficult to replicate than if the knowledge was simply held internally. Certainly, the flow of knowledge, enabled by information and communication technology, is changing the way individuals and organisations interact and work, both within and with those outside their boundaries, such as suppliers, consultants and contractors (Dixon 2000; Galbreath 2002). In many instances new organisational forms have seen the boundaries of the firm radically transformed, not only by increasing moves to outsourcing and other forms of relational contracting and networks, but because of the implications of the fluid nature of knowledge capital versus the relatively static nature of physical capital (Foss 2002; 2007; Galbreath 2002).

CASE STUDY: MAIN ROADS WESTERN AUSTRALIA

Established in 1926, Main Roads Western Australia is the State's statutory road authority and its oldest public sector organisation. Its net assets are worth \$22.5b and responsibility extends to total asset management of the road network, project delivery to expand and maintain the network, and traffic and road user management (Main Roads WA 2006). The network has a replacement value of \$21.4b. Western Australia has 174 008 kilometres of roads, of which declared highways and main roads comprise 17 706 kilometres or about 10 per cent. Main Roads also contributes funding to assist in the maintenance of 125 968 kilometres of local roads.

Contracting guiding principles

Three clear guiding principles govern contracting processes. These specify that contracts should be commercially viable; transfer appropriate decision-making and risk to industry; while Main Roads retains responsibility for standards and compliance (Main Roads WA 2007). Projects are classified into three categories. Category 1 projects are discrete major projects, with significant scope, costing more than \$20m. They are either delivered by design-and-construct or alliance contracts. Category 2 projects generally cost between \$1.5m and \$20m and are competitively tendered either as design-and-construct contracts or as a mixture of separate design and separate construct. Category 3 projects are maintenance and rehabilitation projects, including capital works up to \$1.5m, delivered through term network contracts and term asset contracts.

History of alliancing in Main Roads

Up until the 1980s Main Roads had total control over the design and construction of roads. While as much as 60 per cent of work was handled by contractors, the organisation continued to employ a huge internal labour workforce and employees felt that the organisation had a very strong sense of control over its own destiny. In 1996, Main Roads began a metamorphosis from maker and maintainer of roads to owner and manager (Edmonds 1997). Change was driven by the state government's economic rationalist reform agenda. The rapid refocusing on outsourcing to the private sector resulted in severe staff reductions (Edmonds 2007). A 2001 ministerial report into the effects on Main Roads of contracting out virtually all services, including design, found that the 'full-on' contracting-out approach had severely impacted Main Roads knowledge base (Edmonds 2007). The report recommended that within three years, Main Roads rebuild about 25 per cent of its in-house design capacity, so that it was not just an 'informed buyer', but a partner in the state's road industry. Another critical step in becoming a partner in the road industry was the move towards relationship contracting and particularly alliancing. In December 2002, a new commissioner brought with him a wealth of contracting experience and knowledge about relationship contracting (Edmonds 2007). Relationships based on goal congruence were placed on the strategic agenda as a focus of the strategic plan. In November 2003, Main Roads entered into its first public–private alliance (Edmonds 2007). This initial alliance contract was still fairly prescriptive, but was a significant step in an evolutionary process toward relinquishing control to the alliance entity as an autonomous decision-making body.

An explicit innovation, knowledge transfer and learning agenda

The awarding of alliance contracts is based on multiple criteria including the reputation of the alliance partners, rather than being based on cost alone. The final cost is often not determined until after the contract has been signed and preliminary design work is completed (though there is always an accepted formula or system for determining the eventual cost that is agreed to in advance). In essence, a key driver for Main Roads is to build the best possible roads for the community and they seek alliance partners who can bring innovation to each project (Edmonds 2007). While alliances are primarily risk/reward-sharing arrangements, they afford the opportunity for both public and private partners to engage in projects larger than any one entity would be able to undertake on their own. Thus alliances provide a capacity-building potential for all individuals and organisations involved that is not inherent in conventional contracting arrangements. In addition, alliance partners have to complete all land resumptions, approvals, heritage considerations and stakeholder relations, formerly dealt with by Main Roads ahead of the awarding a contract. These processes now run concurrently, thus speeding up the process, but says one project director: 'For everyone this is a new way of working and we probably didn't appreciate the risk and time associated with what Main Roads does before they award a traditional contract'. At the start of each project, an independent alliance facilitator works with the alliance management team to determine goals, including a commitment that everyone will exit the alliance with enhanced knowledge and skills. This process involves establishing explicit non-cost key performance indicators, which are measured and rewarded by the client as part of the contract. These include training and the development of individual training plans. Thus there is a clearly articulated learning agenda. Says a project director:

> *The sharing of knowledge is a two-way street and no one is bleeding off anyone else. While I have enhanced my knowledge of design and geotechnical issues, I know that the Main Roads guys have a better understanding of contracting issues. Although there is a contract in place, things are very different from a conventional contract in that we negotiate better outcomes and there is a different mindset.*

Transparency between alliance partners

Alliance partners agree that the biggest challenge in establishing an alliance partnership is bringing people from different organisations together to think as one. The alliance facilitator supports much of the team development process and the establishment of common values. A Main Roads alliance member said:

> *Team development is essential for future success. Because of the different cultures it has been a battle from Day 1 to build a team and we have had to constantly work on our team culture and development. We have tried to get people out of their huddles and focused on creating a new team with a unique identity.*

An industry partner comment reflects the assertion that complex cultural differences distinguish firms, including those in the same city (Badaracco 1991a): 'No one way is right, but different organisations have different cultures, behaviours, work ethics and time management and we have had to work to formulating common goals.' Building on this, people feel safe to communicate openly. Thus, the alliance is simultaneously a common space, for alliance members to share knowledge, learn and problem-solve, and a 'collaborative membrane' (Hamel 1991) between the alliance members and their parent organisations. Alliance members indicate that the interface with Main Roads is fluid, but never intrusive. However, from the Main Roads perspective the alliance interface is made complex by the multiple roles which it plays in the alliance, namely alliance partner, client, stakeholder (regional office) and advisor (Technical Advisory Group). Tension arises because those who are integrally part of the process appreciate the flexible and innovative practices employed inside the alliance, while those on the outside may work to maintain the *status quo* and reinforce standards. These tensions raise potential issues for receptivity and absorptive capacity within Main Roads, despite the multiple conduits for knowledge transfer and learning into the organisation.

Receptivity and absorptive capacity within Main Roads

When alliance members return to the parent organisation they take with them invaluable knowledge not only about the practice of constructing a particular road, but also about the way that alliance partners think and the collaborative, problem-solving processes involved to achieve the outcome. Main Roads alliance members indicate that they closely document the contracting award process, and all other processes and lessons learnt at each critical milestone. Specific interventions throughout the project are also documented and all this detail is fed back into Main Roads. Documenting the alliance experience embellishes knowledge which flows back to the organisation through other conduits like formal reporting, designs and the Technical Advisory Group. People entering new alliances have described the knowledge gleaned from the documented processes of previous alliances as invaluable. Many employees see the exchange of ideas, the flexibility to resolve differences of opinion and innovate in the open environment of the alliance as a very healthy way of building knowledge. This is particularly because effective feedback loops are being developed and this new knowledge challenges existing, traditional thinking within the parent organisation. However, some employees are still skeptical about whether these feedback loops are effective fearing that much of the knowledge is still in people's heads and not captured in systems. They suggest the need for conversations which capture not only the lessons learnt, but also the stories that go to make up experience. Certainly the lessons learnt from each alliance are supporting the development of future alliances. Employees involved with developing and implementing design standards see great benefits flowing back to their team.

Main Roads employees have a broad range of opinions about the effectiveness of alliancing and views differ depending on whether or not people have been involved in an alliance. One Main Roads alliance member admits that before going into an alliance he was skeptical when people spoke of the potential for knowledge transfer:

> *I didn't think that the knowledge and skills transfer would work the way people told me it would, but I have learnt a huge amount about how contractors work and I have taught the contractors about how Main Roads works and there has been an enormous transfer of knowledge.*

This attitude reflects some of the anxiety over asymmetric learning expressed in other studies (Hamel 1991; Inkpen 2005). Also, there is an element of frustration with alliances because they are resource hungry and take away some of the best people for extended periods of time. Limited resources potentially lead to a loss of opportunity in other areas. However, this must be balanced against the knowledge flowing back into the organisation. This reflects classic tensions between the rigidity and complexity of traditional organisational structures and the flexibility of alliance project teams highlighted by Nonaka and Takeuchi (1995). Essentially organisations need to develop new organisational structures in order to effectively and continuously create knowledge (Badaracco 1991b; Nonaka and Takeuchi 1995). The hypertext organisation proposes interlacing flexible task forces (project layer) with hierarchical formal structures (business layer) to allow for knowledge to move dynamically between the two structural layers to create the organisation's knowledge base (Nonaka and Takeuchi 1995). The organisational structure and culture needs to be oriented towards allowing the best people to move between these structures for the duration of projects, in the best interests of building the knowledge base.

DISCUSSION AND CONCLUSION

The 'boundaries of the firm' question has long been a central question for management scholars. While a variety of theoretical approaches have been used to explain what determines these boundaries, we suggest that the knowledge-based view with its focus on where the boundaries lie and what drives competitive advantage offers a useful lens through which to study industries in the 21st century. However, rather than focus on simply the location of a firm's boundary, we suggest that it is the nature of the boundary that is more important – with permeable boundaries providing significant advantages in terms of learning opportunities. We then use a detailed case study of Main Roads Western Australia to illustrate how they have rebuilt some of their capabilities via a reconceptualisation of the structure of the boundaries of their organisation such that they were more permeable and focused specifically on both parties to any alliance, benefiting from the learning that is possible.

What was clearly evident from this case study was that organisational structure, especially the location of boundaries (i.e. what was undertaken by each partner) and the nature of the organisational boundary (which was designed to be as permeable as possible) fundamentally affected the learning and subsequent knowledge of Main Roads. Main Roads changed the boundaries of what they did such that their alliance partners worked with them on the preliminary stages (land resumption, heritage considerations etc.) and at the same time, their employees were actively engaged in parts of both the design and the construct phases of the project. Strict delineation of firms' boundaries became far more difficult as both parties to the alliance were involved in many stages. This in itself laid the foundations for knowledge transfer, but what also became central to the attempt by Main Roads to rebuild their capabilities was the design of organisational boundaries that were permeable and in fact the creation of systems to enhance the movement of knowledge between alliance partners.

Because of the structures used, in this environment where it is government policy to de-integrate, the competition for knowledge between alliance partners does not exist as Hamel (1991) describes it. Rather than an alliance between competitors we see an alliance between an elite public organisation and several specialised private suppliers. Here the elite public organisation equates to Quinn's (1992) idea of the 'central firm' which collects together partners to contribute to the whole system (Inkpen and Tsang 2005; Lorenzoni and Baden-Fuller 1995) and whose roles are clearly defined in a positive and creative way. The collaborative nature of these public–private alliances with their strong orientation towards team building, shared learning and relationships, as opposed to competing with partners for knowledge, results in the dual nature of the alliance as both collaborative membrane and common space. This intersubjective space is where the transfer of explicit knowledge easily occurs and as relationships develop the efficacy of tacit knowledge transfer increases. Here knowledge can be seen as neither the representation of reality nor the result of an application of ultimate rational criteria, but instead a competence to engage successfully in practice (Habermas 2003), which is at the heart of tacit knowledge or 'know-how' (Nonaka and Takeuchi 1995; Polanyi 1966). The intersubjective social context and the processes they embody represent knowledge of second-order complexity as explicit and tacit knowledge are combined to create common knowledge which is able to pass from one community to another (Tywoniak 2007).

For the construction industry as a whole, this case demonstrates the need for senior management to consider where they position their operational boundaries (be they highly restricted through the use of outsourcing or far wider in scope) as these boundaries are critical determinants of a firm's knowledge stocks both now and into the future. Restricting the operational boundaries does not necessarily mean limiting a firm's knowledge and its subsequent capabilities. The purposeful creation of permeable boundaries is likely to be even more important than where the firm boundaries were originally set. In fact, coupled with cooperative contracts such as those found in alliance contracts as opposed to taking a more adversarial tack with contractors, could allow a firm to develop its knowledge (and capabilities) to be a systems integrator (as per Brusoni, Prencipe and Pavitt 2001) as opposed to a contracts manager. Finally, at its most fundamental level, this case clearly demonstrates that knowledge management (and subsequent competitive advantage) cannot be disconnected from organisational structural issues as the two are inextricably linked.

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CHAPTER 30

Exemplars of Successful Innovation Delivery by Small and Medium Construction Enterprises

Mary Hardie
Karen Manley

INTRODUCTION AND CONCEPTUAL BACKGROUND

Among the most effective characteristics of small- and medium-sized firms (SMEs) is their innate flexibility and their tendency to favour multiskilling. Despite this ability to respond to particular circumstances quickly, the absence of significant levels of spare capacity or even of the most basic resources can sometimes lead to a tendency for SME construction firms to rely heavily on 'business as usual' solutions rather than risk adopting new or innovative practices. Self-preservation can tend to dictate avoidance of many possible changes which may be the source of successful new modes of operating. This unwillingness to venture into new territory can be a major brake on sectoral performance, particularly in the restrictive circumstances of either:

- an economic downturn when maintaining a good reputation is particularly important and risk aversion is high, or
- in boom times, when resource shortages and time pressures mean it is harder to find the time, money or people for innovation.

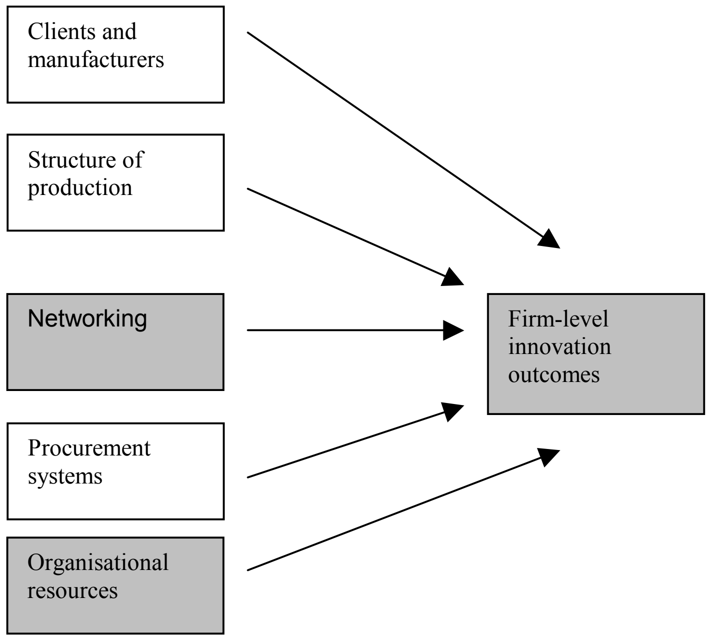
Firms at the smaller end of the spectrum tend to be more subject to these constraints than larger businesses. The resultant conservative attitude, which can be described as 'sticking strictly with what we know for safety's sake', can result in a loss of potential earnings as well as loss of inventive construction solutions which would have benefited the community or the environment. A potential circuit breaker for this state of affairs is provided by the theory of innovation management which suggests that this situation can be turned around by the release of innovation as a driver of economic prosperity. Such concepts have been well known in economic literature since the pioneering work of J. A. Schumpeter in the 1930s and 1940s (Schumpeter 1934; Schumpeter 1942). In recent decades, several researchers have interpreted innovation theory in the context of the construction industry in the United States, United Kingdom and Australia (Gann 2000; Nam and Tatum 1992; Sexton and Barrett 2002; Slaughter 1993; Slaughter 2000; Manley 2006a; Manley and McFallan 2006). In recent years the concept of innovation as a driver of industry performance has been widely embraced by large, international construction companies but this lead has not necessarily been followed by SMEs. Research specifically aimed at small UK construction businesses has pointed out the specific difficulties faced by such firms wishing to introduce innovative practices (Sexton and Barrett 2003; Sexton et al. 2006). Generally, however, there has been limited study of the factors that favour or discourage innovations in firms at the small to medium end of the spectrum. This area has the potential to be very useful for policy-makers wishing to lift overall industry performance by concentrating on a sector that forms a significant part of the construction industry.

While the history of every company which achieves successful adoption and delivery of innovative practice is clearly different in detail, it is speculated that there are some features which such firms have in common. The identification of these common features is useful to the firm itself as a validation of their own choices and practices but more importantly it can provide some suggestions for other companies wishing to lift their performance. In the construction industry context, this idea was championed by Winch (1998, 277), who explicitly identified the need for 'more case studies of the trajectories of construction innovations' to encourage innovative practice. There have been some specific instances of research which attempted to do this for particular segments of the wider architecture, engineering and construction (AEC) industries. For example, Salter and Gann (2003) have identified many of the sources of innovation for engineering firms. Contractors and subcontractors, however, may well have different sources, as noted by Manley et al. (2004). For the industry as a whole and for policy-makers in government, the diffusion of innovative practice has been targeted as a way of improving both the economic and the social aspects of project delivery. Gann (2001) found that most construction organisations get their new ideas through published media and by participating in various industry networks. Blayse and Manley (2004) found that there were six primary influences which either drive or hinder construction innovation. These were:

1. clients and manufacturers
2. the structure of production
3. networking
4. procurement systems
5. regulations and standards
6. the nature and quality of organisational resources.

Recent research indicates that SMEs rely particularly on leveraging their internal organisational resources through networking and relationship building, to promote their innovation efforts. However there has been relatively little research into the operation of these factors for smaller contractors in the construction industry. How smaller contractors perceive and report the relative importance of these factors in the successful delivery of innovation is the principal matter addressed by this research. Analysis is guided by Figure 30.1, and this chapter focuses on the highlighted relationships through descriptive methods.

Figure 30.1 Innovation Determinants



The term 'innovation' may be used loosely as a synonym for change but in the academic literature it is more closely defined. A widely published author on the topic of construction innovation defines it as being understood to be 'a non-trivial change in a product, process or system' (Slaughter 1998). Such a change can be at the level of 'world's first' or it can be at the level of 'a first' for a country, industry or individual organisation. The innovation process generally includes both technological and organisational streams (Bossink 2004). Technological innovations include improvements to construction materials, building processes and equipment. Organisational innovations include matters to do with communication systems, business strategies, human resources and knowledge management. Technological innovations are easier to recognise in an industry like construction, but it is possible that organisational innovations have more long-lasting effects (Barrett and Sexton 2006). Linkages between the these two main streams of innovation have been found to be critical to success in project-based industries like construction (Gann and Salter 2000; Hardie et al. 2005). Both streams of innovation were given consideration in this research.

The definition of what constitutes a small or medium business in the construction industry is a matter of debate. There is a widely held perception that the large majority of construction industry businesses worldwide fall into the category of small- and medium-sized enterprises or 'SMEs'. Despite this perception, extraordinary variation exists between the definitions of what is meant by 'small' and 'medium'. Indeed, the definition of an SME varies widely from country to country. It may be based on the firm's assets, its number of employees or its annual turnover. In the USA, for example, the thresholds are set much higher than in a smaller economy like Australia. The qualifying definition for a small business in construction is $31m in annual receipts (US Small Business Administration 2007). Sexton and Barrett (2002) in their study of small UK construction firms define such firms as having between 10 and 49 staff. The NSW government Small Business Website uses 20 employees, maximum, as the definition of a 'small business' (NSW Government 2004). Another definition states that, for Australia, an SME can be defined as fewer than 100 employees in the manufacturing sector and fewer than 20 employees in the services sector (Hall 1995). The Australian Bureau of Statistics (ABS), however, generally uses fewer than 20 employees for a small business and fewer than 200 for a medium business. They have an additional category of 'micro-business' which is considered to be fewer than five employees. The ABS definition is the one adopted here (small = <20; medium = 21–200) as it covers the jurisdiction of the research undertaken.

An ABS study in 1999 found that 'Businesses with employment of less than five people accounted for 93.8 per cent of all businesses in the construction industry, and just over two-thirds of all people working in the industry' (Australian Bureau of Statistics 1999). Although many of these are single-person operations who work under employee-like directive situations, the study nevertheless found that these micro-businesses produce 53.5 per cent of the industry gross product (IGP). It can clearly be seen that whatever definition is used, smaller businesses account for a significant portion of activity in the construction sector. Any attempt to improve the efficiency, profitability and sustainability of the sector as a whole will have to address the specific conditions, limitations and opportunities which characterise small businesses.

METHODOLOGY

The research reported here is part of a larger study which aims to promote innovation in the Australian construction industry. The study which commenced in 2001, was undertaken by the BRITE Project for the Australian CRC for *Construction Innovation* (Manley 2006b). In 2006, interviews were conducted with the principal or a senior manager of 20 firms identified as high innovators by means of a structured survey, based on previous research done by the BRITE Project (Manley and McFallan 2005). The 20 firms represent the top-ranked applicants to the Australian Innovative Contractors Database, as at January 2007. The database was set up by the BRITE Project as the result of requests from participants in the Australian building and construction industry for a directory of the most innovative firms across the country. The aim was to better facilitate business-to-business networking amongst innovative industry participants throughout Australia. The database facilitates the formation of relationships across a much broader geographical area than that available through the personal contacts of industry participants.

Only qualifying businesses are listed on the database. To qualify, businesses completed a survey, answering questions about their innovation activity, covering the:

- novelty of technological and organisational innovations
- impact of innovation on profitability
- adoption rate of advanced technologies and practices
- importance placed on investing in research and development.

These factors were used to create an index measuring the 'innovativeness' of each business. The answers from a business are scored, and only those businesses with a score greater than the cut-off qualify for listing on the database. The cut-off score is based on results from the first large-scale construction innovation survey conducted in Australia (Manley 2006b). The cut-off point separated the top quarter of the ranked 383 respondents to the survey from the other respondents, and was applied to database applicants. This implies that only about 25 per cent of all Australian contractors would qualify for listing on the database.

As at January 2007, there were over 80 contractors on the database. The database lists registrants' names, contact details and a description of their expertise, to facilitate relationship building. The database is constantly being advertised, and was first promoted in June 2006. Invitations to businesses to apply for registration are made through industry association newsletters and direct email invitations from government client agencies.

The 20 top-ranked businesses as at January 2007 included three that employed fewer than 20 people and therefore can be classified as small businesses as well as one medium-sized business that employed around 70 people. These four businesses are the focus of the current study. The businesses comprise different kinds of contractors. A civil contractor represents the medium-sized business sector and a general contractor, a specialist contractor and a trade contractor represent the small business sector. They are considered to be useful exemplars of SME innovation in construction because the businesses have been praised by their peers in terms of their innovation efforts and because they have been able to provide associated examples of project-based innovation that illustrate different kinds of innovation delivery. It is intended that the case studies are exploratory in nature and that with further research they will be used to generate theory as a means of initiating industry-wide cha*nge (Gummesson 1988).*

The data gathered from these three businesses forms the basis for this paper, which investigates the research question: What are the enabling factors that characterise the successful delivery of project-based technical innovations by small and medium contractors? The data is based on the interviews summarised in Table 30.1.

A prepared question list was used for all interviews, but the interviewees were encouraged to contribute ideas that were a particular priority for them even if not on the scheduled question sheet. Topics covered included employees, transitions, networking, government policies, and client attitudes. The interviews were recorded, transcripts were made and the answers then entered into a categorised spreadsheet to aid the identification of common themes and attitudes via content analysis. The interviewees were also given the opportunity to nominate a project which illustrated their innovative capacity and to describe the project in detail.

Table 30.1 Case Study Firm Details

Firm	Employment (full-time equivalent)	Title of Interviewee	Length of Interview	Type of Interview
A	70	Senior project manager	120 mins	Telephone
B	20	Partner	120 mins	Telephone
C	15	Director	120 mins	Personal
D	19	Managing director	120 mins	Personal

CASE STUDIES

The four SME case studies are now described as background to the research question: What are the enabling factors that characterise the successful delivery of project-based technical innovations by small contractors?

Firm A: Regionally based civil contractor

A civil contractor based in western Queensland and covering much of regional Queensland and western NSW was the first case study firm. The firm delivers roads, bridges, feedlots and civil infrastructure for subdivisions. The company has been in business for more than 40 years and maintains a good reputation within the local community. It employed around 70 full-time equivalent (FTE) staff at the time of interview. The interviewee mentioned the current skills shortage as a result of the variety of employment choices open to good workers in his area. The firm has a low staff turnover, but has great difficulty finding suitable new employees. For this reason, maintaining and enhancing staff conditions was a priority for the company. Barbecues or other social gatherings were held at least once a month to encourage teamwork and elicit comment on projects and performance.

The interviewee felt that the civil contracting sector tended to be more open and collaborative than the building sector although it was just as competitive. There was more sharing of ideas and practices and this was seen to lead to a better atmosphere for innovation generation. The interviewee was enthusiastic about the prospect of alliances and consortium-type contracts being extended to include the small contractor sector through the efforts of government departments such as Queensland Department of Main Roads.

Networking with industry associations was regarded as extremely important by his company and the Civil Contractors Federation (CCF) was named as particularly significant. Such networking enabled this regionally based firm to keep in touch with 'what is happening … and the way things are moving' in the larger industry context. This firm communicates with industry associations weekly. This was mainly because their staff form acquaintances with other contractors and are always talking about projects that are current or about to happen. The company also had an ongoing relationship with their regional university. They used the university's services for analytical work on bridge and piling systems, as well as setting up their own testing facilities registered with the National Association of Testing Authorities (NATA).

The innovative project delivery example provided by this interviewee was a fully precast modular concrete bridge for a river crossing in northwest NSW. The 6 x 12 m span dual carriageway bridge was delivered with minimal use of in-situ concrete and with significant savings in cost and construction time. The company was able to design bored concrete piers to suit the geotechnical characteristics of the site. The remainder of the bridge structure – columns, headstocks, prestressed deck units and abutments – were fabricated in modular segments in a manufacturer's yard and shipped to the isolated site. The connecting system allowed rapid site erection with minimum construction risk and environmental impact. The heavy duty prestressed deck units required no correctional topping layer. The elimination of this problematic wet trade enabled construction to occur quickly even in the remote and isolated location. The modular and systematised nature of the structure makes the design solution repeatable in different locations provided that local foundation conditions are assessed by a qualified geotechnical engineer. The system is able to cope with highly reactive soils. The prestressed concrete deck was erected in four working days. This is up to three times faster than a traditionally formed and poured concrete bridge deck, while providing less likelihood of worker injury or environmental damage to the river being spanned.

This study shows that location outside major population centres can act as a spur to effective innovation in circumstances when local knowledge is combined with wide networking to keep abreast of technological developments and latest practices.

Firm B: Regionally based general contractor

A versatile general contracting business with 20 employees based in regional Victoria was selected as the second case study. A family company established over 25 years ago, it is now being run by a second generation and has completed projects in commercial, residential and industrial sectors. The company's management skills are geared to meet project deadlines and prevent cost overruns while providing quality workmanship and high site safety standards. A significant investment is also made in human resources and a continuous improvement culture which encourages quality programs on building sites. The interviewee was one of the two principals of the company with responsibility for planning and building permit applications and preparing plans, quantity estimating, project insurance, client liaison and contract terms and conditions. He stressed that it is company policy to empower employees to make decisions. Employee expertise is recognised and important decisions are in most cases not made without employee input. This inclusiveness is characterised by the company philosophy of a strong emphasis on human resources and training. Employees also have self-assessment checklists where they can propose improvements in work methods for the tasks that they regularly carry out. The company produces management newsletters which are passed on to employees, and include information from industry associations like the Building Commission of Victoria and workplace safety information. The company strongly favours a reward system for work above 'business as usual' which includes bonuses and annual awards for performance throughout the year. They also provide gifts such as tickets to local social and sporting events as well as time off to go to attend such events. In addition, they send letters of appreciation to staff who have made significant achievements.

The interviewee rated network relationships with industry bodies as 'important' to his business (2 on a scale of 1–5 from very important to not important) and noted relationships with both the Master Builders Association and the Housing Industry Association. He also stated that in Victoria some of the functions of these industry bodies were now largely filled by the Building Commission of Victoria. As well as its regulatory function, the Commission is responsible for many industry information and education programs which are of particular benefit to small businesses. Indeed the indications are that this avenue of knowledge sharing plays a much greater role for small businesses than it does for larger contractors who tend to operate through a higher level of personal contacts. The interviewee stressed the value of industry associations as 'interpreters' of building regulations to the average small builder. There had been no specific contact with university research bodies, but the firm encouraged staff to do courses at the local regional university and pursued a mix of theoretical and practical training.

The special project singled out by this interviewee as an example of innovative project delivery was a townhouse development in the regional town centre. The nature of the site, its restricted space and close proximity to neighbouring buildings, meant that a problem was identified with working at height close to site boundaries. It was decided to build the second storey of the townhouses on the ground (including flooring and roofing) and crane the finished top floor module into position when complete. Despite the extra cost of the crane, the end result was significantly cheaper due to reductions in scaffolding and labour time on-site. The local press also covered the lifting of the modules into position thereby providing free marketing exposure for the company. This example illustrates how innovative thinking can produce benefits even in relatively straightforward projects which would otherwise have been handled by traditional, though less effective, building systems.

Many of the organisational ideas expressed by this contractor may be common practice in business management in other industry sectors, but they have not often been part of the structure of a small construction company. The other attitude which singles out this company as different is that they actively seek out the difficult jobs and aim to maintain a reputation as problem solvers in project delivery. This is identified as an attitudinal lesson which would have benefits for many small construction businesses.

Firm C: Specialist contractor

The third case study firm was a specialist subcontractor with 15 employees, based in South Australia. They have a patented system for providing energy efficiencies in airconditioning services. The interviewee was a principal of the company. This case study involved a technical innovation which dehumidifies and cools the outside air intake in an airconditioning system before merging it with inside air. The system eliminates the need to use energy twice to overcool and reheat air in order to maintain humidity in an occupied space. The delivery of this particular innovation required a rethink from consultants who were used to a more traditional airconditioning approach. Nevertheless, convincing potential clients and their advisors of the environmental benefits of the system was the major barrier encountered by the firm. The major driver of the system's acceptance has been the need to achieve energy efficiency targets as expressed in Australian Buildings Greenhouse Rating (ABGR) star-rating scheme.

Commitment by the firm's staff to the system has been a major factor in its success. They have a partnership or shareholding scheme whereby employees have the option of foregoing overtime, instead putting the money into a trust account so that when senior staff retire, newer staff can buy out their shares. This allows for continuity and succession planning, as well as recognition that the value of the innovation is not exclusively a matter for the originators. The interviewee stressed the friendly 'extended family' atmosphere of the company and its decision-making processes.

The interviewee rated relationships with industry bodies as 'very important' (on a scale of 1–5 from 'very important' to 'not important'). The firm has strong relationships with Engineers Australia, Business South Australia and the National Electrical and Communications Association as well as various airconditioning organisations. The principle value of these organisations to the company was for diffusing innovative ideas throughout the industry. They also allowed for the establishment of contacts in the early phase of the innovation development when it was not yet possible to point to completed successful projects. The interviewee reported having contact with the three universities in his base city of Adelaide. This included encouraging current honours students to study the system and its delivery, as well as assistance with the development of the original patents for the method.

The project described by this interviewee as an example of innovative delivery was an office building retrofit. The use of the patented method enabled the building to lift its Green-Star rating from a poor 'two stars', to an optimum 'five star' rating. Greenhouse gas emissions were lowered by more than 50 per cent and peak electrical demand was lowered by 30 per cent. The result far exceeded the improvement envisaged when the renovation was first considered. Consequently it set new benchmarks for such projects in the future.

This study shows that persistence and care in the delivery of very innovative systems can be especially valuable if the innovation supports a strongly held community goal such sustainability and energy efficiency.

Firm D: Trade contractor

A trade contractor with 19 employees, which produces specialist cages for civil contracting in Queensland, was the fourth high innovator studied. The production of reinforcement cages for use in bridges, pylons and foundations usually involves on-site fabrication which leaves builders and their workforce exposed to the risk of significant injury and lost time due to back problems, strains and cuts as well as work position fatigue from constant bending. A patented cage system was developed by the firm which can be used on- or off-site by an operator working in an ergonomically safe position. The system is believed to be unique in the world and has very few competitors who can do a comparable job. The system enables labour to be reduced, while quality and flexibility of product delivery is maintained.

The firm emphasises employee training and safety awareness. Weekly toolbox meetings are held, where workers are encouraged to share ideas, experiences and mistakes. The relationship between the administration and the people who do the physical work in the workshop is carefully managed so that decisions are not made which ignore the workshop perspective. Communication and conversation were reported to be an integral part of a culture where all employees are encouraged to share in the process of product delivery. The company prefers to invest in training their own staff as it finds that staff from labour hire companies do not always have the certifications that they claim to have. The core competencies of the firm are kept intact by using day labourers and tradespeople only for peripheral activities.

The interviewee rated relationships with industry bodies as 'very important' (1 on a scale of 1–5 from 'very important' to 'not important'). Engineers Australia and Australian Technology Showcase were mentioned as being key sources of information and promotion. It was also stressed that the company needed to keep in close contact with the bodies that set Australian Standards for their area. The interviewee noted that, as a small firm, they had difficulty defending patents. The company owner believes that his position in the market is only secure as long as the major steel suppliers continue to allow him to function at his current level. Small firms are particularly vulnerable to supply chain manipulation by larger companies who control a large part of their market. Despite the groundbreaking nature of its technological innovation the firm did not have any ongoing relationships with universities or research bodies although they do see the potential of such relationships in future expansion plans.

The innovative delivery example described by this interviewee was a transmission line project in rural Queensland, where steel cages were used on pylons supporting overhead powerlines. The patented fabrication process was able to produce identical, high-quality cages to suit the client's project requirements. There was a nil rejection rate for the supplied cages, along with significant labour savings and occupational health and safety benefits. The innovation makes it possible to produce larger cages than any other existing system and therefore enables redesign of projects for larger spans and in more extreme locations. The lesson from this case study is in the value of looking in detail at an existing delivery system and finding unique ways to improve performance by attempting to incorporate more worker safety features and investing in worker training as a means of ensuring quality.

ANALYSIS AND CONCLUSIONS

Several common points can be drawn from the experience of the four innovative contractors despite their differences in location, size and specialty area. These points will be discussed in relation to the conceptual background established earlier, which described the interest of this research in the role organisational resources played in supporting the innovation efforts of small contractors in the context of their networking relationships.

Overall the factors that most clearly underpinned innovation by the small and medium contractors reviewed here were:

- active networking with industry and professional bodies as well as the wider community
- organisational innovation and advanced business practices to support and enable technical innovation
- emphasis on good personnel and knowledge management incorporating environmental and occupational health and safety goals.

In all four instances the companies are heavily involved in networking within their communities and within their specific industry sector. All four businesses closely monitor developments among their competitors and in related fields. The value of industry bodies of various kinds was apparent to all four interviewees. Possible benefits from such involvement include up-to-date information about new developments, interpretation of building regulation and standards changes, confirmation of the smaller business's new practices, and political lobbying on issues important to the industry. Although it was reported that sometimes personality issues can get in the way of the smooth functioning of industry umbrella bodies, the interviewees thought involvement was worth pursuing. Most interviewees also saw a common benefit in involvement with university and other research bodies and agreed that such involvement was helpful to future expansion and validation of innovative processes.

Two of the four interviewed firms, the small specialist contractor (Firm C) and the small trade contractor (Firm D), held patents for new technical processes. This demonstrates that small companies are able to generate new groundbreaking ideas, when they target an area of special interest and focus their energy and effort on that idea. These two case studies, however, also signalled a problem with the ability to preserve and defend patents without the 'very deep pockets' of larger businesses. It is possible that the wider construction industry needs to look more closely at its attitude to the generation of intellectual property and the return that is due to genuinely new ideas. Several issues around the accessibility of Australian Standards were also identified. It is often critical that small businesses keep up with changes and amendments to the relevant standards in their area. When conflict occurs between different standards, small businesses, in particular, need access to expert opinion to sort out any discrepancies. This may well be another very useful role for umbrella bodies in the industry to fill. The cost of standards information and its availability to small business is signalled as an area for government and regulators to look into. There may well be benefits from ensuring that relevant information is dispersed more widely.

In the case of the small specialist airconditioning contractor (Firm C) it was evident that community priorities on climate control formed a significant driver towards energy-saving innovation. The regional civil contractor (Firm A) was also motivated by environmental concerns, particularly with regard to reducing polluting runoff to waterways during construction and reducing overall water use through prefabrication. Clients, particularly government clients, are responding to the growing community concern on environmental issues and this can be a motivating factor for small-firm innovation. Industry bodies could benefit from putting more effort into encouraging small businesses to respond to this community concern.

All four case studies illustrate the emphasis successful innovators place on personnel and knowledge management. Whether it be in attention to occupational health and safety issues, encouragement of staff involvement in decision-making or providing appropriate incentives and rewards, innovative firms actively manage the delivery of their product by means of a human focus. Personnel and intellectual property issues were shown to be critical to ongoing successful performance.

The case studies demonstrate that high-level innovation is possible in small and medium regionally based firms if they know their market and develop a high level of problem-solving expertise. The ability to produce a flexible response to unique project-based situations is the basic strength of SMEs. However, smaller firms need to compensate for their lack of size by forming diverse and extensive networks with other businesses, industry bodies and their local communities. Such contacts can reduce the isolation and stress of running a small business and can provide feedback on the innovation processes being undertaken.

Although the four case studies involved technical innovations in the delivery of products or processes, all four firms also stressed the importance of organisational innovations which support the development of the technological solution. It would seem that in small business it is hard to separate the technological from the organisational innovation as they have to work concurrently and synergistically in order to be successful at this scale. To this end all the interviewees were deeply involved in human resource issues in terms of the management of their companies. All favoured consultative and inclusive policies in staff's involvement in decision-making. The 'soft skills' of people management and communication were revealed to be as important to success as the mastery of the technological problem being confronted. In an industry like construction, which is often seen as combative and even cut-throat, this is a valuable lesson to have learned.

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Climate for Enhancing Innovation Diffusion: Pathways to improved business performance

Kriengsak Panuwatwanich
Rodney Stewart
Sherif Mohamed

INTRODUCTION

Innovation is widely recognised as a driving force for a firm's economic growth (Gann 2003). Particularly in the design sector where creativity and innovation dictate business competitiveness, firms capable of successfully generating and/or adopting innovation are more likely to stay competitive than those who do not. To achieve this, firms need to be able to understand how innovation can be effectively diffused. Diffusion, as defined by Rogers (1983), is the process by which an innovation is communicated through certain channels over time among the members of a social system. As a result, innovation diffusion has been viewed as a result of a social psychological process.

Generally, social psychological process can manifest itself in the form of an environmental stimulus namely 'climate', which is considered as a determinant of motivation and behaviour (Kozlowski and Doherty 1989). Climate is defined as 'a shared and enduring molar perception of the psychologically important aspects of the work environment' (Ashfort 1985). Furthermore, as pointed out by Schneider and Reichers (1983), members of an organisation are exposed to numerous events and situations which are perceived in related sets. Therefore, when examining climate in an organisation, it is imperative that climate be related to a specific issue. In view of this, the study presented in this paper concentrates on analysing 'climate for innovation'. In addition, the study is concerned with the context of 'design', which is an important element of a construction project lifecycle. In the realm of innovation research, design has long been recognised as an important part of the innovation process, yet it is poorly understood in innovation studies (Salter and Torbett 2003). Milne and Leifer (1999) maintain that what is less understood is how the quality of the environment (i.e. climate) may impact design activity aimed at developing innovative products. To address this gap, the present study aims at examining the climate for innovation and its role in determining innovation-related outcomes among AED firms.

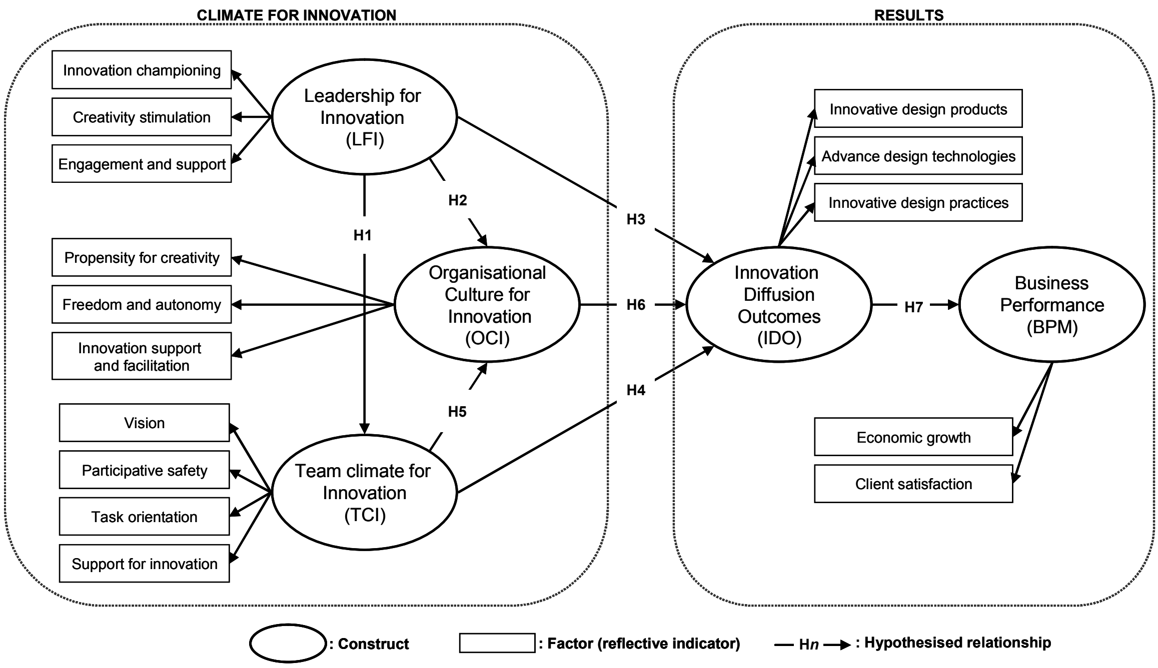
CONCEPTUAL MODEL

Overview

Past research studies have identified a number of social psychological factors forming a climate which can be perceived by members of an organisation. These factors can be grouped as leadership, organisational culture and team process (Amabile et al. 1996; West 1997). These groups of factors (constructs), acting as enablers to the diffusion of innovation, are also consistent with those identified and reported in the research conducted in the area of building and construction (e.g. Egbu et al. 1998; Steele and Murray 2004). However, the relationships between such enabling constructs and their outcomes have not been examined extensively from an empirical standpoint. To overcome this deficiency, the present study attempts to model the dynamics of these constructs by exploring the relationships between them, and their effects on innovation-related outcomes.

Figure 31.1 illustrates the conceptual model consisting of two main elements: climate for innovation and results. Within the element of climate for innovation, there are three key constructs: organisational culture for innovation, leadership for innovation, and team climate for innovation; whereas the 'results' element consists of two constructs: innovation diffusion outcomes, and business performance. The following section details the model constructs and the formation of associated research hypotheses.

Figure 31.1 Conceptual Model and Hypotheses



Model constructs and hypotheses

Leadership for innovation construct

Leadership is a key ingredient if organisations are to function effectively. It generally involves a process whereby intentional influence is exerted by one person over other members in order to guide and facilitate activities and relationships in a group or an organisation (De Jong 2004). In construction, leaders and champions are commonly identified as crucial players in the success of innovation in construction projects (Nam and Tatum 1997). Generally, innovation-conducive leaders display championing behaviour by constantly seeking out and promoting creative and innovative ideas (Howell and Higgins 1990; Yukl et al. 2002). They also stimulate creativity from team members by inspiring a future vision and encourage members to develop their own ideas (Bass and Avolio 1994). To achieve innovative outcomes, these leaders obtain support from their subordinates by maintaining the quality of work relationships, and encourage team members to share ideas and resources (Bass and Avolio 1994; Yukl et al. 2002). Recent empirical studies have shown that supervisors/leaders who exhibit such behaviours significantly influence innovation directly and indirectly through such variables as organisational learning and team cohesion (e.g. Aragón-Correa et al. 2007; Montes et al. 2005). Accordingly, it is expected that leadership will influence organisational culture, team climate, and the level of innovation diffusion outcomes; thus the following hypotheses:

- H1: Leadership for innovation positively influences team climate for innovation
- H2: Leadership for innovation positively influences organisational culture for innovation
- H3: Leadership for innovation positively influences innovation diffusion outcomes.

Team climate for innovation construct

Understanding factors that hinder or foster creativity and innovation in teams is crucial for firms seeking to enhance the diffusion of innovation since innovation has usually originated and subsequently been developed by teams into practice. To provide an understanding of such factors, the study adopted the 'four-factor theory' proposed by West (1990), which outlines four factors characterising team climate for innovation: (1) *vision* refers to an establishment of clearly defined and shared goals that provide focus and direction to team members as a motivating force at work; (2) *participative safety* is a climate in which involvement in decision-making is motivated and reinforced without fear of criticism; (3) *task orientation* refers to a shared concern with excellence and quality of task performance; and (4) *support for innovation* refers to the expectation, approval, and practical support of attempts to introduce new and improved ways of doing things. Empirically, innovative team climate was identified as a predictor of innovation outcomes by several authors. For example, Hurley (1995) studied employees' perception of work group culture (i.e. team climate) and found a significant and positive influence of the innovative group's culture on innovative productivity. Reasonably, it can be presumed that team climate for innovation can predict the level of innovation diffusion outcomes. The foregoing supposition led to the following hypothesis:

- H4: Team climate for innovation positively influences innovation diffusion outcomes.

Organisational culture for innovation construct

Organisational culture is a primary determinant of innovation, having major facilitating and constraining effects on the successful implementation and maintenance of innovation (Ahmed 1998; West 1997). Thus, the promotion of a culture for innovation is most important in order to maintain a proactive and entrepreneurial organisation (Steele and Murray 2004). In general, an organisation that favours innovation always provides a high level of freedom and autonomy, and exhibits a propensity for creativity by having a culture where there is a presence of flexibility and risk tolerance (Amabile et al. 1996; Ekvall 1996). Within such culture, innovation efforts are recognised and supported, and adequate resources are usually set aside to facilitate such efforts (Amabile et al. 1996; Fernando 2006). Several empirical studies have found a significant contribution of the perceptions of such cultural characteristics on innovation-related outcomes (e.g. Lau and Ngo 2004). As such, it can be expected that organisational culture for innovation will influence the outcomes of innovation diffusion. As a final note, since creative people in an organisation play a significant role in shaping a culture of innovation (Ahmed 1998), it is also proposed that organisational culture for innovation will be influenced by team climate for innovation; hence:

- H5: Team climate for innovation positively influences organisational culture for innovation
- H6: Organisational culture for innovation positively influences innovation diffusion outcomes.

Innovation diffusion outcomes and business performance constructs

Innovation can come to an organisation by means of generation or adoption (Damanpour and Gopalakrishnan 1998). In the design sector, innovative design solutions can be considered as a generated innovation representing a bottom-up diffusion process, whereas the adoption of advanced design technologies and/or practices represents a top-down diffusion effort. Both of these were considered as indicators of innovation diffusion outcomes in the present study. Although there is no empirical study on the direct benefits of such design innovation on business performance of AED firms, it is anticipated that business performance will be improved with the presence of design innovation. In other industries, innovation was empirically found to have a positive impact on business performance (e.g. Aragón-Correa et al. 2007; Han et al. 1998); thus the last hypothesis:

- H7: Innovation diffusion outcomes positively influence business performance

It should, however, be noted that past research regarding the benefits of innovation on the business performance also produced inconsistent results. For example, Darroch (2005) and Kemp et al. (2003) found no relationship between innovation and business performance.

RESEARCH METHOD

The study adopted a sequential mixed method research design which combines quantitative and qualitative research approaches (Tashakkori and Teddlie 1998). The use of such a hybrid strategy has been strongly encouraged in the area of construction management research (see Wing et al. 1998). As a predominant method in the measurement of climate, a quantitative-based questionnaire survey was first conducted to provide an initial step for assessing the developed conceptual model. This involved employing a quantitative analysis of survey data to determine how well the model represents the prevalent phenomena among AED firms. Following this, qualitative case studies were sequentially conducted to further ascertain the validity of the model. As a result, the analysis consisted of two phases: quantitative analysis serving the conceptual model assessment; and qualitative analysis ascertaining the model's validity. The details of both analyses are presented in the following sections.

Quantitative analysis: Conceptual model assessment

Questionnaire survey

A questionnaire was developed based on an extensive review of literature and past empirical studies. Questionnaire design was carried out following Dillman (2000) and was pre-tested using the expert-review technique. Postal mail was the primary method for delivering the questionnaire. Additionally, respondents were provided an option to complete the questionnaire online.

Overall, the questionnaire contained three distinct parts. The first part consisted of a set of questions measuring the three climate constructs, based on a five-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). Organisational culture for innovation was measured by 12 items ($\alpha = 0.877$) drawn up from Amabile et al. (1996), Ekvall (1996), and Scott and Bruce (1994), which represent three factors: propensity for creativity, freedom and autonomy, and innovation support and facilitation. Leadership for innovation was measured using 12 items ($\alpha = 0.883$) derived from Bass and Avolio (1994), Howell and Higgins (1990), and Yukl (2002). This construct consists of three factors: innovation championing, creativity stimulation, and engagement and support. Team climate for innovation was measured by a modified short-version of team climate inventory (TCI) by Kivimaki and Elovainio (1999). The TCI consists of four factors: vision, participative safety, task orientation, and support for innovation. The original short version of the TCI contains 14 items; however, two items were dropped as a result of the questionnaire pre-testing thus resulting in the modified 12-item scale ($\alpha = 0.883$).

The second part comprised questions measuring the 'results' element of the model. Innovation diffusion outcomes were measured by 21 items ($\alpha = 0.849$) reflecting three aspects: innovative design solutions (e.g. awards and recognition received), innovative design practices (e.g. the use of value-based design methods), and advanced technology utilisation (e.g. the use of IT in design development and integration). Business performance was measured by eight items ($\alpha = 0.870$) capturing two aspects: economic growth, and client satisfaction. Finally, the third and last part focused on soliciting respondents' background information.

Model assessment

Structural equation modelling (SEM) technique using AMOS 7.0 was employed to assess model fit and to test the hypotheses. In general, SEM is a technique to determine whether an *a priori* model is valid by specifying, estimating and evaluating linear relationships among a set of observed and unobserved variables (Shah and Goldstein 2006). These linear relationships imply causal links whose estimated path coefficients can be used as a basis for hypothesis testing. In order to estimate model parameters, maximum likelihood (ML) method with covariance input matrix was used. The study employed five common indices to assess model fit: (1) normed chi-square (χ^2/df); (2) goodness-of-fit index (GFI); (3) comparative-fit index (CFI); (4) incremental-fit index (IFI); and (5) root mean square error of approximation (RMSEA). To be considered as having an adequate fit, all the indices were measured against the following criteria: $\chi^2/df < 2.00$; GFI, CFI, and IFI > 0.90; and RMSEA < 0.08 (Hair et al. 2006; Kline 2005).

In order to ease the assessment process, the conceptual model was represented as partial disaggregation (Bagozzi and Edwards 1998) where the questionnaire items were averaged into a first-order factor within a respective construct. As a result, each model construct was treated as a second-order factor having multiple first-order factors as its reflective indicators (See Figure 30.1). This partial disaggregation model was used in the subsequent analysis.

Qualitative analysis: Model validation

After the conceptual model had been quantitatively assessed, qualitative analysis was sequentially conducted to validate the model through case studies. In general, case studies can be classified as descriptive, exploratory and explanatory: *descriptive case studies* focus on determining what needs to be described; *exploratory case studies* usually focus on theory and/or hypothesis development; and *explanatory case studies* focus on theory and/or hypothesis testing (Yin 2003). Since the aim of conducting case studies was to validate the results from the conceptual model assessment phase, an explanatory approach was adopted. In this regard, the final model derived from the quantitative analysis served as a set of hypotheses to be tested. In order to perform the model validation, the paper employed the 'pattern matching' technique whereby patterns of the relationships between the constructs obtained from each of the case studies were compared with those predicted (hypothesised) by the model (Yin 2003). Specifically, the paper followed a pattern-matching approach described in Nicholson and Kiel (2007). Such a technique provides a test of the model's ability to describe actual organisational phenomena that take into account the significance of people and reality of the situation.

RESULTS

Conceptual model assessment

Survey respondent profiles

A survey was conducted in Australia from May to August 2007. Target respondents were design professionals employed in AED firms. The sample was chosen first by randomly selecting a number of AED firms from the Dun and Bradstreet's *The Business Who's Who of Australia* directory. An attempt was then made to obtain individual contact details of engineers, architects and para-professionals (e.g. civil/structural designers, draftspersons) working in the selected firms. In total, 520 design professionals were identified. Questionnaires were mailed to each individual along with an incentive and a cover letter explaining the purpose and benefits of the study. As a result, 181 usable questionnaires from 57 firms were received thus achieving a response rate of 34.8 per cent. Most of the respondents are engineers (44.8%) and architects (39.2%) aged between 26–30 (37%) and 31–40 (22.1%) with a bachelor degree (77.3%). Most of them are employed in engineering consultancy firms (48.6%) and architecture firms (41.4%) with a size ranging from small-to-medium (≤ 200 employees, 57.8%) to large (> 200 employees, 42.2%). Overall, the respondents were considered a good representation of the survey population.

Model assessment results

SEM was performed to initially evaluate the fit of the conceptual model as well as to test the hypothesised relationships between the constructs. According to Table 31.1, the results of the initial conceptual model assessment show that the paths from leadership for innovation to innovation diffusion outcomes (LFI → IDO) and from team climate for innovation to innovation diffusion outcomes (TCI → IDO) are not statistically significant. As a result, these two paths were removed from the conceptual model resulting in a refined model which was then reassessed. Chi-squared difference test between the conceptual model and the refined model shows non-significant results ($\Delta\chi^2$ = 0.73, p = 0.694, n.s.) – indicating that both models fit the data equally well. Accordingly, the refined model was chosen as a final model since it is more parsimonious (Kline 2005). As presented in Table 31.1, the fit indices of the final model proved to be satisfactory: χ^2/df = 1.86; GFI = 0.89; CFI = 0.93; IFI = 0.93; and RMSEA = 0.07. The final model along with its standardised path coefficients are illustrated in Figure 31.2.

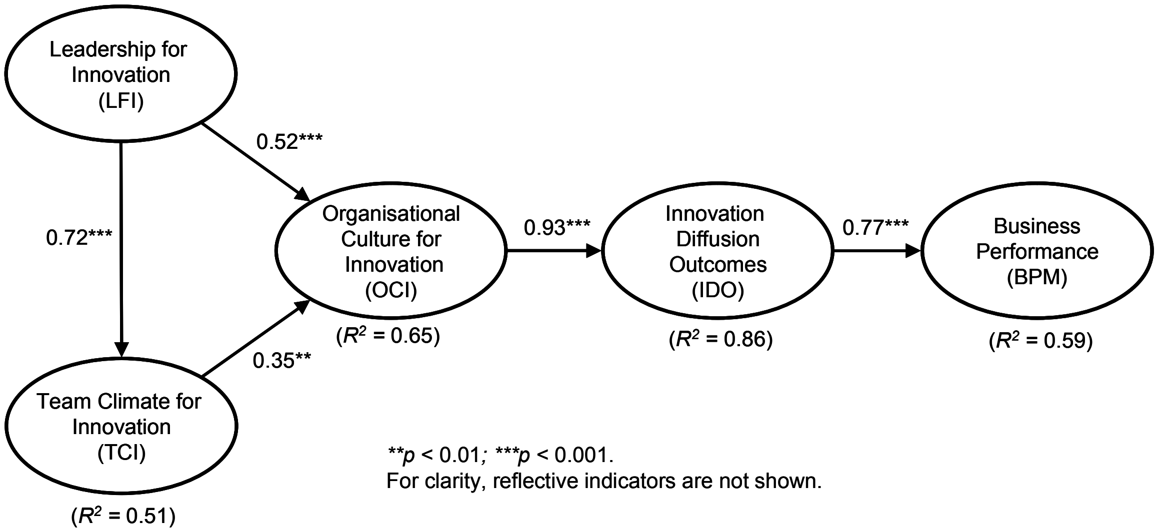
Table 31.1 SEM Results

Path	Initial model†		Final model‡		Hypothesis testing results
	Standardised path coefficient	*t*-value	Standardised path coefficient	*t*-value	
LFI → TCI (H1)	0.71	7.15***	0.72	7.14***	Supported
LFI → OCI	0.54	4.18***	0.52	4.30***	Supported
LFI → IDO	-0.01	-0.05n.s.	Path removed		Not supported
TCI → IDO	0.11	0.66n.s.	Path removed		Not supported
TCI → OCI	0.32	2.58**	0.35	2.99**	Supported
OCI → IDO	0.85	4.78**	0.93	8.88***	Supported
IDO → BPM	0.77	7.66***	0.77	7.63***	Supported

†Initial model fit indices: χ^2 = 157.47, df = 83, χ^2/df = 1.90, GFI = 0.89, CFI = 0.93, IFI = 0.93, RMSEA = 0.07

‡Final model fit indices: $\chi^2 = 158.20$, $df = 85$, $\chi^2/df = 1.86$, GFI = 0.89, CFI = 0.93, IFI = 0.93, RMSEA = 0.07
$^{**}p < 0.01$; $^{***}p < 0.001$; n.s. = not significant

Figure 31.2 Final Model with Standardised Path Coefficients



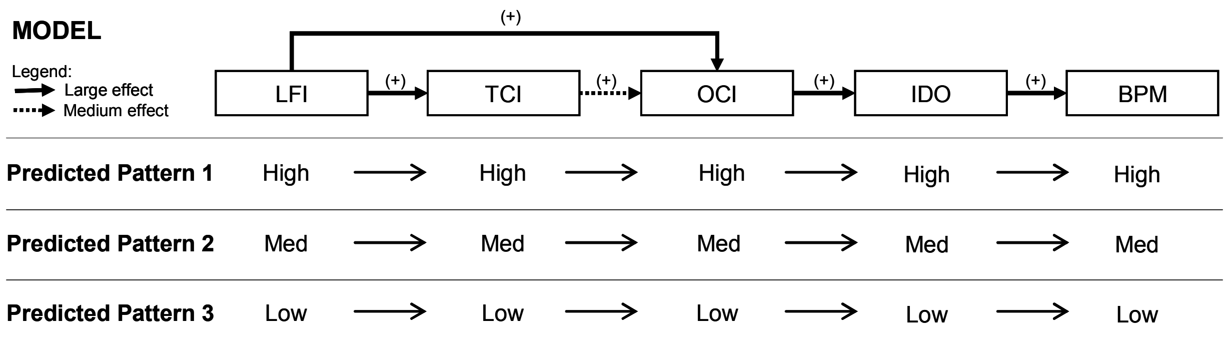
According to the results, leadership for innovation was found to have a very strong and positive influence on team climate for innovation (0.72, $p < 0.001$), accounting for 51 per cent of its variance ($R^2 = 0.51$), thus supporting H1. Both leadership (0.52, $p < 0.001$) and team climate for innovation (0.35, $p < 0.01$) were found to positively influence organisational culture for innovation and jointly account for 65 per cent of the variance of this construct ($R^2 = 0.65$), thus providing support for H2 and H5. Organisational culture for innovation, in turn, strongly and positively influence the innovation diffusion outcomes (0.93, $p < 0.001$), accounting for 86 per cent of its variance ($R^2 = 0.86$); hence H6 was supported. However, since the construct of innovation diffusion outcomes was not found to be influenced by leadership and team climate for innovation in the initial model assessment; H3 and H4 were not supported. Finally, business performance was found to be strongly and positively influenced by innovation diffusion outcomes (0.77, $p < 0.001$) with 59 per cent of variance accounted for ($R^2 = 0.59$), thus providing support for H7.

Model validation

Predicted pattern development

Following model assessment, predicted patterns were formulated based on the final outcome of the quantitative analysis (refer to Figure 31.2). Overall, the predicted patterns were developed using high, medium and low value descriptors for the exogenous construct (i.e. LFI). The values of other corresponding endogenous constructs (i.e. TCI, OCI, IDO and BPM) were determined by following the paths depicted in the model and by taking into account their standardised coefficients. Specifically, the standardised path coefficients in the model were classified on the basis of Cohen's (1988) effect size criteria as small (0.10 – 0.29), medium (0.30 – 0.49) and large (≥ 0.50). As a result, three main predicted patterns were developed as presented in Figure 31.3.

Figure 31.3 Predicted Patterns



Case study results

During the first quarter of 2008, case studies were conducted with three Australian AED firms. The profiles of the three cases are summarised in Table 31.2. In each case, four members from the design team participated in the study. Semi-structured, face-to-face interviews were carried out to solicit opinions from the participants. Each interview was tape-recorded and transcribed. The contents of each interview were coded, summarised and rated against the developed criteria. To increase the internal validity of the results, secondary sources of information including newsletters and online documents published on the website were obtained from each firm and were analysed to complement the interview findings. Table 31.2 presents the final results of the case studies in terms of the qualitative evaluation for the constructs and a systematic assessment as to whether the cases match the predicted patterns illustrated in Figure 31.3.

Table 31.2 Case Profiles

Case	No. of employees	Area of expertise	Scope	Interview participants
Firm A	360	Civil and structural engineering, infrastructure planning, value engineering	International	• 1 senior structural engineer • 2 junior structural engineers • 1 structural drafting manager
Firm B	110	Civil and structural engineering, surveyors, geosciences	Regional	• 1 engineering manager • 1 senior structural engineer • 1 junior structural draftsperson • 1 senior structural draftsperson
Firm C	250	Architectural, urban and interior design	National	• 1 principal architect • 1 senior architect • 2 junior architects

Table 31.3 Case Study Results

Case	Construct evaluation					Matching results
	LFI	TCI	OCI	IDO	BPM	
Firm A	High	High	High	High	High	Perfect match to pattern 1
Firm B	Med to High	Med to High	Med	Low to Med	Med	Partial match to pattern 2
Firm C	Med to High	High	High	High	High	Good match to pattern 1

According to Table 31.3, the patterns of relationships between the observed constructs for Firm A and Firm C show a perfect and a good match to the predicted pattern no. 1, respectively. At both firms, the level of LFI seems to highly correlate with the level of TCI. Both of the two constructs are also associated with the high level of OCI. The participants from both firms agreed that their supervisors/team leaders greatly influence the climate for innovation within their teams. They also pointed out that innovative leaders and teams definitely have an influence on the firms' culture of innovation. The pattern also indicates that the higher level of OCI contributes to the higher level of IDO. Most of the participants also shared similar views. For example, in Firm A, the participants believed that by instilling a 'think beyond the square' culture, the firm can consistently introduce innovative solutions and is always ahead in the use of advanced engineering design techniques. Similarly, participants from Firm C believed that by having a culture that is inclusive and supportive, new ideas and knowledge can be quickly diffused and implemented to produce high-quality designs. In addition, the higher level of IDO results in the higher level of BPM, as evident from the pattern matching results for both firms. This can be exemplified by a comment made by the senior structural engineer from Firm A that the high level of the firm's innovativeness has helped it to maintain business competitiveness as well as a high level of client satisfaction.

The pattern of relationships between the observed constructs of Firm B indicates a partial match with the predicted pattern no. 2. The level of leadership for innovation appears to highly correlate with that of team climate. Both constructs are also shown to correlate with the level of organisational culture for innovation, but with a slightly weaker effect. The level of organisational culture for innovation, however, is not strongly associated with the level of innovation diffusion outcomes as predicted, thus does not match the predicted relationship completely. Perhaps this deficiency can be explained by the fact that the firm has recently undergone a management restructure. According to the engineering manager who championed the restructuring process, such a change has started to drive the firm toward an improved culture for innovation by being more flexible and more inclined to use innovative approaches in carrying out its works. Finally, despite innovation diffusion outcomes being rated as low to medium, this construct was found to have a slight strengthening effect on business performance, which was rated as medium.

DISCUSSION

The results from the conceptual model assessment indicate that leadership for innovation is the most influential construct among the underlying climates for innovation. Leaders/supervisors who possess an innovation-conducive leadership style seem to directly shape an innovation culture by creating and maintaining policies and practices that are suitable for the diffusion of innovation. Indirectly, they create such a culture by influencing the climate for innovation among teams, and this has, in turn, become an important building block of a culture for innovation.

Examining the relationships between the three climate constructs and innovation diffusion outcomes revealed that organisational culture for innovation is the only construct that directly influences the outcomes of innovation diffusion. Moreover, leadership and team climate for innovation appear to contribute to this construct indirectly through organisational culture. Such a pattern of relationships implies that organisational culture is a mediating construct, functioning as a portal to an effective diffusion of new technologies and creative ideas. Without a culture for innovation, it is unlikely that creative ideas will be transformed into innovative products. In the same manner, even though a firm decided to adopt a particular innovation, such innovation is not likely to be fully used if the employees perceive no encouragement and support from the organisation. In addition, such a pattern also suggests that the pathways to innovation diffusion outcomes appear to originate from leadership for innovation. This highlights a critical role that leadership plays in bringing about innovation through stimulating and motivating creativity in teams, whilst creating an innovation-conducive culture to support such creativity and foster innovation adoption.

Although past empirical research studies have shown mixed results regarding the benefits of innovation, this study demonstrates a significant relationship between the outcomes of innovation diffusion and the business performance of AED firms. With the prevalent uses of advanced technologies and innovative design practices coupled with innovative design solutions, firms can improve the overall quality of design deliverables, thus increasing the level of client satisfaction. This in turn improves the ability to expand market share which leads to turnover and profit growth, thereby strengthening overall business performance.

Regarding the results from the case studies, it appears that for firms A and C the derived model can be used adequately to explain the actual relationships between the climate constructs and their contribution toward innovation-related outcomes. In the case of Firm B, however, the results of pattern matching suggest that the model does not fully explain the actual phenomena. The degree to which the pattern of the observed constructs deviates from the pattern predicted by the model, in this case, does not appear to be substantial when considering the possibility that the actual constructs might be affected by other factors, as evident from the presence of unexplained variance in the model. Reasonably, it can thus be concluded that the model derived from the quantitative analysis was adequately validated by the findings of the case studies.

CONCLUSIONS

This paper presents an empirical study of climate for innovation and its outcomes regarding innovation diffusion and business performance of Australian AED firms. Specifically, the study highlights three climate constructs: leadership for innovation, team climate for innovation, and organisational culture for innovation. Based on the developed conceptual model, the study was carried out using a sequential mixed method design integrating quantitative-based questionnaire survey and qualitative case study research. The final model derived from the SEM analysis of the survey data indicates that organisational culture for innovation appears to be a gateway to innovation diffusion by mediating the relationships between both leadership and team climate, and innovation diffusion outcomes. To create such a culture, the model suggests that firms should place an emphasis on cultivating a leadership-for-innovation style among leaders/supervisors. More importantly, the study found that the level of innovation diffusion outcomes significantly leads to an improved business performance, thus supporting the benefits of innovation in AED firms. Finally, by using an explanatory case study approach, the model was validated through three cases of Australian AED firms. Pattern matching analysis corroborated findings from the quantitative study indicating that the actual relationship patterns can be reasonably explained by the model. This confirms the identified mechanisms of climate for innovation in enhancing innovation diffusion that ultimately leads to improved business performance.

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Environmental Sustainability as an Innovation Driver Among Small- and Medium-sized Construction Companies

David Thorpe
Neal Ryan
Michael Charles

INTRODUCTION

The construction industry is recognised as a significant contributor to the global and Australian economies. For example, the 2004 Science, Technology and Industry Outlook published by the OECD (2004) reported that, across the various OECD countries, construction added 6.0 per cent to gross value added (a measure of the contribution made to GDP) in 1995, and 5.4 per cent to gross value added in 1999. In Australia, in the five years to 2003, the Australian construction industry similarly contributed, on average, almost 6 per cent of the nation's GDP and, in 2002–03, was the fourth-largest industry. Indeed, in that financial year it added approximately $46b to the economy (Australian Bureau of Statistics 2005a, p. 562). Because of its significant size, not only do improvements in industry effectiveness and efficiency have a significant impact on the economy, but also any gain in environmental sustainability resulting from developments in the industry can also have a significant positive impact.

This growth of the importance of environmental sustainability is reflected in an increasing discussion of environmental issues in both academic and practitioner-oriented circles, and also in changing regulations and building codes (Department of Trade and Industry 2006). In addition, environmental sustainability has emerged as a potential consideration in multi-criteria contract selection processes (Adjetunji et al. 2003). However, while the increased emphasis on sustainability in the construction industry may be recognised as one of the factors influencing its future direction, it is uncertain whether the small- and medium-sized enterprise (SME) sector sees it as an important driver of innovation. A lack of interest in the adoption of innovative practices could arise on account of a number of reasons, such as the relatively high cost and unavailability of many sustainable materials compared with traditional materials, uncertainty regarding lifecycle performance of such materials, a lack of confidence in the benefit to the firm of sustainable building practices, and a lack of informed client demand, particularly in the residential building market.

In order to better understand the importance of sustainability on innovation in the construction sector in the residential building sector, a sample of smaller domestic builders in South-East Queensland were asked, as part of a broader study of innovation in these firms, to provide their views on environmentally sustainable practices. While a number of these firms identified a particular sustainability-related innovation as being important to them, responses were less clear about the benefits of using sustainable practices to the industry and the firm, and the impact of sustainability initiatives on practices within the firm.

This chapter, which uses this research as a basis for analysis and discussion, examines the issue of sustainability as a potential driver for innovation in the SME sector of the Australian construction industry. It also explores the potential impact of an increasingly environmentally conscious marketplace on SME business practices and operations.

INNOVATION IN THE CONSTRUCTION INDUSTRY

An important characteristic of the Australian construction industry is the strong representation of SMEs. One source, for example, noted that as many as 94 per cent of Australian construction businesses employ fewer than five people each (Hampson and Brandon 2004, 10). This finding is supported by a 2002–03 survey of the private sector construction industry, which stated that the average number of employees in the Australian construction industry was, at the end of June 2003, 4.7 persons (Australian Bureau of Statistics 2004, 6).

While any contribution to productivity in the construction industry can significantly and positively impact on world economies, reports on the Australian construction industry have indicated that, although innovation occurs, the rate of innovation for the industry is not as high as that experienced in comparable industry sectors, such as manufacturing. It was found by the Australian Bureau of Statistics, for example, that the construction industry, at 30.7 per cent, had one of the lowest proportions of innovating businesses (Australian Bureau of Statistics 2005b, 5). This finding is supported in the international context by European research (Koivu and Mantalya 2000; O'Farrell and Miller 2002). Other research reports that there is a low level of innovation in the European construction sector, and that the level of investment in research training and development in the European construction industry was generally lower than 0.5 per cent (European Commission 2004, 2). While the construction industry as a whole may not be especially innovative, there have been reports of considerable innovation at firm level. For example, it has been reported that a considerable number of ideas are generated in the industry (Winch 1998). Studies have also reported that, when required, the industry has independently developed new approaches in order to solve project-related problems (for example, Harty 2005).

It has also been observed that factors such as globalisation of the business environment, demographic change, environmental sustainability and climate change, new materials and technologies, ICT, and governance and regulation may have a significant impact on the industry (Hampson and Brandon 2004, 2). At the same time, there appears to be a paradigm shift affecting the industry, with the award of contracts moving from lowest price to multi-criteria selection processes (Charles et al. 2008).

Incorporating sustainability in such processes has been claimed to reduce risk and improve the chances of obtaining value for money (Adjetunji et al. 2003).

One of the industry sectors in which the amount of innovation not only impacts on value for money, but also sustainability and occupational health and safety (OHS), is the highly important domestic building construction industry (Miller et al. 2004). In Australia, for example, the residential building sector in the financial year 2003–04 undertook 44.4 per cent of all construction work done (an amount of $33.9b out of a total of $76.3b) (Australian Bureau of Statistics 2005a, 564).

In common with the industry as a whole, this sector contains a large number of SMEs. It is also not as well researched as other industry sectors, especially in its degree of innovation. As a result of these shortcomings in knowledge, pilot research into innovation in this sector of the Australian construction industry was undertaken in South-East Queensland, Australia. The study sought to look at innovation practices in 20 smaller residential building construction firms. One of the focus areas of this research was sustainable design and construction. This paper employs results from this research to shed light on whether sustainability can be an innovation driver in the SME sector of the domestic building construction industry.

WHAT IS INNOVATION?

Put simply, an innovation is 'an idea, practice, or object that is perceived as new by an individual or other unit of adoption' (Rogers 2003, 12). A further definition is provided by the OECD (2005, 46), which defines innovation as 'the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method'. Another view is that it is a process through which economic and social value is extracted from knowledge through the generation, development and implementation of ideas in order to produce new or improved products, services or processes (Business Council of British Columbia 2006, 1). An innovation, in its broadest sense, is thus something new (or possibly altered) in processes, products, organisation or marketing, all of which are intended to have an economic benefit. This is the definition of innovation used in this chapter. According to this description, the term 'economic' has been broadened to include environmental and/or social outcomes, in addition to traditional monetary outcomes.

It is well known that innovations have a limited lifecycle. Indeed, the market performance of technologies decreases with time, a relationship shown by the well-known 'S' curve of an innovation's performance over time (Lee and Nakicenovic 1988). For this reason, innovations need to be employed early in their lifecycle if they are to provide maximum benefit to users. Conversely, there is greater risk associated with using untried innovations very early in their lifecycle.

Research has found that there are a number of drivers and barriers to innovation. A wide-ranging survey of innovation in Australian businesses found that the primary drivers of innovation were profit- and market-related, followed by legal-related drivers, while the main barriers were cost and market-related (Australian Bureau of Statistics 2005b, 20, 28). Other factors influencing innovation include the amount of effort put into the innovation, management commitment, and favourable expectations as a result of implementing the innovation, in addition to the level of interest and capabilities of team members (Dulaimi et al. 2003; Ling 2003).

A previous study of the Australian construction industry found that the two main drivers of innovation in the industry were the need to improve efficiency and productivity, and the need to respond to customers' demands; conversely, the two major obstacles were time and cost (Manley et al. 2005, 34-35). Additional barriers to innovation include risk, uncertainty, change and knowledge (Love et al. 2001); organisational size (Arias-Aranda et. al. 2001; Acar et al. 2005); and cultural context (Acar et al. 2005).

SUSTAINABLE PRACTICES AND CONSTRUCTION

A common definition of 'sustainable development' is that proposed by the author of the 1987 report of the World Commission on Environment and Development, which defines this term as 'meeting the needs of the present without compromising the ability of future generations to meet their own needs' (Brundtland 1987, 54). This represents a significant challenge for the construction industry, the purpose of which is to undertake development of the earth for the benefit of human beings, a process which inevitably leads to the consumption of resources.

At the same time, sustainability is becoming an important focal point from a global construction perspective. For example, it has been observed that construction activities significantly impact on waste, energy use and greenhouse gas (GHG) emissions. In addition, it has been reported that, in the United Kingdom, 17 per cent of wastes going to land disposal (which can potentially have an impact on the earth's atmosphere by means of oxidation) are directly related to construction activities (Wallace 2005, 82). Such impacts have led to a growing emphasis on corporate sustainability. This, in turn, is reflected by pressure being exerted by clients, government and other stakeholders for the construction industry to be more accountable for its social and environmental impacts. Thus sustainability considerations are increasingly salient in the construction process, including, as stated previously, contractor selection. In this context, adopting sustainable practices and processes reportedly reduces risk and increases the probability of obtaining value for money (Adjetunji et al. 2003).

Regulatory authorities are also recognising the importance of sustainable practices in construction. In 2000, the United Kingdom implemented a strategy for more sustainable construction that packaged the traditional components of sustainability (that is, environmental, economic and social) into a single set of objectives that aim to make the construction industry more profitable and competitive, all the while considering the requirements of stakeholders, the natural environment, and energy consumption (Department of the Environment, Transport and the Regions 2000, 8, 14-16). This strategy is ongoing, with revised targets and visions set for 2015 and beyond (Department of Trade and Industry 2006, 100-103). In similar fashion, Australia has implemented new energy-efficiency measures for buildings (Australian Building Codes Board 2005). This focus on sustainable construction by both building authorities and the academic literature has given it a wide-ranging meaning that includes design and operations, in addition to actual construction process.

When considering the impact of environmental sustainability on construction innovation, it is important to understand that the generally positive outlook discussed above should be tempered with uncertainty and potentially high risk. For example, it has been reported that there is a threat of environmentally unfriendly materials leaching from the Portland cement binder into the recycled concrete aggregate used in road construction (Apul et al. 2003; Petkovic et al. 2004). Managing risk, however, is likely to lead to increased time and cost.

METHODOLOGY AND FIRM CHARACTERISTICS

The need to address global issues such as sustainability provides the construction industry with challenges that can only be met by the development and use of innovative materials, processes and practices. In order to establish a better understanding of the way in which innovation occurs in SME firms in the residential building construction sector, owners or senior management personnel of 20 smaller building construction firms in South-East Queensland (Australia) participated in a face-to-face interview. This took place in September and October 2006 and dealt with the interviewees' use and adoption of innovative materials and practices.

This form of research was undertaken because of the potential to gain rich data from the representatives of the firms (generally owners or managers) being interviewed. The research design, which used a semi-structured interview process, also allowed the interviewer to explain the project to the interviewee and to focus on the innovation process. This would have been more difficult with a mailed questionnaire. The approach also suited the work environment since there were only a limited number of firms available for interview, largely on account of the time constraints being experienced in the industry.

The firms responded to a request for interview made to 100 businesses randomly selected from publicly available lists of residential property builders. Builders who agreed to take part were visited at their workplace or office and interviewed for an average of 45 minutes. The research aimed to explore the extent of innovation in these firms, assess why it occurred, establish the factors aiding or impeding its development, and learn what could be applied from this for the benefit of researchers, practitioners, and the broader industry. An important section of the interview questionnaire sought views of builders about environmentally sustainable design and/or construction practices.

Seven of the firms interviewed had 4 or fewer staff, 11 had 5–19 staff, and two had just over 19 staff. Of the firms, 18 were primarily constructors, and the other two were primarily engaged in renovation and maintenance. Several firms undertook design as well as construction. All were involved in private sector residential work, with smaller projects (such as private dwellings) predominating. Since only 20 per cent of the firms contacted responded to the request for an interview, it could be argued that these were the firms most interested in innovation. Yet it should be borne in mind that, at the time of the interviews, the Australian building industry was experiencing a period of high activity. Thus a number of builders interested in innovation may have been unable to spare the time for this research (the authors were advised of this by several builders). Low rates of response to research studies are not unusual in the construction industry, and at least one researcher has noted that rates of 15–20 per cent are viewed as reasonable in this industry (Manley et al. 2005, 19).

RESEARCH RESULTS

The following section of this chapter introduces the results garnered from this research. Given the relatively small sample size, numeric values rather than percentages are used to convey the research results where appropriate.

Sustainability-related innovation in the firms

The firms whose management were interviewed provided 50 examples of innovation, with incremental product and process innovations (using the OECD 2005 classification) predominating. While 16 of the 20 builders interviewed had developed at least one innovation in their firm with minimal or no external input, all except a handful of the innovations could be considered new to the firm rather than new to the construction industry.

Close to a quarter (14 out of 50) of the innovations could be classed as primarily meeting a sustainability objective. A further two innovations were assessed as having sustainability as a secondary objective. Of this total of 16 innovations, nine could be considered product innovations, two as process innovations, four as product and process innovations, and one as a product and marketing innovation. Examples of sustainability-related innovations were provided by 11 of the 20 participating firms.

The firms were requested to select a particular innovation. They were then asked why they developed or used the particular innovation. To answer this question, the firms selected a response from a short set of example responses, or else were instructed to describe in their own words why they selected the innovation. The responses showed a range of reasons, which varied from an interest in sustainability by the principal of a particular firm, to the specific business objective of improving productivity and/or efficiency. Seven of the firms nominated an innovation that was either primarily or secondarily related to sustainability as the innovation that would be explored in depth. These seven innovations are shown in Table 32.1, which shows the OECD (2005) classification of the selected innovation (i.e. a product, process, organisational or marketing innovation). In addition, it lists the reason why the firm developed or used the particular selected innovation.

Table 32.1 Selected Sustainable Design and Construction Practices

Innovation	OECD (2005) classification	Why Innovation was Developed or Used
Design and construction focused on sustainable practices	Process	Better way to develop houses
Improved design to suit sustainable construction and energy efficiency	Product	Client requirement; improve productivity
Retrofitting solar passive principles to older buildings	Process	Personal interest
Comprehensive sustainable housing package	Product	Need to demonstrate leadership in this area
Adoption of new building materials to improve environmental efficiency	Product and process	Committed to sustainable practices
Use of polystyrene blocks as substitutes for other materials as they are insulating and do not emit dust when cut	Product and process	Seemed good practice
Use of new engineered products such as laminated veneered lumber (LVL) beams as substitutes for timber beams	Product and process	Improve productivity and efficiency

The remaining nine sustainability-related innovations nominated by the firms included orientation of buildings to maximise use of the natural environment, insulation using suitable materials, environmentally aware surface water management, and saving water through the use of plastic downpipes flowing into tanks.

Some of the sustainable design and construction innovations also impacted on project efficiency, in addition to the health and safety of workers, because the materials were lighter than the traditional materials they replaced. For example, polystyrene blocks are lighter and easier to place than conventional bricks, while laminated veneer lumber products, on account of their relatively light weight compared with conventional timber, save time in handling and placing. This may be an important consideration when considering how sustainability practices might drive innovation.

Why firms might use sustainability-related innovations

As part of the process of identifying drivers for the use of sustainable practices in Australian construction industry SMEs, the firms were asked to undertake the following:

1. Identify the key issues in sustainable practices in the construction industry.
2. Evaluate the main benefits of using such practices.
3. Assess any changes to business practices resulting from their use.
4. Rate the reasons why firms might use them.
5. Rank (if applicable) possible reasons why firms might not use them.

The most common issue identified was the need for sustainable design, followed by the use of ecologically friendly materials. One of the main negative issues in sustainable construction practices was cost, particularly the cost of materials and construction processes related to sustainable practices.

There were also a number of business-related issues identified. Positive business-related issues included:

- key driver for business
- good idea
- makes firm competitive
- a point of difference
- water efficiency.

In addition, one firm based its business on ecologically sustainable design principles. Negative business-related issues in sustainable practices included:

- cost and availability (of suitable materials)
- firm would only undertake sustainable practices if required
- tight margins, which were viewed as a barrier to adopting sustainable practices
- some sustainable practices are being forced on firms.

These responses appear to indicate a generally positive attitude to sustainable design and construction practices. Cost seemed a major negative issue.

Builders were also asked to rank a number of benefits, from their point of view, of using sustainable practices on a 5-point Likert scale, with 1 for the lowest ranking, and 5 for the highest. The results of this ranking for these perceived benefits are shown in Table 32.2.

Table 32.2 Benefit of Using Sustainable Practices: Builders' Viewpoint

Benefit of Using Sustainable Practices	No. Firms Responding	Mean (5-point Likert Scale)	No. Firms Ranking this as Least Important	No. Firms Ranking this as Most Important
Improved reputation in the industry	20	3.90	1	5
Improved prospects for firms	19	2.95	4	4
Improved productivity	19	2.35	9	3
Improved profit	20	2.30	9	2
Less exposure to long-term risk	18	2.90	4	5
Other	3	0.45	1	1

Among the other benefits cited by firms were improving the quality of living spaces, minimising the need for airconditioning, and improved energy efficiency, all which are related to sustainability. Yet Table 32.2 clearly indicates that the main benefit expected by the sample builders from using sustainable practices was improved reputation of the firm in the industry. Ranked next were improved prospects for the firm and reduced exposure to long-term risk. Negative responses to this question included negative perception of products by clients, increased building costs, and risk associated with possible long-term liability for the contractor because of building performance issues related to the increased complexity of sustainable construction. While the relatively small size of the sample means that these results are not statistically significant, they do give an important insight into the views of builders operating in the residential construction sector.

The builders were also asked whether any aspects relating to the use of sustainable practices required them to make changes to their business practices. Twelve of the 20 builders interviewed responded negatively (one stated that sustainable practices were now part of business). Furthermore, only eight believed that they would be required to make business changes as a result of using such practices. Reasons for business change included:

- introduces another step in the process
- cultural changes
- training of trades and contractors
- need to do more research and better understand the issues
- practicability.

Next, the builders were asked to rate the reasons why they might use new or improved environmentally sustainable design and/or construction practices. The results of this ranking are shown in Table 32.3.

Table 32.3 Reasons Why Builders Might Use New or Improved Environmentally Sustainable Design and/or Construction Practices

Reason for Using Innovations Related to Sustainable Practices	No. Firms Responding	Mean (5-point Likert Scale)	No. Firms Ranking this Reason Least Important	No. Firms Ranking this Reason Most Important
You know it is good practice	20	**4.55**	0	13
Client imposed	20	**2.80**	5	3
Required by legislation	20	**4.45**	1	15
Other (e.g. client awareness)	1	**0.25**	0	1

Table 32.3 shows that the main drivers for the use of sustainability-related innovations were likely to be the desire to conform to what is regarded as good practice, together with legislative or regulatory requirements. Client requirements were not generally significant in this decision, although one builder (whose business was based around sustainable construction) did note the importance of clients in the decision to use sustainability-related innovations.

Only seven of the 20 builders interviewed indicated that they would not use new and/or improved sustainable practices. A low response rate to this question precluded any real assessment of the reasons why these builders would not use such practices. The most cited issues, however, were that these practices were not profitable (related to increased cost), and that they had not been sufficiently tested. Time was also an issue. Other concerns included a lack of tradespeople with the necessary expertise to implement sustainable practices, a loss of competitiveness (presumably relating to increased costs), potential increased liability (arising from, for example, increased project complexity), and the inability of legislation and/or regulation to keep up with innovative sustainable practices (such as the use of grey water).

Sustainability-related ranking of innovation process factors

A final step in the research process was to ask the builders to rank 25 factors in the innovation adoption and transfer process on a 1–5 Likert scale, again with 1 for lowest ranking and 5 for highest ranking. Two of the questions related to environmental sustainability. Of related interest were three questions focusing on the use of new ideas or products (which gives a view of the firms' attitude to innovation) and receiving either short-term gain or long-term gain from an innovation (which gives an insight into long-term issues as opposed to a short-term focus). All builders in the sample responded to all questions asked. Their rankings are shown in Table 32.4.

Table 32.4 Ranking by Builders of Sustainability-related Innovation Process Factors

Innovation Adoption and Transfer Factor	No. Firms Responding	Mean (5-point Likert Scale)	No. Firms Ranking this Reason Least Important	No. Firms Ranking this Reason Most Important
Using new ideas or products in your firm	20	**4.40**	0	12
Receiving short-term gain from adopting an innovation	20	**2.85**	4	3
Receiving long-term gain from adopting an innovation	20	**4.45**	0	12
Developing or using an innovation that improves environmental sustainability	20	**4.10**	0	6
An industry-wide approach to environmental sustainability (such as a voluntary code of practice)	20	**3.80**	1	8

Table 32.4 shows that the builders in the sample interviewed ranked the use of new ideas and products in their firms highly, in addition to the potential for long-term gain as a result of using innovations. They also ranked quite highly the development or use of innovations that improve environmental sustainability, and ranked fairly highly the need for an industry-wide approach to environmental sustainability. They did not, however, rank very highly the receipt of a short-term gain from innovations. In sum, firms were positive about innovation and its impact on their long-term viability. While they were less positive in their attitudes towards environmental sustainability, it still ranked fairly highly.

DISCUSSION

Of the 50 examples of innovations provided by the firms interviewed, 16 (or close to one-third) were related to sustainability. These innovations were developed or adopted by 11 of the 20 firms. In addition, several of the firms showed a positive approach to sustainable practices, with some taking a leading role in this area (refer to Table 32.1). In addition, the firms believed that using sustainable approaches improved their reputation in the industry (see Table 32.2), and was good practice (refer Table 32.3). Finally, as shown in Table 32.4, there was considerable interest in using new ideas or products and receiving long-term gains from innovation (as opposed to short-term benefit). There was also some interest in developing or using innovations that improve environmental sustainability.

On the other hand, several builders interviewed were unsure about the benefits of introducing sustainable practices. Such concerns included cost, client concerns (which can also be related to cost), inability to obtain tradespeople with the necessary expertise, and long-term risk arising from complexity of and uncertainty about innovative practices and sustainable materials. These matters align with the innovation barriers of cost, market-related issues and uncertainty identified previously. Therefore, while the builders, on the whole, were in favour of sustainable practices and maintained a long-term focus on innovation, the uncertainty of several of them with respect to such practices indicates that it cannot be concluded that environmental sustainability is at the moment a significant driver for innovation in the residential construction sector. This conclusion is underscored by the quite high ranking in Table 32.3 of legislative or regulatory requirements as a reason why builders might use environmentally sustainable design and/or construction practices.

While caution is required in extrapolating the results of the research beyond the sample of builders interviewed, it would appear that barriers for smaller building firms to the development or adoption of sustainability-related innovations include possible negative client perception, perceived costs of using sustainable practices, and risks to the firm from using untested sustainability-related products and processes. A number of firms would also use such practices if required to do so by legislation or regulation. As a consequence, if environmental sustainability is to become a significant driver for innovation in construction SMEs, as it increasingly is for other sectors of the industry, such concerns should be dealt with swiftly.

The cost and risk of using sustainable materials and processes is likely to be investigated through research. Builders may become more comfortable in using such practices through the development of an industry-wide approach to environmentally sustainable practices – something which has the potential to develop a sense of uniformity in the industry. Client concerns, which could be expected, like those of the builders, to relate to cost and risk, might be answered through an education process. Researchers will undoubtedly have an important role in such education. However, it is expected that such education would be best managed by industry associations, which could communicate in language understood by clients and builders. Firms that are currently taking the lead in using sustainable practices might also play a role in this process, particularly if their success can be demonstrated and communicated to the more resistant elements in the industry.

CONCLUSION

While this research into a sample of small builders has shown that SMEs can be quite innovative, particularly at the practical level, the impact of environmental sustainability on innovative business practices, and the motivation to develop innovations related to sustainability, varies from firm to firm. In view of this, it cannot be definitely concluded that sustainability is currently a significant factor in innovation for this sector. Given the obvious and increasing importance of sustainable practices in minimising human impact on the planet and its ecosystems, it is incumbent on the industry to investigate ways of bringing about a greater degree of environmental awareness among firms and their clients.

On the other hand, the research discussed in this paper has demonstrated that, on the whole, firms are becoming increasingly committed to innovation and long-term gains, and maintain a generally positive view regarding sustainable design and construction practices. This outcome demonstrates that, in the industry sector under discussion, there are leaders committed to take the sector to higher levels of sustainability. These leaders, working in conjunction with industry associations and researchers, would, it is contended, be in a good position to demonstrate and communicate the success of sustainable practices to clients and fellow builders.

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Part 8
Sustainable Construction for the Future

EnviroDevelopment: Inspiring and delivering sustainable developments

Kirsty Chessher
Tanya Plant
Brian Stewart

THE CONTEXT

Broad media coverage and credible scientific research of environmental issues has elevated community awareness in recent years. Climate change, pollution and resource scarcity (particularly water, fossil fuels, habitats and land) threaten biodiversity, human health and lifestyles. With rapid population growth in Queensland particularly, there is a need to develop our cities and towns carefully to reduce their environmental impact and conserve our resources.

The gradual recognition of the urgency of addressing these issues has seen a number of initiatives emerge. This has largely included regulation, exemplar projects guidelines about some specific aspects of relevance to the building industry and a few rating tools. While some of these initiatives have enjoyed some success, they have had some limitations.

Environmental regulation is rapidly increasing, but regulation can generally only set minimum standards. Regulation offers no reward to high performers and its inflexibility can cause perverse outcomes. In 2002, UDIA[1] and the Queensland Environmental Protection Agency formed a partnership to encourage and promote sustainable practices. The Sustainable Urban Development Program was able to inspire those already interested in sustainable development but who had limited success in mainstreaming sustainability in on-the-ground projects.

Other initiatives have been limited in their scope, focusing on particular environmental elements or on particular types of buildings, and generally not applicable to the initial stages of planning or development focus. Many of these initiatives have been limited in their uptake and market recognition, due either to their complexity, cost, limited scope, or lack of incentives for developers to implement. UDIA recognised a need to develop a framework which offered benefits to government, service providers and the community, and gains for the environment.

WHAT IS ENVIRODEVELOPMENT?

EnviroDevelopment is a scientifically based branding system designed to make it easier for purchasers to recognise and select more environmentally sustainable developments and lifestyles. The goal of EnviroDevelopment is to increase the uptake of sustainable urban development. To achieve this goal, implementation of the EnviroDevelopment Technical Standards must enhance sustainability and motivate developers to implement sustainable development principles in their developments. Importantly, the framework must be embraced by the industry, because if the program is not taken up by industry, it will have limited impact on the sustainability of the communities we live in.

The objective of EnviroDevelopment is to inspire and reward high-performing developments in the field of sustainability. Designed to encourage flexibility and foster a proactive culture of innovation and environmental benevolence, it is performance-based and is adaptable to a range of development types and situations.

EnviroDevelopment is also designed to clarify the issue of sustainability in developments for local governments and consumers, uniting sectors through partnerships based on benefits, incentives and common purpose.

To ensure that the community understands what EnviroDevelopment certification represents, the message is kept simple yet meaningful through an innovative branding system. However, the system is supported by analysis using the best research available at the time, and the scrutiny of professionals in the field.

THE JOURNEY

EnviroDevelopment has been developed in consultation with a range of stakeholders to ensure that the process of EnviroDevelopment certification is rigorous and maintains integrity. The Technical Standards Taskforce was formed at the beginning of the project to draft the technical standards of EnviroDevelopment. The Taskforce includes representatives from developers, consultants, and state and local government. Careful balance was required during the formation of the concept and technical standards to ensure that EnviroDevelopment was flexible enough to encourage innovation and broad application, straightforward for consumers to understand with little interpretation and reliable enough to ensure its perennial integrity and achievement of enhanced sustainability outcomes.

The EnviroDevelopment Board of Management was established to oversee the operation of EnviroDevelopment at a strategic level and is responsible for overseeing the certification process. The Board consists of small-, medium- and large-scale developers, lawyers, and environmental consultants and also involves the foundation partners and supporting organisations as observers. The EnviroDevelopment concept has been supported by four foundation partners – St. George Bank, Boral, Brisbane

[1] UDIA is the official name used by the Urban Development Institute of Australia, www.envirodevelopment.com.au. Their foundation partners are Boral, Brisbane City Council, St George Corporate and Business Bank, and Caroma Dorf.

City Council, and GWA Caroma Dorf – with support also from the Queensland Environmental Protection Agency. Greening Australia and the Australian Green Development Forum have offered support as supporting organisations.

ENVIRODEVELOPMENT TECHNICAL STANDARDS

EnviroDevelopment standards are structured to be substantially higher than standard practice and regulation. The standards have been set to recognise the performance of a development in achieving broad environmental goals, whilst facilitating the most appropriate or innovative method to be chosen for individual situations.

The level EnviroDevelopment is targeting is roughly such that the standards are set at a level that only the top 10–20 per cent of developments are currently achieving. However, given sufficient encouragement and incentives, the level set by EnviroDevelopment should be within the grasp of many more developers. The Technical Standards Taskforce was mindful of not setting the standards so high that they would be perceived as too difficult or expensive to attempt compliance. Such a situation would see EnviroDevelopment become irrelevant and have little positive impact on industry performance or consumer awareness. The EnviroDevelopment Technical Standards draws together and builds on the strengths of existing research and tools to provide a comprehensive system.

Table 33.1 EnviroDevelopment Technical Standards

Element	Objective	Target	Notes
ECOSYSTEMS	Healthy, sustainable ecosystems based on natural processes and rich with native biodiversity	Development that aims to protect and enhance existing native ecosystems and encourages natural systems and native biodiversity and rehabilitation of degraded sites.	Includes consideration of water quality, landform, flora and fauna.
WASTE	Reduce waste sent to landfill, more efficient use of resources	Development that includes better waste management procedures and practices and reduces the amount of waste that is disposed of to landfill.	Considers demolition or land-clearing phases as well as construction and post-construction phases.
ENERGY	Reduce use of polluting and non-renewable energy sources	Measures that achieve considerable (i.e. 40%) reduction in greenhouse gas production from energy use across the development.	Considers both energy efficiency measures and source substitution such as use of solar energy.
MATERIALS	Environmentally responsible material usage	Development that significantly uses environmentally responsible materials to lower environmental impacts in preference to other materials.	Encourages reuse of resources, materials with recycled content, materials from sustainable, renewable sources and non-toxic products.
WATER	Improve water use efficiency	Measures that achieve considerable (i.e. 40%) reduction in potable water use across the development.	Considers both water efficiency mechanisms and/or source substitution such as water reuse facilities.
COMMUNITY	Vibrant, cohesive, healthy, happy, adaptable, sustainable communities	Development that encourages community spirit, sustainable local facilities, reduced use of private motor vehicles, and accessible and flexible design that welcomes a diversity of people and adapts to their changing needs.	Includes consideration of consultation, transport, community design, local facilities, safe, accessible housing and indoor air quality.

The details of the standards of EnviroDevelopment and the evidence required, have been carefully set based on input from developers, local government, state government and green groups. It is also intended that the standards will be raised over time to remain above the levels mandated by regulation. The standards will also be updated periodically to ensure improvements in technology and new relevant research are incorporated in the standards and to ensure the EnviroDevelopment standards continue to set a high standard.

CERTIFICATION PROCESS

Developers wishing to apply to have a project certified as an EnviroDevelopment are required to demonstrate how they have met the EnviroDevelopment standards and submit the appropriate documentation as evidence of their achievement.

The EnviroDevelopment certification process has to withstand the scrutiny of the industry, government and community as well as EnviroDevelopment foundation partners and supporting organisations. The applications are assessed by

EnviroDevelopment staff; however certification still requires the consideration and approval of the Board of Management. A site visit is also undertaken prior to certification being granted.

Certified EnviroDevelopments are subject to random site checks. Developers are required to advise UDIA within ten working days of any changes made or proposed to be made, to the proposed or existing EnviroDevelopment certified development which may affect eligibility for EnviroDevelopment certification.

EnviroDevelopment certification is valid for twelve months from the date of approval. Renewal of EnviroDevelopment certification is possible through a review and renewal process.

INCENTIVES

A key aspect of the EnviroDevelopment program is the incorporation of incentives to encourage more sustainable development. This can assist developers in evaluating which incentives are available and the best strategies to increase the sustainability of a particular project. The benefits and incentives offered by the EnviroDevelopment framework generally fall under two categories – the marketing benefits of EnviroDevelopment certification and the incentives facilitated by the EnviroDevelopment partnership.

Marketing

A suite of logos has been developed, and each logo ('leaf') represents an element of EnviroDevelopment, as shown in Figure 33.1. Developers who achieve the required performance standard for one or more elements of EnviroDevelopment are awarded the right to use and display the logo appropriate to that standard, for twelve months.

Figure 33.1 The Six Elements of EnviroDevelopment

Figures 33.2 and 33.3 show alternative logos that could be used by a development which has met the requirements for certification under each of the six EnviroDevelopment elements.

Figure 33.2 Certification Logo for a Development Achieving All Six EnviroDevelopment Elements

Figure 33.3 Alternative Logo for a Development Achieving All Six EnviroDevelopment Elements

Figure 33.4 is an example of a logo that could be used for a development that has met the standards for three of the six elements of EnviroDevelopment, namely water, materials and ecosystems. This could also be displayed in a format comparable to Figure 33.3.

Figure 33.4 Certification Logo for a Development Achieving Three of the EnviroDevelopment Elements: Ecosystems, Materials and Water

Figure 33.5 shows the generic marketing logo used only by UDIA (Qld) to promote the EnviroDevelopment concept and is primarily used for marketing and communication of the framework and for educational purposes.

Figure 33.5 EnviroDevelopment Marketing Logo: UDIA Use Only

Developments certified under the EnviroDevelopment initiative ('EnviroDevelopments') are featured on the EnviroDevelopment website (www.envirodevelopment.com.au) and in various related publications and media. Information about EnviroDevelopment itself and certified developments is also available at EnviroDevelopment stands at UDIA and other events. Through such mechanisms and responses to inquiries approximately 1500 EnviroDevelopment standards manuals have been disseminated to industry.

Partnerships and mutual benefit

The EnviroDevelopment concept has evolved on the basis of win-win partnerships. The framework is based on the provision of benefits for a range of stakeholders, in order to unite them towards the mutual goal of enhanced sustainability of developments.

Home buyers, for example, will be able to clearly identify which of these elements a particular development has excelled in. For instance, a development may be awarded recognition for its performance in the areas of water, energy and ecosystems or any combination of the six elements outlined above if it meets the standards set by EnviroDevelopment for the particular elements. Purchasers of 'EnviroDevelopments' will also have the benefit of any reduced operation costs, or enhanced liveability and lifestyle benefits resulting from the sustainable focus of the development, as well as peace of mind knowing that they have made an environmentally responsible selection. They may also have, for example, greater self-sufficiency of energy or water supply, improved access to local facilities and access to 'green loans' and rebates.

Similarly, local governments will be able to rapidly assess some of the likely benefits of a development application relating to an EnviroDevelopment project. There are also benefits to local authorities in terms of more efficient use of resources, more attractive and sustainable urban areas, benefits to the local environment and reduced infrastructure costs. For example, a particular development may be expected to reduce demand on potable water supplies by more than 40 per cent, or to have undertaken significant efforts above and beyond the average to protect biodiversity. Where local government can see such benefits, these EnviroDevelopment partners may be willing to provide incentives such as reduced infrastructure charges, increased densities or ensuring that the application is processed efficiently. Similarly, there are benefits for other levels of government, service providers and the community through the better outcomes and efficiencies inspired by EnviroDevelopment.

Through partnerships with multiple levels of government and suppliers, it will be possible for EnviroDevelopment to offer a range of benefits to developments. The suite of incentives available to developers will include marketing and promotion advantages and improved corporate image as well as incentives offered by government or other stakeholders. The benefits afforded through the program will determine the effectiveness of EnviroDevelopment in achieving its goal of increasing the implementation of sustainability in mainstream developments.

At the time of writing, UDIA was in the process of negotiating with a number of Queensland councils to secure incentives for developments that are to be certified under the EnviroDevelopment initiative.

IMPLEMENTATION

Presently, there are six certified developments, representing over 2 700 lots. At the time of writing, an additional three applications were being considered by the EnviroDevelopment Board of Management. Interest from developers across Queensland has been significant and the EnviroDevelopment standards are being used by developers and consultants to guide future development plans.

Following the successful launch of EnviroDevelopment in October 2006, and widespread industry acceptance, UDIA has commenced a national rollout of EnviroDevelopment. At the time of writing, EnviroDevelopment was being trialled by two developments in South Australia and following significant interest from developers, a commitment has been made to progressing such development in Victoria and Western Australia.

Already EnviroDevelopment has achieved significant outcomes in terms of sustainability outcomes. Certified developments are saving more than 775 mL/yr of potable water and 17 417 tonnes of greenhouse gas.

LESSONS LEARNT

The level of interest EnviroDevelopment has received from both the industry and broader community suggests that sustainable development is becoming a key priority for a growing number of people and organisations. However, obstacles such as costs and delays still exist and impact on the industry's ability to deliver more sustainable development. The industry is still experiencing some delays in the development approval process, particularly in instances where some local governments are unwilling to approve innovative systems such as on-site water treatment and re-use. This can result in some compromises and hindrance of sustainability achievements.

Feedback to date indicates that developers of certified projects have found EnviroDevelopment to have merit. The continued high level of interest in EnviroDevelopment and regular inquiries and website hits also indicates that there is growing interest in certifying new developments as 'EnviroDevelopments' and in using the principles of EnviroDevelopment in designing new developments. This is expected to continue as the value of EnviroDevelopment certification rises with increased brand use and recognition, and the provision of incentives from all levels of government.

EnviroDevelopment has also been recognised for its merit as an educational tool. As well as its assistance to industry and government in this regard, it has also been of interest to a number of universities and schools.

In addition to general learnings and research on the subject, the various EnviroDevelopment applications received and assessed have also highlighted instances where the lack of valid and reliable data can be problematic and further research would be of merit. This includes lifecycle assessment of materials, modelling of energy and water efficiencies in various scenarios, and understanding the benefits of various ecosystem and community attributes designed into developments. However, as further research is being conducted in many of these fields, further clarity may be achieved in future years.

CONCLUSION

EnviroDevelopment provides the effective interface between the real world and sustainability ideals. It offers a framework to bring together the multitude of piecemeal research, tools and general goodwill that actively promote and reward sustainable development. It is industry-led, practical, revolutionary and urgently needed.

CHAPTER 34

Social Sustainability in the Implementation Process of Low-Energy Houses

Wiktoria Glad

INTRODUCTION

Energy is of major importance in society, influencing many aspects of our daily lives. We depend on energy to keep us warm, heat our food, run electrical appliances and so on. At the same time, energy-related emissions constitute a major environmental impact. Any major reduction of carbon dioxide emissions will require an improvement of energy efficiency measures of the building stock. The housing sector accounts for approximately 40 per cent of total energy demand in Western European countries, including Sweden, and fossil fuels are used to produce heat and electricity for housing. Goals for a reduction of the energy use in dwellings are set both politically and within the housing sector itself (Governments Bill 2005–2006; Walden 2003).

In the late 1970s and early 1980s, a few experimental housing projects using mainly passive technologies for heating were carried out in Sweden. They were funded by the Swedish Council for Building Research (BFR) and evaluated thoroughly. Detailed data was collected, analysed and presented in official reports (cf Eek 1987). The results from these projects showed that the technologies used were expensive and sometimes not very energy efficient. As funds for experimental projects diminished, the number of building projects using unconventional concepts decreased. In 1996, BFR was reorganised and the government decided to stop the funding of experimental projects through BFR.

Parallel to the negative implementation process for passive housing concepts in Sweden, a German researcher studied the attempts with passive technologies in Sweden and tried to develop and implement a passive house concept in the south of Germany (Feist and Adamson 1989). The implementation was much more successful than the Swedish attempts and eventually, the Passive Haus Institut and a standard were established. Germany, Austria and Switzerland have been the main market for passive houses so far, and, there, no more than 15 kWh per square meter per year should be used for heating. This is achieved because the dwellings are extremely airtight, have thick insulation and rely mainly on passive sources of heating, for example solar heating through window panes and heat surplus from humans and domestic appliances. A passive house may reduce the energy demand for heating in dwellings by 80 per cent compared to the average used in the German building stock (Feist et al. 2005).

RESEARCH DESIGN

The purpose of this paper is to discuss sustainability aspects, and especially the social sides, of passive houses in the phases of introduction and implementation in Sweden. My main focus will be to explore how and why sustainability ideas were or were not accepted and implemented in the building processes. An overall aim is to see what we can learn from this example for future implementation of environmentally friendly innovations.

This is a new analysis of the empirical findings in Glad (2006). The empirical work was conducted between 2002 and 2005 and was a case study (cf Ragin 1992; Yin 1994; Merriam 2002) of the introduction and implementation of passive houses in Sweden. Data was collected from multiple sources consisting of written documents from both the internal building process and the public planning process, in-depth interviews with stakeholders and text analyses of the media coverage. Information from these sources were compiled and presented according to the narrative approach in social science (Flyvbjerg 2001; 2006).

Sustainability as theoretical framework

In this paper sustainability will be used to frame the empirical findings. The dictionary meaning of sustainability is for something to be sustained at a certain level, but since the 1980s the notion of sustainability has developed and is today different in different contexts. A common ground for a basic understanding of sustainability originates from the World Commission on Environment and Development (WCED) report *Our Common Futures* from 1987, often referred to as the 'Brundtland-Report', where the concept of 'sustainable development' was defined:

> *Humanity has the ability to make development sustainable – to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs*
>
> (World Commission on Environment and Development 1987, 8).

This definition is highly ethical and targets policy-makers globally, and the notion in the WCED report was appealing to politicians since that environmentally friendly actions did not have to be in conflict with continuous economic growth and increased welfare. Earlier, environmentally sound living usually implied choosing an alternative way of living, but the WCED report promised this did not have to be the case, we could actually have both. With the launch of Agenda 21 during the UN Rio de Janeiro conference in 1989, social sustainability became integrated in the sustainable development concept. Since then the common understanding of sustainable development is based on the three principles of ecological, economic, and social sustainability and it is only when all three principles emerge in development that it is sustainable. The concept has later been included in a range of different sectors and in the corporate world the triple bottom line is probably the best known (cf Elkington 1994). In the construction sector sustainable buildings are marketed as a way to be ethical in regard to our common future, but also a way to save money since sustainable houses usually consume less energy when used (Reardon 2005). The construction sector as well as the other sectors in societies in many part of the world can be defined as included in the sustainability discourse, since it is impossible to say that you strive towards a future which is not sustainable.

As the statements in the WCED report continues, the authors show a positive attitude to what can be achieved with new technology and social change:

> *The concept of sustainable development does imply limits – not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities. But technology and social organization can be both managed and improved to make way for a new era of economic growth*
>
> (World Commission on Environment and Development 1987, 8).

Today, much research about technology and social change are framed within the interdisciplinary socio-technical research field arguing that development in technology always depends on the social environment and the two can never be separated (cf Callon et al. 1986). Therefore, a systems approach is necessary and has been used in a range of different studies within the research field of sustainability (Robèrt 2002, Clayton and Radcliffe 1996).

However, the difficulty of using sustainability as a theoretical research framework lies in its normative and political allusions. The WCED had a political mission and indeed political implications, although based on science. In applied research it is important to adopt different strategies to assess and evaluate various developments and projects in relation to sustainability. Fundamental research has another aim and has the opportunity to adopt a more analytical approach to sustainability. The current research will draw on such frameworks from the field of urban sustainable development.

SOCIAL SUSTAINABILITY

Social sustainability in the context of developments has only recently attracted attention from the research community (Patridge 2005). There are many different approaches to social sustainability, and the relevance depends on the research field you aim to target. Accordingly, the starting point in this paper is the built environment, or to chose a more socio-technical term – the housing environment, when referring to residential areas. The definition of social sustainability in the housing environment might be: 'Policies and institutions that have the overall effect of integrating diverse groups and cultural practices in a just and equitable fashion' (Polèse and Stren 1999, 3). The analysis will accordingly be based on policies and institutions on different levels in a building process. But it is also important to acknowledge policies and institutions that are not integrative. The building process includes a variety of stakeholders and processes during the lifetime of the building and this analysis will cover several of these processes, and policies and institutions in relation to people. Furthermore it is important to acknowledge the roles, norms, values, concepts and applications of power in the policies and institutions (Clayton and Radclife 1996).

PASSIVE HOUSES IN SWEDEN LINDÅS PARK

Ten years after the successful implementation of the passive house concept in Germany, a Swedish architect made a new attempt to establish a passive house concept in Gothenburg, Sweden. Drawing on the success in Germany, his own experience from experimental projects in the 1980s and on the fact that although the concept might be new, it consisted mainly of technologies found on the common market combined in a new way, he managed to engage a research council, researchers and developers in the process. The result was 20 Swedish passive houses in the residential area of Lindås Park[2]. The project was called 'Houses without a heating system' and aimed to evolve the passive house concept to suit the Nordic climate. The research funds were granted due to the promises in the application to 'decrease energy use to a minimum, without using complicated technologies and without adding extra costs' (Glad 2006). This phrasing implies that two aspects of sustainability were considered: ecological and economic.

Before the project was awarded with research grants, it was evaluated by experts in Sweden. The experts were not exclusively positive. One expert argued the houses would not be economically sustainable, since the proposed heating system would not be sufficient for the residents and they would buy additional, mobile heaters to achieve a comfortable temperature. And also the costs for the technology installed would be higher than proposed in the application. Despite the reservations stated in the evaluations, the project received government funding.

At this stage, different research departments, from three different research facilities and cities, became involved. The researchers made data simulations of different window areas and scenarios with different household sizes and time spent indoors. They set the standards based on a 'normal' family consisting of two adults and two children, all of whom spent a certain amount of time at home using different appliances, and the amount of electricity a normal household in Sweden was expected to use. To provide a back-up during cold winter days, a reheater of 900 watts was installed in the air-to-air heat exchanger. Because the building contractor found it hard to fulfil the demand from researchers and the architect's office regarding the energy goals, the energy concept was reformulated when put into practice. The goal for energy demand was changed from 15 kWh to 39 kWh per square meter per year.

At this point, the project management was centred on the architect and consequently, a non-researcher acted as leader of a research project and an architect acted as manager of a construction project, which is not common in Sweden. However, the architect was the driving force for the whole project and the researchers were all personal contacts in his network. In addition to the researchers, the architect also engaged a developer, a company owned by the municipality in Gothenburg. Components for the Swedish passive houses would imitate the technology installed in the German houses, and considered part of the concept. These were also the technologies installed in Lindås Park.

Compared to previous attempts to introduce passive house concepts in Sweden, a new component was added to the previous socio-technical systems. The new component has to do with the organisation of the social part of the system. This time, more stress was put on learning about the new system. Not only was the technology important to learn about, but the surrounding environment and

[2] The English translation of Lindås Park would be 'the Park of the Lime Tree Ridge'

especially how energy should not be wasted, and could be saved, using passive technologies in buildings. A two-hour introduction was given to all participants in the process: developers, builders, subcontractors, etc. It is possible to argue that the diffusion of the passive house innovation failed earlier because the social organisation attached to it did not suit the culture in the Swedish construction sector. Hence, the socio-technical system of the passive house became more complete in the late 1990s than in the early 1980s, when the social subsystem became acknowledged and supported in the Lindås Park case.

The economic part of sustainability was only stressed in the beginning of the project, in the applications for funding, and it was an important reason why the project received funding. It was promised to all stakeholders that the houses would not be more expensive than ordinary houses. Savings from not installing a heating system would be transferred to finance passive technologies, like thicker insulation, low-emission windows and also solar panels for hot water (which is an active technology). However, the calculations failed to show extra costs for more hours of work needed. The seminars and research activities were more or less covered by funding from the Swedish Research Council, but the developers' and builders' work to install the passive technologies were not thought of at the time. Consequently the building contractor experienced financial loss due to miscalculations early in the project.

The energy use was measured and evaluated by one the participants in the design process for Lindås Park, the Swedish Research and Testing Institute. The total energy consumption (heating and electricity for household use) turned out to be higher than expected, 69 kWh per square meter per year (Ruud et al. 2005). This was explained by a fault in the heat exchanger, and the unexpected household demand for a higher indoor temperature than calculated, with the consequent use of extra heaters. This was just what one of the experts in the earlier evaluations had predicted. On average, 36 kWh were used for heating but, for most parts of the year, passive heating was enough and no heating system was used. It was suggested that extra heat was necessary during cold periods in winter and the reheater had been used by the inhabitants more extensively than a 'back-up' heating system suggests. The suggested solution was to install heaters of more than 900 watts in future passive house projects. To respond to the criticisms of not fulfilling the concept of being 'Houses without a heating system', SP changed the name to 'Houses without a traditional heating system'.

Since the ecological dimension of sustainability was the priority in Lindås Park, the environmentally sound technologies were a focus and how they could achieve low energy use and a healthy indoor climate for the residents. The architect managed to put these questions on the agenda and made other stakeholders commit to the task. His knowledge was essential to the whole project and he became indispensable to the project as the others depended on him. As the project continued, the architect locked himself in the position of project leader, the others were locked out of this role, and the organisations taking the economic risks lost power over the project. Mass media also played an important part in the network and was just as involved in marketing the concept as other stakeholders. The reports about the houses were uncritical and the journalists usually let the architect's words stand alone and trusted the predictions about how much, or little, energy would be used to provide heat and hot water to Swedish passive houses.

This stage of the passive house development was driven like a triple helix project involving stakeholders from the local and national government, industry partners and researchers from universities and institutes (cf Etzkowitz and Leydesdorff 2000). The core evolved around a team of committed researchers and the architect who balanced on the border between research and industry in his profession. They shared values on ecological sustainability and had experienced well-designed and working passive houses or building parts which could be included in the designs. However, the concept excluded experience from residents or knowledge about living habits which could have been provided by researchers from fields other than science and technology.

BOTTNEVÄGEN: ECONOMIC AND SOCIAL VIABILITY

One of the new projects for passive houses following Lindås Park was also in Gothenburg. The purpose of the project was to learn from the Lindås Park experience and be more 'economically responsible', adding economic sustainability to the Swedish passive house concept. Both the building proprietor and the construction company had suffered financial loss at Lindås Park, but the owners of the cooperative flats, the residents, made a good profit if they sold their houses, since the value on the market was substantially higher than the price they had paid to the building proprietor. The new project, called Bottnevägen[3] was planned in 2005 and built in 2006, and would not be as ecologically sustainable as Lindås Park, since some 'green' technologies were dismissed due to bad experiences and costs.

The municipality of Gothenburg had acknowledged that the Lindås Park project was considered a success and encouraged the developer to build more of its kind. At this point, around 2003, the concept was not referred to as passive houses, but the 'Lindås Houses'. In Lindås Park the name 'passive house' was dismissed because it was considered 'ugly'. Also, there were no particular technologies or standards associated with passive houses in Sweden, and the concept had not taken a final shape. The municipality therefore had little knowledge about what to ask for and were very vague in their writings when they granted land to the developer. The housing company however, had its own experience and knowledge not expressed in public documents and reports. The knowledge they commonly referred to came from talking to the inhabitants in Lindås Park, who expressed concerns about the energy system of the houses. The system designed for Lindås Park did not have sufficient heating and cooling abilities. This became the main task for the housing company to work on, not to reduce energy demand at all costs. In this sense, the inhabitants became influential and the housing company included their wishes in order to give the new residents a better quality of life.

A passive house design in other parts of Europe usually contains solar panels for domestic hot water. It is considered a prerequisite to obtain the low energy consumption prescribed in the passive house standard in, for example, Germany and Austria. Results from Lindås Park showed that the solar panels did not contribute so much to the energy savings as expected since the design did not fit the habits of the residents (Boström et al. 2003). The Bottnevägen project tried to learn from this experience and make a different design for the solar panels, putting them in a central place. As the project continued and costs were reconsidered,

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[3] The English translation of Bottnevägen would probably be 'the Bottom Road'.

it was decided that the solar panels would be a financial risk, partly because it was uncertain how much they would contribute and partly because the ownership of the panels would be difficult to administer. Other technologies dismissed when the Bottnevägen project was planned were extremely low-emittance window panes and the reheater in the ventilation system. The windows because the difference between 0.85 W/ m²K, and 1.0 W/ m²K was not considered substantial, and the reheater because a heat pump would provide more options for the residents to chose from when selecting different temperatures in their houses. The project was finished in 2006 (refer to Figure 34.1).

Figure 34.1 The Bottnevägen Project 2006: Almost Finished

The stakeholders in the Bottnevägen project chose actively not to be a part of the network of Swedish passive houses. To make the concept more sustainable, and adjust it to the economic and social dimensions, they excluded the powerful architect from Lindås Park and some of the technologies he had been in favour of. In addition, the Bottnevägen project did not receive any grants or extra funding, neither did they attract attention from the mass media or study tours. The energy performance of these buildings will not be independently evaluated. However, residents in previous passive house developments were considered by the developer in Bottnevägen and their experiences were analysed and seriously considered as input to the planning and design of the houses.

OXTORGET: ECONOMIC AND SOCIAL VIABILITY

In the city of Värnamo, in southern Sweden, a municipal-owned housing company planned for conventional multi-family dwellings at Oxtorget[4]. In other parts of the world, this would be defined as affordable or social housing, but in Sweden everybody can, and does, rent flats owned by municipal housing companies. Also specific to Sweden, the local community can be deeply involved when new construction projects are planned and has the power to refuse new construction developments, if they have legitimate reasons. In this case, the proposed project experienced severe resistance since it would reduce the green areas in the neighbourhood.

Due to the delay in the planning process, as residents in the neighbourhood made appeals to stop the plans for Oxtorget, the housing company had time to think about new approaches. The managing director, board members and personnel all made a study tour to Lindås Park in 2002 and came back inspired by the successful results and attractive design. The concept lifecycle costing (LCC) was recently introduced to this housing company and the director saw opportunities in the Lindås House concept to develop LCC for rental flats. The Oxtorget site would suit this purpose perfectly. The passive house design was then introduced by the housing company, as a way to overcome the dispute with the residents. The positive atmosphere surrounding the passive house concept in Gothenburg was transferred to Värnamo and, as in Gothenburg, the mass media helped in marketing the concept. Also, the project drew attention from outside the city and even the country. Several delegations from Japan visited the construction site in early 2006.

Unlike Bottnevägen much of the technology used in Lindås Park was directly transferred to the project in Värnamo. The housing company in Värnamo did not have the same experience as the developer in Gothenburg, and trusted the technical results and verbal statements of professional stakeholders from Lindås Park, which the Bottnevägen project did not. Therefore most of the technologies and design features found in Lindås Park can also be found in Oxtorget (refer to Figure 34.2).

[4] The English translation of Oxtorget would be 'the Ox Market'.

Figure 34.2 The Oxtorget Project 2006: Almost Finished

Oxtorget remained a part of the network of Swedish passive houses but included new values like the lifecycle costing approach and flats for rental, which would make low-energy housing accessible to other income groups than in previous developments. Neighbours influenced the path of the project and created an opportunity for creative ideas to enter the development. Decisions for this development were based on data made available by stakeholders in Lindås Park but the developers in Oxtorget interpreted the results from Lindås Park differently than the developer in Gothenburg. Also in Oxtorget, access to information from the residents was limited resulting in different conclusions regarding the need for additional heating and cooling needs in Swedish passive houses.

CONCLUSIONS

A main theme in this paper has been to analyse low-energy house implementation in relationship to sustainability and in particular social sustainability. As has been shown, the driving force behind the implementation in Sweden was the concept's ability to reduce energy use for heating in dwellings, which can be related to both the ecological and economical dimension of sustainability. The ecological part was related to global issues and showed that it is not necessary to use as much resources for space heating and hot water as a Swedish household normally does. The economic dimension was explicitly stressed in Lindås Park but was lost in the process, even though a passive house also reduces lifecycle costing significally. In later projects, the economic dimension was stressed and perceived as an important part of the concept.

Social sustainability should include residents in the process. Often the residents are excluded even from the term 'stakeholders' during the planning and design stages of building processes. Experience from the passive house development in Sweden provides a framework for inclusion of residents in the early stages of building processes. Post-occupancy evaluations should provide data both on *what* energy resources residents are using, and *why* the pattern of use looked like that. A problem in the Lindås Park case was the 'matter of fact' attitude in the evaluations stating that residents wanted a higher indoor temperature than expected. The reason for this was partly because the technology failed, due to errors in the heat exchanger, but also due to misperceptions by the residents on how to operate the technology, which was mentioned but not analysed in the initial evaluations. However, later projects were based on assumptions that might have been misleading since the question *why* was not investigated thoroughly by the designated evaluators.

Post-occupancy evaluations must also be *accurate* and *accessible* to provide input to new developments. Accuracy has to do with the quality and the form of data. This data must be in a form to be used as input in various simulations and modelling of new developments. Since the outcomes of data modelling provide basic data for decision-making in important phases of the building process the quality must be good. Evaluations are often performed by stakeholders from the design process, who are biased since they evaluate the system they themselves designed. Also if data is collected and stored with private companies, future developments might not be able to benefit from them and lack of data will result in poor design of buildings and infrastructure. This is especially important when designing developments which are generally self-sufficient in, for example energy, like the passive houses.

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Developing Frameworks and Processes to Enhance Sustainability Deliverables in Infrastructure Projects

Soon Kam Lim
Jay Yang

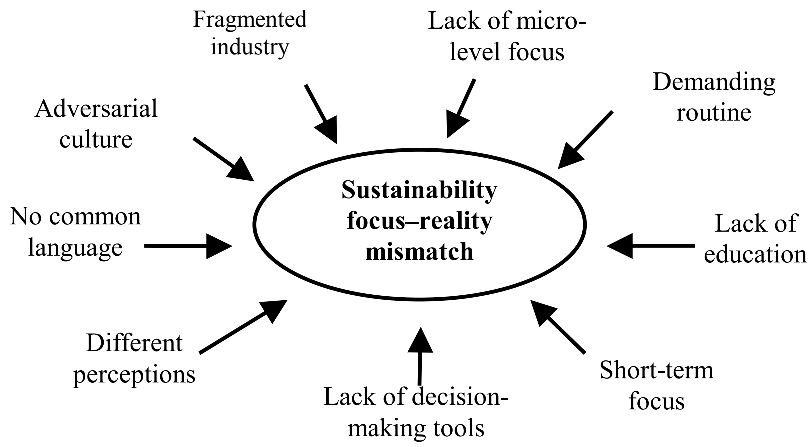
INTRODUCTION

Infrastructure is often considered as the backbone of a nation's economic growth. The industry, which is involved with large-scale and long-term construction, has direct impact on the nation's wellbeing and progress by providing infrastructure essential for daily living such as roads, rail, water and electrical supply, telecommunications and public facilities. Therefore, continued development of the infrastructure industry is critical to sustain economy, cater for increased population and enhance the general prosperity of a nation.

The huge and significant commitment to resources, large-scale and one-off nature, that characterise the development of infrastructure projects over long spans of time often causes serious implications to the local economy as well the environment. This places pressures on government, as well as stakeholders, to look for economically feasible, socially viable and environmentally responsible project outcomes. As a result, this calls for the need of infrastructure development to respond to sustainability challenge, especially new projects.

In a broader context, sustainability has become both a catchword and watchword practically in any development initiatives. Following this new development trend, construction industry world-wide has, since the last decade, started to respond to supporting the agenda of sustainable development. Despite an increasing level of adoption of the sustainability agenda by the construction industry, the actual sustainability deliverables from the industry are not substantially tangible, especially at the project levels. The grandeur of sustainability promises during project conception phase is often not matched by implementation in the real-life project at subsequent stages. Previous literature studies have identified that fragmented industry, lack of common understanding among stakeholders on what constitutes sustainability and different vantage points are part of the factors (Figure 35.1). Different companies have described different individual and organisational perceptions and definitions of sustainability (Shelbourne et al. 2006). Often the disciplines are unwilling (or unable) to consider the views represented by others because there is no common language in place (Lombardi and Brandon 1997). As a result, policies on sustainability remain largely ideological, as they are not reflected in the actual project delivery. Hence, achieving sustainability outcomes in infrastructure projects remains a formidable task.

Figure 35.1 Sustainability Focus–reality Mismatch in Construction Projects



Accordingly, this calls for the need to establish new approaches that are able to integrate and synthesise all the dimensions and different point of views for a holistic consideration by various stakeholders in infrastructure projects. The establishment of a suitable operational framework and guidelines, to which this research is motivated to, will help facilitate collaboration, consultation and communication among key decision-makers to improve consistencies of sustainability outcomes in infrastructure projects.

OVERVIEW OF AUSTRALIAN CONSTRUCTION INDUSTRY AND INFRASTRUCTURE

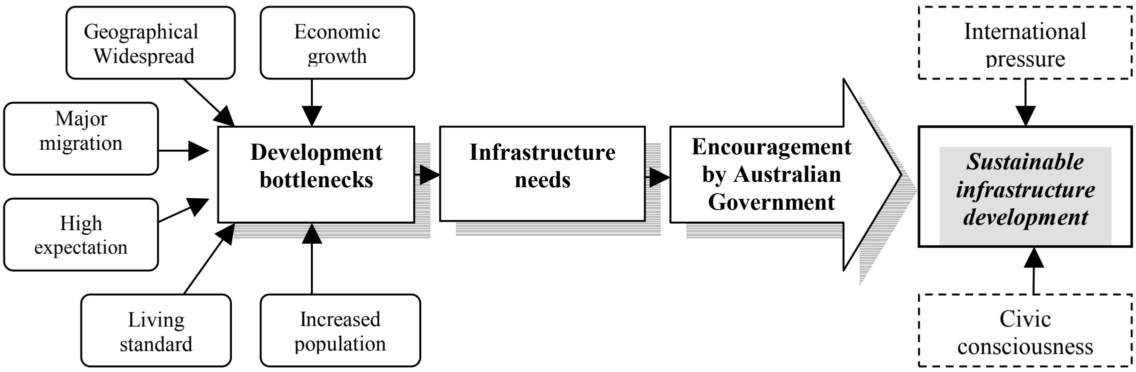
The Australian building and construction industry is dynamic and diverse. It is one of Australia's most important industries and an integral engine of growth driving the national economy. More so, the industry has a direct influence on Australian's wellbeing and progress, providing homes, schools, offices, hospitals and the infrastructure essential for daily living such as roads and highways, water and electrical supply and telecommunications.

Official statistics reveal that as one of the largest sectors in the Australian economy, property, design, construction and facilities management account for 14 per cent of Australia's GDP. It also employs around 860 000 people through 250 000 firms and contributes significantly to the rest of the Australian economy as an enabler. Indirectly, the industry has had a greater impact on the economy and wider community due to every Australian and every business using the built environment. More than nine million Australians, through their superannuation alone, invest in listed property trusts; and, the industry contributes more than $24b each year to the nation's tax system. Further, the industry has a significant influence on the effectiveness and efficiency of other industries to compete locally and in global markets and provides for a myriad of support businesses (CRC for *Construction Innovation* 2006).

The engineering construction market segment is mainly engaged in engineering or infrastructure projects such as railways, dams, roads and bridges, major pipelines, and eletricity and other utilities infrastructure. An analysis conducted by the Commonwealth of Australia (1999) on Australian building and construction industries revealed that the engineering construction market segment is employing 35 600 people (4.8% of the total industry's employment) with approximately 3100 firms.

Infrastructure underpins the delivery of both mundane and essential services, drives economic growth, supports social needs and is closely linked to the overall quality of life. Having recognised the potential economic hindrance resulting from an inadequate infrastructure, the Australian government has been exerting its continuous effort to build, improve and upgrade its infrastructure. Despite the effort, the demand on Australian infrastructure development is constantly on the rise. This is being fuelled by stable economic growth with a large scale of foreign investment in the country and resource boom, general prosperity with improved living standards, increased population, major migration (with a wide geographical spread) which calls, for example, for a need for greater overall transport infrastructure (Figure 35.2). Besides, Australians have become used to a high standard of infrastructure and their expectations are that this will continue. This is now becoming a matter for concern as new capital works still predominate in the public mind and the renewal of existing infrastructure is taken for granted (Burns et al. 1999).

Figure 35.2 Infrastructure in Australia



Though sound infrastructure is critical for continued economic growth and prosperity of the nation, infrastructure project development involves large resources and mechanisms, and the issue of achieving sustainability, not only in the economy but also environmental and social responsibility, becomes crucial. This is further pressured by the global push on sustainable development as well as enhanced civic consciousness within the country. Given the relatively mature industry, coupled with strong government support, Australia has the potential to take lead and drive sustainable infrastructure development.

THE NEED FOR SUSTAINABLE INFRASTRUCTURE DEVELOPMENT

No society has aspired to greatness and a capacity to endure without the ability to build, operate and maintain to a competitive standard of infrastructure required to drive its economy (O'Neill 2002). Sound, well-functioning infrastructure in a country is essential for its sustained economic growth, international competitiveness, public health and overall quality of life (Mirza 2006).

According to Allen Consulting Group (2003), infrastructure is a key component of Australian nation's capital stock. The services from economic infrastructure account for more than 12 per cent of GDP and employ 6.5 per cent of the workforce. Infrastructure services are major intermediate inputs to Australian businesses. In turn, businesses represent some 70 per cent of demand for power, sewerage and water, road and rail transport and postal and communication services. Economic infrastructure also accounts for some 5 per cent of consumer expenditure.

Such facilities (e.g. water supply, sanitation, urban roads) contribute to economic production and therefore are, not surprisingly, closely correlated with levels of development (Kessides 1993). Also, they are essential to the wellbeing of a community (Davidson 1991). Therefore, the provision of physical infrastructure must be seen as a prerequisite for the achievement of sustainability of human settlements and of the meeting of basic human needs (Choguill 1996). Similarly, the same holds for developed countries such as Australia. One of the major challenges facing Australia is meeting demand for new infrastructure which will result from population growth, while maintaining, upgrading or replacing aging infrastructure (Engineers Australia 2005).

Though concerted efforts by the Australian Government in developing infrastructure, this crucial initiative will be more profitable and meaningful when infrastructure development is integrated with the concept of sustainable principles, since it will not only bring about economic gain, but also social and environmental benefits. This calls for a greater need for infrastructure sustainability in its overall delivery, especially for new infrastructure projects.

So far, much of the focus on sustainability has concentrated on buildings and construction processes. Less has been done on infrastructure systems, such as sanitation, transportation, and utilities, which may extend over large geographic spaces, have much wider and more varied potential impacts, and may be harder to understand from a sustainability perspective by multiple stakeholders (Dasgupta and Tam 2005). To advance this thinking, due attention must also be given to the development of infrastructure sustainability, which this research tries to do.

CRITERIA AND INDICATORS FOR SUSTAINABLE INFRASTRUCTURE PROJECTS

Indicators are useful for monitoring and measuring the state of the environment by considering a manageable number of variables or characteristics (McLaren and Simonovic 1999). On the other hand, a sustainability criterion is the yardstick against which a sustainability indicator is measured, i.e. the goal or ideal condition in the relative comparison of indicators (Sahely et al. 2005).

Sahely et al. (2005) proposed a set of criteria and generic sub-criteria for sustainable infrastructure systems based on ‘triple bottom line’, with an addition of engineering criteria pertinent to infrastructure project undertakings, as follows:

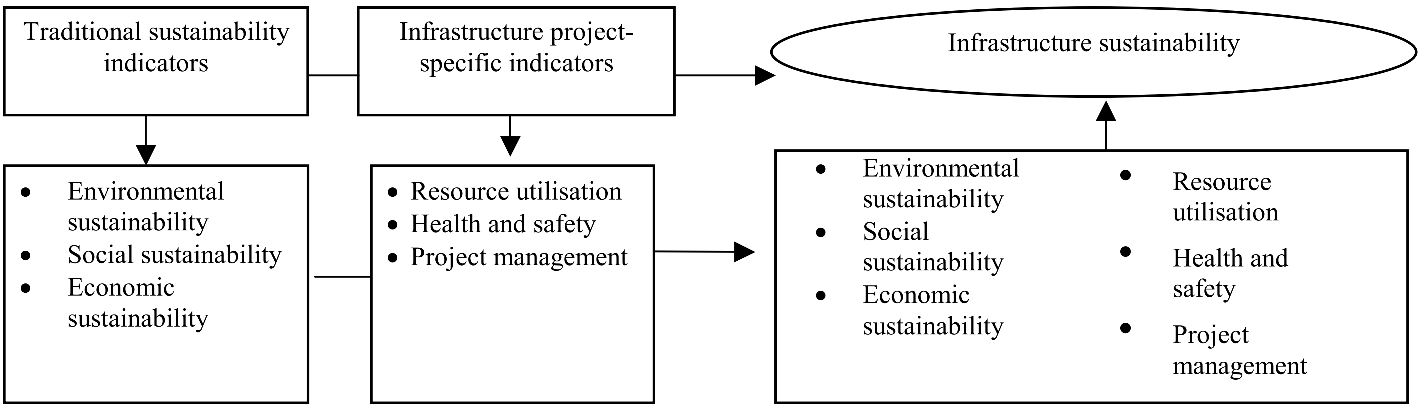
- Environment: including resource use and residuals production.
- Economic: including expenditures (capital, operation and maintenance).
- Social: including accessibility, acceptability, and health and safety.
- Engineering: including performance.

However, Engineers Australia (2005) contends that an infrastructure is sustainable if it meets the following sustainability criteria:

1. Environment sustainability: Reducing greenhouse emissions, lowering pollutant levels in stormwater and effluent discharge into rivers and oceans. Resources (particularly water and energy) are limited and need to be managed through conservation, reuse and renewable strategies.
2. Social sustainability: Reducing commuter times, increasing road safety, improving air quality and providing access to broadband communication to all citizens.
3. Economic sustainability: Ensuring that taxation and regulatory systems promote new private sector investment in all infrastructure capable of generating adequate returns of investment.

In a recent research of identifying key performance indicators (KPI) for infrastructure in South Africa’s construction industry, Ugwu and Haupt (2005) have developed a comprehensive list of key sustainability items and its indicators. These constructs incorporate internationally accepted sustainability metrics such as economy, environment and society. Besides, as suggested by the industry, it incorporates other performance-based indicators such as health and safety (e.g. occupational and public), resource utilisation (e.g. site access and material availability) and aspects related to project management (e.g. contract and procurement method).

Figure 35.3 Infrastructure Sustainability Conceptual Framework



According to Bourdeau (1999), sustainable construction has different approaches and different priorities in different countries. Different types of indicators have been developed for different purposes and therefore have different focuses, and operate at different spatial and functional scales (Hezri and Dovers 2006). Besides, Ugwu et al. (2006) highlighted that the indicators should be specific to the type of project domain and community to which it will be applied. Therefore, changes in indicators are inevitable to suit the local context.

BRIDGING TOWARDS INFRASTRUCTURE SUSTAINABILITY

Previous research on sustainability issues mainly focused on environmental protection. However, there has been an increased focus on the studies of urban sustainability in recent times. But the methods and decision tools development have focused mainly on buildings, and there is noticeably poor coverage of construction and operation stages of project development (Lippiat 2003; Deakin et al. 2001a; 2001b). Little has been done on infrastructure systems which may extend over large geographical spaces, have much wider and more varied potential impacts, and may be harder to understand from a sustainability perspective by multiple stakeholders (Dasgupta and Tam 2005).

At one end, sustainable development efforts mainly remain ideological as seen in macro-level policies and broad-based concepts. They have not explained how they could be translated into practical decision-making during project delivery. The same observation holds for infrastructure projects where the current focus is largely on macro-level policy planning, with little research focusing on the micro-level design and construction stage (Ugwu and Haupt 2005). The situation is exacerbated by multiple stakeholders having different expectations and perceptions towards achieving sustainability in infrastructure projects.

At the other end, there were many research initiatives attempting to develop sustainability assessment (Ugwu et al. 2006; Mirza 2006; Sahely et al. 2005; Ugwu and Haupt 2005; Dasgupta and Tam 2005). In between the two, there is a perception–reality gap and mismatch, specifically on how to enhance sustainability deliverables during infrastructure project delivery.

However, the multifaceted nature of these sustainability objectives requires all stakeholders involved in infrastructure projects to adopt an integrated approach. There is a need for multidisciplinary action and to ensure the appropriate stakeholders are involved in the decision-making process (Loucks et al. 2000; Mergerun 1999). This explains that decision-making for sustainable development in the built environment requires new approaches that are able to integrate and synthesise all dimensions and different points of views in a holistic manner (Deakin et al. 2001a; 2001b; Mitchell 1999). To do this, it requires the application of a suitable operational framework and an evaluation method or approach that is able to guide stakeholders through the decision-making processes. However, at the moment, such a structure for organising the information required in decision-making is not yet available or at least not agreed upon by the different disciplines and fields of activities. This lack of an agreed structure that can help decision-making processes achieve greater sustainability is a major problem (Brandon and Lombardi 2005).

THE *CONSTRUCTION INNOVATION* RESEARCH AT QUT

As an exploration on ways of rectifying some of the problems discussed above, a research project is being undertaken at the Queensland University of Technology, Australia. It is aimed at identifying and integrating the different perceptions and priority needs of the stakeholders, along with identifying issues that impact on the gap between sustainability focuses and its actual realisation at project-end level. Filling the gap found in previous studies, this research focuses on the practicality and real-world implementation of sustainability agenda in infrastructure projects delivery. This can be achieved based on the common understanding by various stakeholders, with individual viewpoints shared, understood and mutual benefits supported.

The ongoing research project employs a combination of face-to-face interviews with industry professionals, Delphi study among experienced practitioners and academics, and case study techniques to collect expert opinions as well as real-life project information. This is coupled with secondary data such as existing government guidelines on environment impact assessment and management, sustainable construction environment, and literature on sustainability research. Both the primary and secondary data will provide triangulation of results covering the perceptions of various stakeholders in infrastructure projects that will underpin the basis for establishing a decision-making process model for sustainable infrastructure projects.

While still at the early stages of development, initial industry consultation and feedback has indicated strong interest in this research among stakeholders of infrastructure projects. The guidelines to be formulated will help promote more integrated decision-making and actions on the implementation of sustainability strategies and focuses during the construction project delivery processes. With the different perceptions and views shared, discussed, debated, and with common values and mutual benefits identified, fragmentation on the responsible roles of sustainability will be avoided. Accordingly, this helps facilitate collaboration, consultation and communication among all stakeholders involved, thereby achieving consistent decision-making steps throughout the lifespan of infrastructure project developments.

CONCLUSION

In Australia, infrastructure development is currently going through an unprecedented boom due to strong economic growth and resource exports. While sustainability is a logical link to the complex nature of infrastructure projects, past research for this industry sector focused on policies, generic performances and assessment methods. As such they tend to ignore specific applications at project implementation level. A holistic set of indicators specific to infrastructure projects and agreed-to by involved stakeholders is important for monitoring as well as measuring sustainability deliverables throughout development phases. At the end of project delivery, information on tangible enhancement of sustainability focuses during infrastructure development will need to be properly collected and evaluated for ongoing reference and reapplication.

To achieve this goal, the need to identify then integrate the sustainability expectations of various stakeholders, along with solving problems that arise during project development stages, has been amplified through the research reported in this paper. Sustainability performance indicators at project levels, decision procedures to process and act upon these indicators, and the guidelines to facilitate collaboration, consultation and communication among key decision-makers will be integral parts of the deliverables of this research aimed at improving consistencies of sustainability outcomes in infrastructure projects.

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CHAPTER 36

Lifecycle Assessment: The sustainability power tool

Aruna Pavithran

INTRODUCTION

Llifecycle assessment (LCA) is a powerful tool used to calculate or estimate the environmental impact of a product, from the extraction of its raw materials to the end of its life. Like any modern tool, it has its tricks and failings; this and the technical bent of the content of the assessment have seen it used only by the most dedicated sustainability proponents in the construction sector.

It is the purpose of this paper to make the case for extensive use of LCA, indeed, integrating it in to standard planning practices in the construction of commercial buildings, much as NPV (net present value) is a common tool for the evaluation of business projects. To do this, a robust understanding of its merits and weaknesses is required, which can be best demonstrated through a case study.

This paper is divided into three parts. The first is a discussion of the purpose to be served by sustainability evaluation tools such as LCA. The second part provides an overview of the LCA process, using structural steel beams as a case study. The insights of these sections are combined in a third part, to discuss the practicalities of using LCA as the primary means of driving sustainability in commercial buildings.

COMMERCIAL BUILDINGS: THE SUSTAINABILITY CHALLENGE

With the sustainability revolution gaining momentum around the world, commercial buildings have come into focus as a particular challenge. Buildings in general are known to be significant sources of greenhouse gas emissions in construction as well as in operation, with the Organisation for Economic Co-operation and Development (OECD) reporting (in Bates, Hes and Morison 2006, 6) that

> *buildings consume 30 per cent of available raw materials and 42 per cent of energy, generate 40 per cent of our emissions to air, and 40 per cent of waste to landfill.*

The outlook is even more stark. Business-as-usual scenarios published by the Australian Greenhouse Office show that emissions from commercial buildings are projected to increase by 97 per cent from its 1990 levels by 2010. This outstrips projections for residential buildings (17% increase), transport (39%), fugitive energy (27%) and even stationary energy (56%) and industrial processes (52%). The gap between where we are and where we want to be (and the rate at which we are falling behind) reveals the huge size of the task at hand. A study by the Australian Greenhouse Office has shown that for commercial buildings to meet Kyoto-inspired emissions targets of 108 per cent of 1990 levels, reliance on known solutions – such as energy- or emissions-efficient products – is inadequate. Innovation and radical rethinking of the design and process of construction of commercial buildings – old and new – is required.

THE RIGHT TOOL FOR THE TASK

Major developers and the leaders of the construction industry acknowledge the need for change. To that end, a wide variety of frameworks, guidelines, policies, techniques, and even software have been created to support decision-makers, particularly in the selection of construction materials. However, no single tool has been adopted as an industry standard, which may be due, in large part, to some ambiguity on the outcome they all seek to uphold. What exactly makes a commercial building sustainable? How much energy use is the right amount? Is zero a good number? What about its toxicity to humans, in the quality and functionality of the space it creates for them to work? And how do each of these characteristics relate to the other – how do zero greenhouse gas emissions compare to human comfort and amenity?

Sarja's (2002) holistic and ambitious definition for sustainability in buildings has four categories:

1. **Social** aspects of welfare, health, safety and comfort
2. **Functional** and **economic** aspects of use incorporating flexibility
3. **Technical** aspects of serviceability, durability, reliability
4. **Ecological** aspects of biodiversity and resource depletion plus air, water and soil pollution.

A building that successfully integrates superior performance in all these aspects would certainly be considered by most people to be a 'sustainable' building. The challenge, then, is to determine how to define, then encourage through robust measurement, superior performance in each of these areas by way of sustainability evaluation tools, without further complicating an already complex construction value chain.

Into the space created by the heights of this aspiration and the absence of a single, agreed and holistic evaluation structure is the unexpected and welcome emergence of the 'green maverick'. These visionary and committed 'boutique' development teams have created a handful of benchmark sustainable buildings in the commercial sector. Projects such as Council House 2 in Melbourne and Beddington Zero in the United Kingdom have demonstrated that a building can be safe to work in, aesthetically pleasing, economically viable and have very low impact on the natural environment, using current technologies and processes.

These achievements mark a path to an absolute measure at the aspirational end of the sustainability spectrum, one that the development industry – and hence most of the existing sustainability evaluation tools – have been reluctant to acknowledge as the true goal of sustainable construction. This mark may be described as 'free, perfect and benign', where:

- 'free' refers to the elimination of cost elements and delays, particularly in ongoing maintenance of the building, but also in the construction process
- 'perfect' refers to aesthetic harmony and natural utility of the built environment for human occupancy
- 'benign' refers to a zero whole-of-life impact on the natural environment.

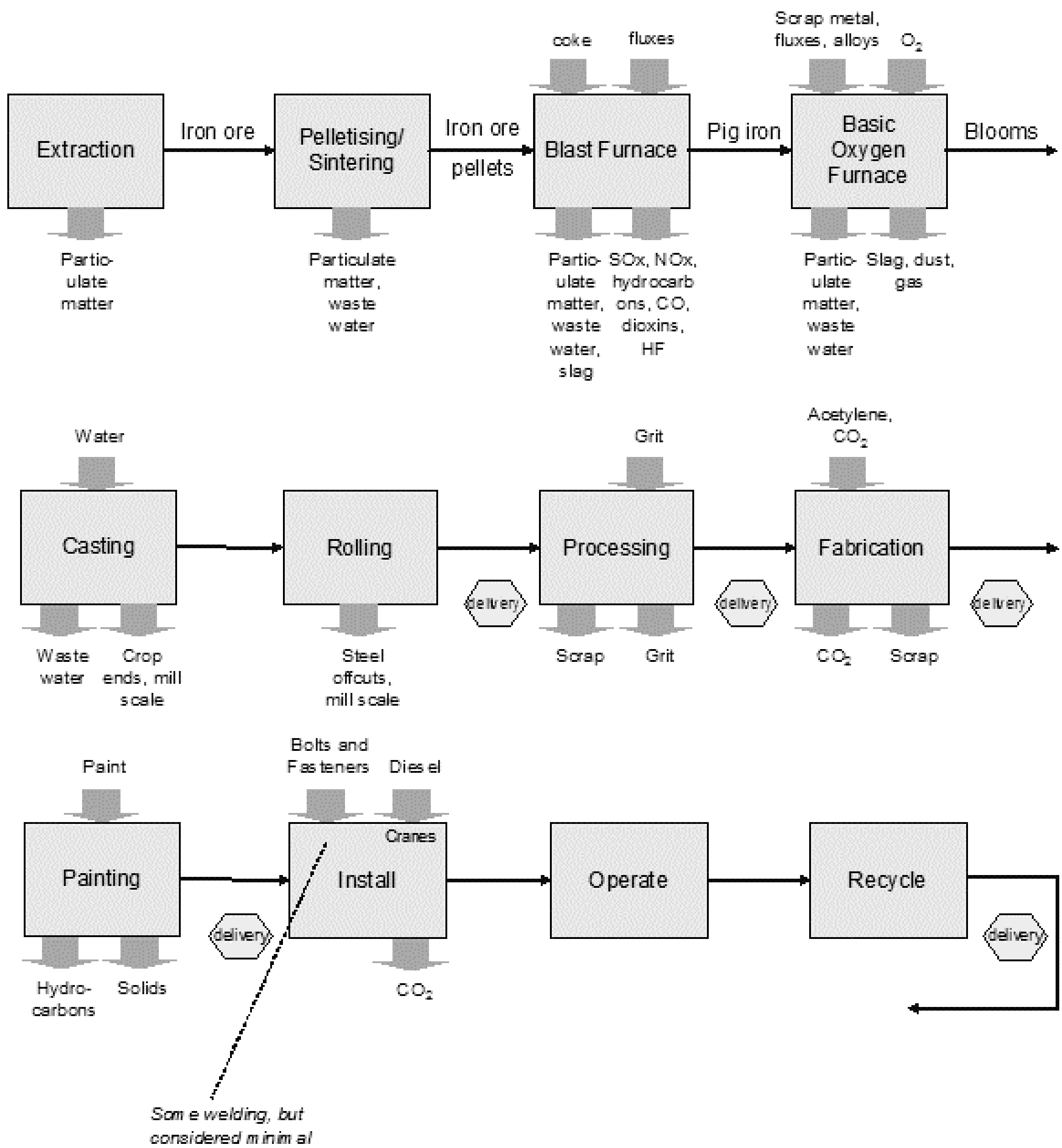
Irrespective of whether this goal is achievable with our current capabilities, a sustainability evaluation tool that may be integrated into industry standards must be able to cater to this absolute end, or else face redundancy, or worse, the unintentional 'capping' of progress to a lesser outcome. As discussed in the third section of this paper, establishing any kind of evaluation standard poses a major undertaking in the construction industry. The process of changing the entire development mindset from high-return to 'free, perfect and benign' is unlikely to be simple, or speedy. Absolute standards are required, which in turn require the widespread use of absolute measurement. Much as the spreadsheet and net present value (NPV) standardised the evaluation of business projects for a new era of entrepreneurship, commercial construction requires a sustainability evaluation power tool.

LIFECYCLE ASSESSMENT

LCA is currently the only process that can quantify the whole-of-life impact of a building's materials, construction process and operations. It brings a level of analytical rigour and detail to planning that is unfortunately not common in construction today. Without this kind of rigour, the impact of planning decisions is yielded to guesswork; this Modus Operandi is unlikely to deliver the goal of 'free, perfect and benign'.

As LCA work is still in its infancy, nor is the limited experience thus far in this field widely distributed, a case example of the process is provided here.

Figure 36.1 Lifecycle of an Australian Structural Steel Beam



CASE STUDY: STRUCTURAL STEEL BEAMS

The generic lifecycle of a structural steel beam used in a building is shown in Figure 36.1. This is the process by which an Australian-made steel beam is most likely to be produced. In addition to the inputs and outputs illustrated, there are also:

- substantial heat energy flows into the manufacturing steps, created by burning coal
- heat, light and noise energy outputs at most stages
- multiple physical deliveries between sites, as indicated, requiring fuel (typically diesel) and generating carbon dioxide emissions
- additional manufacturing activities producing the major inputs of the process
- various recycling activities using the byproducts of the process.

Perhaps the first thing noticeable in the steel beam lifecycle is its overall level of technical complexity. The information in this LCA could only be compiled with technical knowledge of the steel value chain (i.e. the value-adding stages of the manufacturing process), although its interpretation is not so technical to be beyond the capability of a non-specialist (such as an analyst working for a developer). In the case of steel beams, information on steel manufacturing (i.e. from extraction to rolling) could be gathered from public sources, such as company websites and other reference material. This is consistent for most commodity materials and their immediate derivatives, which comprise most of the building shell and a portion of its fitout.

Beyond commodity manufacturing, information is more difficult to obtain in the public domain at this time[5]. This creates a dilemma for the LCA practitioner. At each successive lifecycle stage, the existence of more suppliers multiplies the number of possible lifecycle outcomes, making it more difficult to come up with a generic product lifecycle assessment. Thus, the LCA usually involves the collection of information specific to a particular supplier. While this makes for an accurate result, the investment of time (and hence cost) to collate this information may yield only a single use if a different supplier is used the next time a building's LCA is to be calculated. Looked at another way, the tendency of this process to zero-in on particular suppliers can also operate as a part of a project's selection mechanism. In the case of steel beams, very few processors, fabricators and painters are sufficiently prepared at the moment to provide information for LCA. This creates a means of supplier prequalification, as indicated by a key decision-maker on the Council House 2 project, and quoted by Morison et al. (2006, 12): 'When a manufacturer is not capable of answering those questions [feeding in to our LCA], it shows their environmental credentials [do not match project requirements].'

The prospect of imported supply adds to the effort required to collate data for the LCA. Importing goods adds a significant transport leg to products, which will show up in the LCA as carbon emissions and in the project plan as a source of supply risk. In this case, the possibility of importing structural steel beams has an additional, unusual effect on a building's Green-Star Rating. Under that scheme, three points are awarded to buildings whose steel content is mostly recycled. With abundant iron ore resources in Australia, supported by substantial and efficient capital, structural items made from recycled steel are currently not available[6]. In contrast, countries like Indonesia and Thailand have no such natural supply, and can provide steel beams with recycled content. In effect, the Green-Star mechanism seems to encourage imported over domestic supply, or discourage the use of steel, which is a fully recyclable product. This issue demonstrates the need for caution in using 'rules of thumb' or 'common knowledge', particularly in a space where experience is limited.

Interpreting the result

The first stage of the LCA of steel beams produces a number, or set of numbers. These are usually expressed as an amount per tonne of product, and include:

- greenhouse gas emissions, in carbon-dioxide-equivalent tonnes
- embodied energy, in gigajoules
- other emissions, such as cubic metres of waste water.

The second stage of the LCA is interpreting these quantitative results to determine the significance of their impact on the natural environment. A range of approaches exists to accomplish this, ranging from simple methods through to complex systems analyses. As the natural environment is a complex system in itself, it is impossible to determine the exact impact of lifecycle outputs in the short or long term, in the same way as it is impossible for us to accurately predict the weather. A reasoned, selective approach to deducing environmental impacts is therefore necessary. This element of subjectivity may appear at odds with the quantitative rigour at the core of the analytical segment of the LCA; however, the correct balance of accuracy and judgment is required to manage the trade-off between precision in execution and the time taken to ensure it.

For example, analysis performed by Beam Solutions shows that over 90 per cent of the greenhouse gas emissions in the lifecycle of a typical structural steel beam are created in the manufacturing process. Therefore, for a decision-maker in the (sustainable) construction value chain, eliminating lifecycle emissions from the steel product means acquiring recycled steel, that is, structural steel from demolished structures (as opposed to steel manufactured with recycled content). The relative impact of other possible actions, such as purchasing offsets for new steel, or importing steel with recycled content, are likely to be far less than that the first, which eliminates the vast majority of new emissions. A project where recycled steel can be sourced locally and integrated into the design yields rewards to the natural environment – and possibly the total cost of construction – that cannot be

[5] Value-added product providers, downstream from manufacturing, such as steel distribution or fabrication, are often represented by industry associations. Many of these associations have undertaken to publish generic lifecycle assessments for their products, which will make this information easier to access in the public domain.

[6] This is anticipated to change over the coming decades, as more steel is recycled.

achieved any other way. Lazarus (2002, 4) states that the Beddington Zero project sourced 15 per cent of total materials in this way, saving 96 per cent of the environmental impact of new steel at no additional sourcing cost.

Indeed, the robust understanding that the LCA delivers of each product's value chain is arguably its most powerful strategic contribution to its practitioners. With this knowledge, completely different processes and construction techniques can be developed to reduce cost and time, eliminate environmental impacts and create new and profitable opportunities. To cite a recent example, a new concrete product was developed as a result of the efforts to reduce embodied energy in the Council House 2 building. Both the project team and the concrete supplier, Boral, broke new territory in the use of recycled aggregate, with estimated embodied energy savings of 20 to 30 per cent of its potential (Bates, Hes and Morison 2006, 20).

FORMING A VIEW ON THE SUSTAINABILITY OF BUILDINGS

We have seen that the LCA provides rich insight into the complex, multi-faceted system of decisions and events that create a commercial building, but it does not have all the answers to the sustainability equation. Using the categories of Sarja's holistic sustainability definition as a guide, decision-makers require some additional tools to evaluate their project's proximity to the aspirational target of 'free, perfect and benign'.

Firstly, social aspects, the first of Sarja's categories, may be only partly assisted by the LCA. While LCA can produce some quantitative factors such as volatile organic compounds (VOCs), it has no means of evaluating the aesthetic and safety qualities of the working spaces which make it 'perfect' to its occupants. Perhaps the simplest, integrated measure for this aspect is the market value of the completed building, which assumes that buyers of commercial buildings attribute increasing value to increasing social amenity. The crux of this approach is also its major drawback, which is that it relies on the market to have similar values as the development team. This raises the question: how much do commercial tenants value safety, or aesthetics, or the comfort of their people? While the answer to this question may not support the use of market value as a social amenity indicator right now, the creation of sustainable buildings and increased awareness of their benefits will surely change the balance of this equation. Until this time, there are a number of measures that can and are used instead, such as lighting quality and gross floor area per person.

The second and third categories: functional, economic and technical aspects, deal with the objective cost-for-service of the functioning building. The LCA does not help measure or make decisions in this regard, but traditional financial analysis does. The target of a building that is 'free' of unnecessary cost and pain to the developer can be realised by minimising the cost of construction and maintenance. Is it plausible to aim for a zero-cost servicing schedule? Perhaps not with current technology, but as concepts such as biomimicry are developed around the world, this situation may change.

Armed with the results of an LCA, a project team has a robust answer to the fourth category of Sarja's sustainability definition, ecological aspects. It is the combination of the impact assessment and the knowledge of the value chain that yields the opportunities to reduce environmental impacts to zero, making a building 'benign'. With the insights created by its LCA, the development team of Council House 2 was able to profoundly alter the impact of the building compared to its original state, achieving:

- 85 per cent reduction in electricity consumption
- 87 per cent reduction in gas consumption
- production of only 13 per cent of emissions
- 72 per cent reduction in mains water consumption.

This approach, while robust, has its consequences for the construction process, particularly planning. The typical process of commercial building construction is to delay detailed planning until a tenant is secured, then follow a 'tried and tested' approach to deliver a completed building with hopefully minimal delay on the contract. The effort and collaboration required to produce sustainable commercial buildings makes this approach unviable. Furthermore, the industry's tendency to accept variations may also be incompatible with sustainability outcomes, as the result depends very much on the careful matching of design, materials and the entire value chain.

The experience of the Council House 2 project provides a useful benchmark, where materials research cost an additional \$50 000 to \$70 000. While this represented less than 0.2 per cent of the total cost of construction, it is a cost that may be borne disproportionately by one entity in the planning team (Bates, Hes and Morison 2006, 22).

CONCLUSION

The prospect of 'free, perfect and benign' commercial buildings not only solves our emissions gap, but represents an engaging challenge for the construction industry. The accomplishments of 'green mavericks' in recent times have demonstrated that this goal is approachable, even if it is not known how precisely it may be achieved.

The path to realising this transformation is undoubtedly by gaining a deep understanding of the true impacts of existing value chains, and working in collaboration to change them. LCA provides this understanding like no other evaluation tool can. Combined with financial analysis and demand-side assessment of market values, we have the right tools for a comprehensive, balanced and auditable measure of a building's sustainability.

More analytical, rather than technical, skill is required to conduct such assessment; however, the real hurdle for the industry is the discipline of intensive, rigorous planning. From where we are now, the task of collating LCAs appears enormous and costly, if only because of the sheer number of value chains feeding into the construction of a commercial building. However, as more information and experience in this area is shared, these costs and risks will inevitably diminish, just as market premiums for sustainability outcomes will improve, in the same way that financial analysis became commonplace even outside the finance industry.

The highly collaborative nature of the construction process spreads the onus for driving this change across a range of industry participants, with perhaps developers and builders forming the necessary critical mass. Investment in quality information and analytical capabilities amongst these organisations is essential, as where sustainability is concerned, there is simply no substitute for better planning. Commercial buildings will be the landscape's monuments of our conviction in this in the decades to come.

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Implementation of an Organisational Innovation: The case of partnering in Sweden

Kristian Widén
Ola Andersson
Rasmus Johansson

INTRODUCTION

Partnering is a form of collaboration that has become increasingly popular in the construction industry (Black et al. 2000; Bresnen and Marshall 2000a; Naoum 2003). It is advocated as a mean for improving the effectiveness of the construction process, ensuring the client gets the desired project result and it results in a 'win-win' solution for the clients and their suppliers (Cheng and Heng 2001). It is said to achieve this through taking a step away from the traditional forms of cooperation, which means that it is a difficult change to achieve (Black et al. 2000).

Lately, there has been an increase in awareness of the differences between traditional manufacturing and project-based sectors. There is a need for cross-organisation integration within large, complex projects (Hobday and Rush 1999) and simpler projects too (Widén and Hansson 2007). Innovations that affect more than one organisation diffuse significantly more slowly than those that are incremental (Taylor and Levitt 2005). Negotiations between organisations and, to some extent, with legislative bodies may be necessary (Widén 2006; Miller et al. 1995). Since successful innovation is largely context-dependent (Blindenbach-Driessen and van den Ende 2006), policy aimed at encouraging innovation or enhancing innovative performance must be fit-for-purpose (Smit et al. 2007).

The research presented in this paper is a study of the factors influencing the successful implementation of partnering. It is done from the perspective of partnering as an organisational innovation affecting more than one organisation. It is also done from the perspective of construction clients, acknowledging the important role construction clients have in promoting change in the construction sector. Another aim of the research was to assess to what extent the concept of partnering was implemented and for what reasons.

PARTNERING

Partnering as a way of cooperation was developed by the US Army Corps of Engineers towards the end of the 1980s. The aim was to decrease the costs for public projects through fewer disputes (Edelman et al. 1991). After the initial success in the US, the concept has been developed over time and applied in a number of countries. Since the mid-1990s partnering has become an established form of cooperation in the US and is still widely used, especially in public projects. The UK is another country where partnering as concept has been widely implemented. In the mid-1990s when the construction sector in the UK faced great problems the government and the construction sector together engaged in a program lead by Latham (Holt et al. 1995) This lead to the world-famous Latham report *Constructing the Team* in 1994 advocating partnering as one solution (Latham 1994).

There is an ongoing discussion about what partnering is, what it takes to be successful and if it is necessary for the construction sector at all (Bresnen and Marshall 2000b). What generally is agreed on is that partnering is a decentralised pseudo-organisational structure designed to allow better flexibility in meeting specific project needs (Crowley and Karim 1995). Partnering is not a contractual agreement and does not create any legally enforceable rights or duties (Edelman et al. 1991). Moral contracts and collaboration rather than confrontation is the key to successful partnering (Uher 1994). Since it is not a contractual agreement and is built on moral and ethic actions it is crucial to ensure that all parties involved and affected agree on it. This implies the importance, that many advocate, of engaging all of the above in the implementation of partnering. Three generations of partnering can be identified (Bennett and Jayes 1998). The key features of the first generation of partnering are:

- agreeing on mutual objectives
- decision-making and conflict resolution according to a predetermined approach
- aiming at measurable targets for continuous improvement.

The second generation is more on a strategic level and is built on seven pillars; strategy, membership, equity, integration, benchmarks, project processes, and feedback (Bennett and Jayes 1998, p. 4). The third generation of partnering identified is characterised by a transition from a craft-based industry to a modern industry, manufacturing and marketing products. In this generation the construction sector develops product and supporting services for their long-term partners (Bennett and Jayes 1998).

Over the years a number of things have been found necessary if partnering is to succeed:

- Trust (Barlow et al. 1997; Scott 2001; Black et al. 2000; Cheng and Heng 2001; Bresnen and Marshall 2000a)
- Top-management support (Barlow et al. 1997; Edelman et al. 1991; Scott 2001; Cheng and Heng 2001)
- Open communication (Thompson and Sanders 1998; Barlow et al. 1997; Scott 2001; Clay et al. 2004)
- The right people (Kadefors 2003; Barlow et al. 1997;Chan et al. 2006; Rahman and Kumaraswamy 2002)
- Conflict management (Edelman et al. 1991; Naoum 2003; Hodgkinson 2001; Fullerton 2005)
- Workshops and team building (Edelman et al. 1991; Cheng and Heng 2001; Jason and Steve 1999)
- Mutual objectives (Hodgkinson 2001; Edelman et al. 1991; Barlow et al. 1997; Matthews and Rowlinson 1999)
- Early involvement of key people (Scott 2001; Barlow et al. 1997; Edelman et al. 1991)
- Mutual risk management (Rahman and Kumaraswamy 2002; Manley et al. 2007).

The development and adoption of the partnering concept in Sweden is nowhere near the level of the US and the UK. There have been a number of projects with some partnering components, but it has been rare for most of the components to have been used. Rhodin (Rhodin 2002) stated that in comparison with the UK, Sweden was in between the first and second generation partnering. For the Swedish context seven components important for partnering were identified: partnering leader/champion, the right people, team building, open communication, predetermined conflict resolution methods, contractual incentives, and continuous and structured meetings (Nyström 2005).

IMPLEMENTATION OF INNOVATION IN CONSTRUCTION

Innovation

There is no clear definition of the concept of innovation. Different interpretations exist:

> *Innovation is the process through which firms seek to acquire and build upon their distinctive technological competence, understood as the set of resources a firm possesses and the way in which these are transformed by innovative capabilities.*
>
> (Dodgson and Bessant 1996).

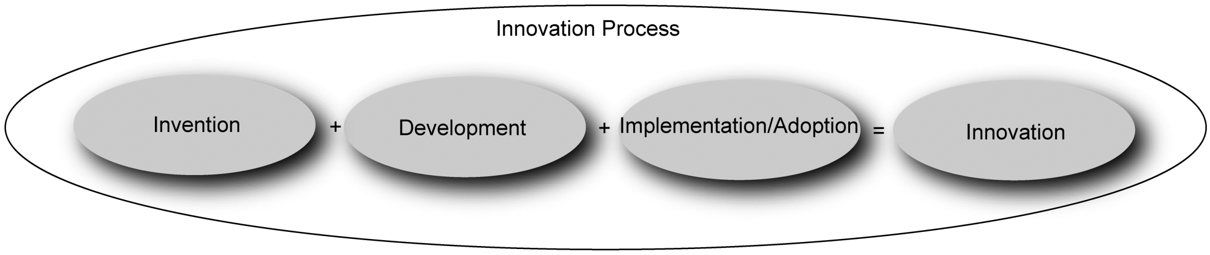
> *Innovation means the application of new knowledge to industry, and includes new products, new processes, and social and organisational change.*
>
> (Firth and Mellor 1999).

> *A technological product innovation is the implementation/commercialisation of a product with improved characteristics such as to deliver objectively new or improved services to the customer. A technological process innovation is the implementation/adoption of new and or significantly improved production or delivery methods. It may involve changes in equipment, human resources, working methods or a combination of these.*
>
> (OECD 1997).

The similarity between these definitions is that something new is created, a product or a process, then put to use (Tidd et al. 2001). However, the definitions do not state that it has to be new for everyone; it is enough to be new for the organisation adopting it. Innovation is basically change; either it is change in the things delivered (product innovations) or change in the way they are produced or delivered (process innovations) (Tidd et al. 2001). Partnering can, to some extent, be seen as a process innovation, but it is more of an organisational innovation. Another way of categorising innovations depends on their effect, ranging from radical to incremental. Radical innovations are of the highest novelty value and often necessitate dramatic shifts in production capabilities, distribution means or customer relationships (Stringer 2000). The opposite, incremental innovations (called continual improvement by some), are small-step, high-frequency, short cycles of change (Gallagher et al. 1997). Each incremental innovation may not be of any particular value, but together with others they may surpass the value of a radical innovation (Utterback 1994). Partnering, being such a shift from traditional forms of cooperation, lies closer to radical innovations than incremental.

Innovation is not the same as invention; which is the new idea that may lead to an innovation through the innovation process (refer to Figure 37.1).

Figure 37.1 Relationship between Invention and Innovation in the Innovation Process



Source: Widén (2006).

The innovation process consists of three parts: the invention/idea, development, and implementation/diffusion/adoption. Traditionally, these three have been described as discrete processes in a linear sequence, a view that has become increasingly challenged.

Innovations do not have to start with an invention. It may be knowledge picked up from another industrial sector or company and does not even have to start with something new. It may start with the notion of a problem, something missing or something needed to be done in an alternative, better way. Solutions are sought after, developed and implemented. Whether the innovation process starts with an invention, new knowledge or a problem, it needs to be developed for the context in which it is supposed to be implemented. Depending on the aim of the innovation it either has to be implemented in the innovating organisation or diffused to others and with the aim of making sure that it becomes adopted.

Partnering as an organisational innovation is not an invention; it has been used with success in other industrial sectors as well as in construction in various countries. In Sweden, though the concept is rather new, it is under development to be adapted to the Swedish context (Rhodin 2002).

Innovation implementation

Much literature on technical change and innovation focuses on creation and development, but it is not until it is used and widely spread, widely diffused, that any real gain is achieved (Stoneman 2001; Hall 2005). Diffusion is the process by which the innovation is communicated through certain channels over time among the members of a social system (Rogers 2003). Diffusion of innovations takes time.

The diffusion of innovations has been studied from different perspectives: historical, sociological, economic and network theoretical (Hall 2005). There are many different models for analysing diffusion patterns, see for example Stoneman (2001), Tidd et al. (2001) and Rogers (2003). Different models aim to analyse and explain different aspects of the diffusion process.

An issue that has emerged is the need for innovation theories for industrial sectors other than traditional manufacturing for which most existing theories have been developed (Hobday 1998; Taylor and Levitt 2005; Nightingale 1998). This will have a significant effect on how the diffusion process is perceived and managed. It is not only the organisational, sectoral or local context that will have an effect on the application of existing theories. There is evidence that country-specific characteristics will be influential too (Miozzo and Dewick 2002).

There are some important differences between the construction sector and manufacturing (mass-production sectors). In the construction sector, new ideas are seldom adopted by the company, as in mass-production industries, but rather into specific projects (Winch 1998; Slaughter 1998). In contrast to manufacturing, the products of the construction sector are large, complex, long-lasting and created by a temporary project organisation (Slaughter 1998). The innovations often affect more than one organisation in the process, making it harder for a single company to adopt something new (Miozzo and Dewick 2004). Partnering, naturally, will affect more than one organisation. It will affect those that are working within the partnering agreement, but it may also affect other organisations within the project that are not taking part in the partnering as such.

A way to increase opportunities for diffusion in the construction sector is to stop considering diffusion as a discrete activity following on from the development of the innovation. Many innovations in construction, of any type, will affect more than the innovating organisation. Diffusing an innovation and even implementing it may be very difficult if one or more affected organisations do not want the innovation in question to be adopted or implemented. It is necessary too, during development, to assess the likelihood of this happening and then to limit that possibility (Widén 2006). Communication is an aspect that, no matter what model or approach for dealing with innovation is adopted, always will be the most important because it facilitates many other aspects such as learning and feedback. Communication during the development of an innovation with the parties that will be affected, to ensure their acceptance of the effect(s), is crucial for diffusion (Widén and Hansson 2007).

As partnering is a tool for increased collaboration between the parties in a project there are many organisations that may be affected by its implementation and/or may affect the implementation process of it in Sweden. This suggests that it is important to allow those parties to be involved from the beginning. Since it is the client that makes the initial choice on whether or not to use the concept, their actions and attitude to it will have an important effect on both the implementation of partnering in a particular project and on the use of partnering over time.

METHOD

The research here is part of a larger study on partnering in Sweden. The study was initiated by the Swedish Construction Clients Forum (SCCF) and this part aimed to find what made the implementation of partnering in Sweden successful for the clients and asses to what extent the concept of partnering was implemented and for what reasons. SCCF, in collaboration with the research team identified 27 organisations within Swedish Construction Clients Forum that had all carried out some sort of partnering project and were suitable as respondents. To get a certain amount of randomness the respondents were questioned on their last-performed partnering project.

A questionnaire was used to collect data from the respondents. The first part of the questionnaire treated the partnering process in itself and consisted almost solely of questions with fixed alternatives. The second part evaluated the result of the project through a number of statements, concentrating on both process and result. A 1–5 Likert scale, from ‘completely agree’ to ‘don’t agree’, was used.

A reference group was used to make sure that the questionnaire was right for the intended study. This group consisted of people with experience in implementing partnering in Sweden. They helped in the search for pertinent questions and pointed out what had to be explained further. The collected data was processed and analysed. Because of the probing nature of the questions and statements with fixed alternatives, which were sent to a small number of respondents, the method basically was of a qualitative nature with a certain quantitative influence.

IMPLEMENTATION OF PARTNERING: GETTING IT RIGHT

The client representatives questioned in this study were all satisfied with the outcome of the projects where they had used a partnering arrangement. They agreed that the overall quality had increased, the cooperation between parties had improved and that cost and time had been better managed than they would have expected from a traditionally managed project.

There were, however, some differences in the degree to which they agreed on these different issues. There were also differences in the extent the partnering concepts were implemented. The following sub-chapters discuss to what extent the differences in implementation strategies on behalf of the client organisations affected the project and partnering outcomes.

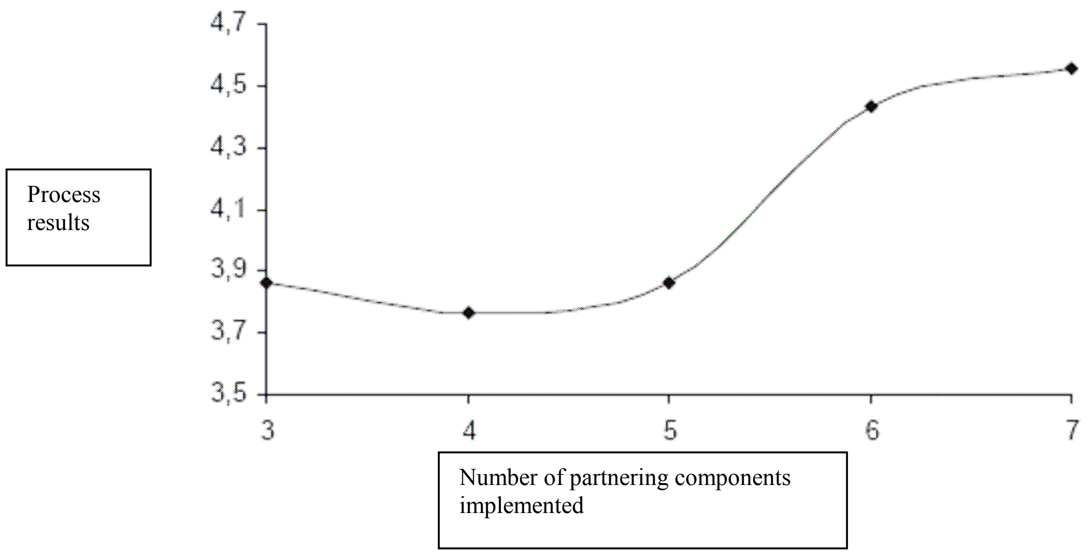
Implementation of the concept of partnering

As the research on innovation diffusion in the construction sector implies, it is necessary to involve the different actors that may be affected by and may affect the implementation as early as possible. That would imply that the earlier the actors take part, the better. The findings from this research is that very few, apart from the client and his advisors, were involved in the pre-design phase and during the design phase it was mostly designer consultants of various kinds, architects, structural engineers etc. In general it is not until the construction phase of the project that the contractors were involved and in many cases only the main contractor. Instead, some chose the approach of using a partnering leader/champion from an early stage of the project, as advocated by, for example, Edelman et al. (1991). The partnering leader/champions came either from the contractor or from a neutral source – only in one of the projects did the partnering leader/champion come from the client's own organisation The projects that used a partnering leader/champion and those that did not, were compared to observe any differences in result. A strong tendency appears in the comparison – projects with a partnering leader/champion had considerably higher results both regarding the process and the actual result. If the group which used a partnering leader/champion is further examined, differences appear here too. In the projects where a neutral partnering leader/champion was commissioned compared to those with one from the contractor, a generally better process and actual result was achieved.

The extent to which the partnering concept is implemented

Another aspect that has been said to be important in implementing an organisational innovation like partnering, especially in the partnering literature, is that it is necessary to use all the components of the partnering concept to be successful. The seven components that were identified as important for partnering success in Sweden were compared to the result from the questionnaires. It was clear that the more of the components used, the better are the process results, see Figure 37.2. In the cases where five or fewer of the components were used the process results were comparatively lower than if six or all of the components were used.

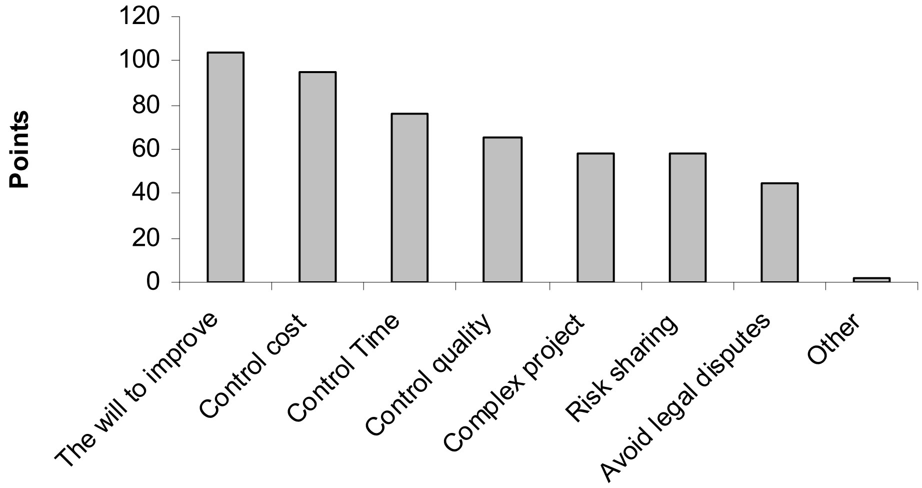
Figure 37.2 Relationship between the Number of Partnering Components Implemented and the Process Results



Reasons for choosing the partnering concept

There are many reasons for using partnering in a construction project. The respondents were therefore asked to rank the most important reasons for choosing partnering for their projects. To be able to educe the most important reason for partnering the ranked alternatives are numbered according to their importance. The distribution outcome is shown in Figure 37.3.

Figure 37.3 Respondents' Rank of the Reason for Choosing Partnering



The will to improve is ranked as the most important reason for choosing partnering. This may indicate that many people consider the industry being in need of change. The explanation for the high rank of 'The will to improve', may lie in the problems that the Swedish construction industry experience today. The reason why 'Avoid legal disputes' was placed last but one is that, though partnering has its origin in avoiding legal disputes, Sweden hasn't really had any big problems with legal disputes as in other countries.

DISCUSSION

Although the sample is rather limited the findings show clear tendencies, and they are in line with the theory already described in the innovation and partnering literature. Implementation of innovations, especially innovations affecting more than the innovating organisation, need to be assessed differently compared to how they are assessed and managed in manufacturing industries. In this study there has not been the involvement of affected actors as early as possible. Instead, in some cases, a partnering leader/champion has been used to tap into the knowledge needed for successful implementation, compared to the concept of innovation brokers (Iansiti 1995, Winch 1998, Widén 2006). An explanation of the better result when having a neutral partnering leader/champion may also be found in that comparison, where neutrality is seen as important. It may not be surprising that projects that take on the whole concept of partnering, implementing all parts, has better results than those that do not. It does however suggest that there is little use in implementing something as profoundly different as partnering compared to the traditional way forms of cooperation, if you do not do it fully.

In its infancy partnering was developed to avoid costly legal disputes. But avoiding legal disputes was ranked among the lowest reasons for choosing partnering in this study. Instead it is the will to change that is the driving force for choosing partnering. This probably has to do with the pressure to change that the Swedish construction industry has experienced in the past decade, similar to the situation in other industrial countries across the globe. Another plausible explanation is the contextual differences between Sweden and the US where partnering was first developed and implemented. Sweden has nowhere near the same tradition as in the US of taking disputes to court. It is noticeable that almost all of the projects succeeded in avoiding legal disputes. The most overwhelming impression is how positive all the respondents are to working with partnering in future projects. All the client representatives agreed, although to different extents, that they as clients had benefited from implementing an organisational innovation like partnering. This shows that partnering is not a just another new fad but a concept that is here to stay. What is also a rather clear tendency is that the more you commit to the implementation of such an innovation the better the result.

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Industry Capacity Analysis: A new methodology for public road infrastructure development in Queensland

John Bateman

BACKGROUND

Much of the current literature on construction procurement has been critical of current procurement processes (Eriksson and Laan 2007). Eriksson and Laan found from their research that the construction industry is being criticised for its:

- failure to innovate and improve
- poor productivity
- cost overruns
- decline in construction quality
- decrease in client satisfaction
- conflicts and disputes
- late completion.

Although the authors refer mainly to their European experience, there are parallels to be drawn with the construction market in Queensland. In particular, the Queensland Department of Main Roads (QDMR) has experienced all of these inefficiencies to varying degrees in road construction. The reasons behind these inefficiencies can be attributed to 'industry fragmentation, the uniqueness of construction as a product, the divorce between design and construction, obsolete procurement methods and lack of cooperation and trust between the actors' (Eriksson and Laan 2007, p. 388). Road construction in Queensland has not been immune to the causes of these inefficiencies.

Set against these concerns is the fact that Queensland's economy is booming and there is record spending on infrastructure development. Tony Pearson, Head of Australian economics at Economics @ ANZ said that Queensland remains resolutely in the group of fast-growing resource-rich states (Economics @ ANZ, 7-8). In the area of non-residential building, which includes construction and engineering, there is continued growth with the value of work to be done in the March 2007 quarter at a record of $13.2b. Economics @ ANZ predicts the economic growth in Queensland to ease in 2007–08 to around 5.5 per cent. Even so, Queensland is still the fasted growing state or territory.

The dilemma for the Queensland Department of Main Roads

In the past QDMR had been in a position where its suppliers would be looking to the department for work. However, the booming mining sector and economy generally, combined with record infrastructure development, had turned this situation around. QDMR was now the one going to the suppliers seeking their assistance, particularly on major infrastructure projects in the south-east of the state. This was a new experience for the department.

Another concern for QDMR was that the department had been set up to operate on a decentralised model with each of its 14 districts operating quasi-autonomously. In addition to what the department was experiencing in the market as a result of the economic situation, QDMR's own culture of decentralisation was now working against it. Although there were internal reforms put in place in 2006 to address the decentralised model and give the department a state focus, these types of cultural reforms are slow to develop.

Under the decentralised model, the districts tended to operate independently. From a procurement perspective, there was no state focus and districts were out in the market competing for the same scarce resources and suppliers. This situation was compounded by the districts holding the information on their suppliers and markets. The difficulties in obtaining statewide data in turn led to difficulties for procurement in planning strategically at a state level.

These difficulties had to be reduced if QDMR was to be able to attract suppliers for its major road infrastructure developments and have any hope of planning and coordinating its procurement activities at a state level. It is the objective of this paper to document the development of public sector procurement in Queensland and focus on how that development assisted the Program Procurement Division (PPD) within QDMR to overcome these difficulties and look more strategically at procurement planning for QDMR at a state level.

A BUOYANT ECONOMY

Government infrastructure spending

The Queensland Premier, Anna Bligh, said in the Queensland Parliament on 5 June 2007, that 'the government was spending on infrastructure at an unprecedented rate. Capital spending in Queensland 10 years ago was 5 billion dollars. Under the 2007–08 Queensland State Budget, the government's total capital program will exceed 14 billion dollars.' (Bligh 2007).

After the release of the 2007–08 Queensland State Budget, Paul Lucas, (the then Minister for Transport and Main Roads) (Lucas 2007), indicated that the Budget provided for spending of $5.53b on road, rail and ports. This was a 39 per cent increase on the $3.97b provided in the previous budget. The minister indicated that this expenditure partly responds to the state's growing demand for transport services, road infrastructure and port and freight facilities.

Road construction in Queensland

Concern has been expressed for some time within QDMR about the overheating of the construction market, the large increases in budgets and infrastructure projects and the ability of the department's traditional suppliers to continue to supply to the department into the future. QDMR is competing in the market with other organisations building infrastructure in ports, busways and transport infrastructure, railways, under-river tunnels, hospitals, commercial and residential developments as well as mining. These organisations are all competing for the same suppliers and resources, particularly in the south-east of the state.

BIS Shrapnel (BIS 2006), in a report commissioned by QDMR in 2006, confirmed that this growth has been the catalyst for the unprecedented strength of this construction activity in Queensland which has been increasing at a greater rate than the rest of Australia. The report forecast further growth of around 15 per cent to 20 per cent through to 2008–09. The level of total construction activity in Queensland in 2006 was around 70 per cent higher than it was five years ago.

The report was commissioned to gain an insight into the likely environment that the department will be operating in over the next five years. Road construction was found to be the major contributor to this construction growth and in 2006 it was 73 per cent above the levels recorded in of 2001–02. BIS Shrapnel has forecast a further increase of 77 per cent in real work done to the end of 2008–09.

The department's concerns about the effects of the unprecedented growth in construction activity were borne out by the reports findings that all this activity is leading to problems with labour and other shortages, particularly in Queensland. QDMR has already experienced shortages in labour (particularly in skilled and professional labour), transport, steel and precast concrete products. Of particular concern was BIS Shrapnel's forecast that there will be a need for between 2700 and 3000 additional skilled workers (mainly engineers) by 2008–09.

The other concerns of the Department about the capacity of its suppliers to meet this increased activity and likely cost increases were also discussed in the report. BIS Shrapnel confirmed that possible shortages, supplier capacity and cost increases will have a negative effect on the volume of construction work in Queensland over the next two-to-three years. In other words the likely effect on QDMR would be that it will be difficult to substantially increase the program of road works in Queensland.

BIS Shrapnel's report (2006) predicts that:

> *…the delay of some work until later in the decade (once construction activity starts to fall) might result from a realistic assessment of capacity to deliver, but would also, on our forecasts, mean that the work would be undertaken in an environment of greater cost certainty. The delaying of work until the downturn phase would also provide countercyclical support to the state's construction industry.*

The imperative for QDMR is to deliver on the Roads Implementation Program (RIP). The RIP sets out QDMR's intentions for planning, building and maintaining the state-controlled road network over a five-year period. The document provides for firm funding of projects in the first two years, but funding allocations are only indicative for planning purposes for the following three years. In terms of spend, the RIP for 2007–08 to 2011–12 is at a record $13.3b. This is an increase of 15 per cent ($1.75b) over last year's RIP.

PROCUREMENT INNOVATION

It has become clear to QDMR that in order for the department to deliver the RIP, it needed professional input into its procurement activities, planning and supply market analysis. Like many government departments QDMR had a procurement area which had traditionally been, through custom and practice, more concerned with operational and tactical procurement issues. Over the past three years PPD has developed a strategic focus to its procurement planning. PPD is responsible for enabling the delivery of the roads program across the state. It does this by assisting the programs in matching their demand with the market's capacity and capability, and fostering and developing good supplier relationships. It is QDMR's policy to be seen by its suppliers as their 'Customer of Choice'. In addition, PPD is responsible for researching internal and external data to support accurate cost estimation of road programs.

PPD is now recognised across the Queensland Government as a leader in the field of strategic procurement management. In particular, the Queensland Government Chief Procurement Office (formerly Queensland Purchasing), has acknowledged that QDMR is at the forefront of leading change in supply chain management and strategic procurement planning within the Queensland public sector. This recognition can be attributed to the professional manner in which PPD is establishing and maintaining a sound understanding of the department's supply markets and using this information in the development of innovative ways of purchasing the infrastructure and services required for the successful delivery of the department's roads program commitment.

In 2006, the Queensland Government Chief Procurement Office undertook a review of PPD to identify and quantify where procurement practices were efficient and effective in delivering value for money as well as identifying opportunities for improvement. The results of this review further reinforced its view that strategic procurement planning and supply chain management within QDMR were at the vanguard of Queensland public sector procurement practices. It was stated in the report that 'the results [for PPD] are comparable with "best in class" for a public sector organisation especially in strategy development' (Queensland Purchasing 2006). PPD is now working with the Queensland Government Chief Procurement Office in implementing the recommendations from the report to ensure that PPD harnesses opportunities for the identification and implementation of procurement strategies and business practices that provide operational efficiencies and cost savings to the department.

Public sector procurement in Australia has undergone significant change over the past decade. Within the Queensland context the pace of change is set to increase with the release, on 9 August 2007, of the Service Delivery and Performance Commission's *Report on Review of Purchasing and Logistics in the Queensland Government* (SDPC Report), (Service Delivery and Performance Commission 2007).

One of the main catalysts for undertaking the SDPC Report is the increasing cost to government of procurement. The economic conditions in Queensland at this time are producing a booming economy with record spending on infrastructure development and the government is also increasing its expenditure on supplies and services (Department of Public Works 2007). This is occurring at a time when the procurement environment is also becoming increasingly complex with the introduction of new business models, new technology and globalisation of markets. The government found that there has been little or no corresponding increase in the level or capability of the resources that agencies have dedicated to the procurement function. The combination of substantially increased procurement spend, increased complexity and lack of any substantial procurement expertise is costing the government dearly.

The SDPC Report found, among other things, 'that there is the potential to improve procurement outcomes and achieve significant efficiencies through better organisation, management and skilling of the procurement function across government' (Department of Public Works 2007). As part of this review, the SDPC commissioned A. T. Kearney to undertake a procurement benefit assessment for the Queensland Government. The assessment covered 26 common categories of expenditure (representing 43% of the total expenditure). It concluded that improved procurement practices in these 26 categories alone will deliver savings of between 5 per cent and 10 per cent. If this is applied to the full $6b per annum expenditure on supplies and services, the SDPC believe that there is a total potential benefit of between $314m and $663m per annum. If this is added to the identified potential capital works savings of between $172m and $257m per annum, there is a total potential saving of between $486m and $835m per annum (Service Delivery and Performance Commission 2007).

The SDPC Report has been the shot in the arm that public sector procurement in Queensland needed to push along the reform of procurement that is so desperately needed across government. To this point many agencies had only paid lip service to the reforms introduced by the State Purchasing Policy in 2000. The Queensland Government Chief Procurement Office now has the authority under the recommendations of the SDPC Report to lead whole-of-government procurement reform.

DELIVERING THE PROGRAM OF WORKS: MAIN ROADS

On 1 July, 2006 QDMR began operating under a new organisational structure aimed at ensuring the delivery of the statewide roads program. Under this structure, the department was realigned into a program delivery model. One of the main aims of the reorganisation was to ensure that the organisation is best placed to meet the current delivery task in the face of industry-wide resource constraints, and take advantage of future opportunities. QDMR's annual report 2005–06 focuses the department at a state level. It provides for an improved statewide consistency of QDMR's business while maintaining the strength of its community-based district delivery through the 14 districts. There is now a focus on ensuring that QDMR's business systems are consistent and integrated across the state. In maintaining the statewide theme, the report also ensures the coordination of the statewide functions such as road system planning, program development and delivery, major projects and corridor management and operations.

One of the main concerns about the old structure, from a procurement perspective, was that each of the department's 14 districts operated quasi-autonomously. Under these conditions each district was out in the marketplace competing for the same resources and suppliers. This led to districts virtually bidding against each other to engage suppliers to commence their particular project. The other concern was that it was the districts that held information on suppliers and markets in their area of influence. As there was no central data or intelligence, it was difficult, if not impossible, to plan strategically for procurement at a state level without considerable effort and time.

This situation with the districts operating independently and more or less in isolation had a long history. However, as it was now occurring in a booming economy, where there was increased competition for resources and suppliers, it was counterproductive for a department which was attempting to deliver the RIP from a statewide perspective. The districts were using traditional non-relational 'go to market' strategies without understanding the level of competition or capacity in the marketplace. This led to unsatisfactorily high numbers of tenders or at the other extreme, one or no tenders.

The concern for PPD in late 2005 was that it was unable to provide the department with any detailed or meaningful reporting or planning at a whole-of-state level because of a paucity of data on suppliers and supply markets across the state. It was difficult to plan for projects which ran across districts or where there were common suppliers, as most of the information on future projects as well as local supply markets was held by districts.

In order to be in a position to deliver the RIP in this environment of unprecedented construction growth and large increases in budgets, the department has implemented procurement planning as a tool to assist in the delivery of the expanded roads program over the next five years or more. Procurement planning will place QDMR in a position of being an 'informed buyer' through understanding the marketplace in which it operates, its effect on the marketplace, what and how much it buys and how well (or otherwise) it interacts with the marketplace.

DEVELOPMENT OF PROCUREMENT INITIATIVES

The key role of QDMR is to 'deliver roads infrastructure and manage the road asset' (QDMR Annual Report 2005–06). Within the department, it is the Program Development and Delivery Group (PDandD) that has the direct responsibility for the cost-effective delivery of the RIP and developing and matching capacity of the roads industry to meet QDMR's program delivery needs. PPD, as part of PDandD, wanted to be in a position to address these areas of responsibility through:

- matching program/projects with supplier capability and capacity
- establishing procurement delivery strategies that complement supplier capability and capacity
- developing and maintaining a relationship of trust and sharing with suppliers.

In order to deliver on these initiatives PPD initiated the District Supplier Capability and Capacity Assessment (DSCCA) Project. The DSCCA Project is essentially a supply market analysis of the pre-construction and construction segments of the current market. The analysis was undertaken across the three sectors of the market, namely, local government, RoadTek[7] and private sector firms. From the data available PPD were able to establish key suppliers in each district. These key suppliers together with other suppliers (including potential suppliers) were interviewed in each district by PPD to obtain a 'snapshot' of the supply market capacity and capability across the state.

The DSCCA Project is now complete and has captured information that is seen as essential to a better understand how geographical influences impact the supply market, position QDMR as an informed buyer in the infrastructure market and as the 'customer of choice' with its suppliers. The data gathered as part of this process will enable QDMR to be better positioned to match its demand with known market capacity and capability. It is this information and data that will assist in developing and delivering the RIP. An added bonus for PPD will be that QDMR staff will be able to see and appreciate the benefits that procurement planning can make to an organisation.

Reports have been prepared for each of the department's districts and are essentially a 'snapshot' of the supply market in a district at the time the research was conducted. This 'snapshot' was essentially a cross-section of the district's suppliers and was not necessarily an exhaustive list. In compiling these reports, information has been captured through interviews with key suppliers representing the various market sectors. The purpose of the DSCCA reports is to provide an informative and validated view of market conditions for each district. In particular the DSCCA reports will provide the districts with information on district and supplier opportunities, and procurement risks as well as a brief insight into future project work (demand) and possible delivery options based on the market's capability and capacity. This will give the districts an understanding of supplier capability and capacity which will help each district identify and understand competing markets and the impact this has on the supplier's ability to supply.

The DSCCA reports, together with research data focused on the external forces on the market (derived from published indices), assist in developing strategies for future events. In particular, the DSCCA reports and research data will be used to fine-tune the development of the RIP in terms of developing the best delivery opportunity combined with the best probability of success. It will also assist in fostering and developing good supplier relationships.

The overwhelming feedback amongst suppliers was that they welcomed the opportunity to talk to QDMR and share their views about their industry and the market in general. On many occasions suppliers were 'surprised' that QDMR was interested in their business and were keen to provide feedback. From the information captured during the interviews with key suppliers from the various market sectors (local government, RoadTek and private sector firms) as well as from the district offices, common themes or trends emerged across the state. Whilst some districts do have their own issues, the themes described in the next section appear to be common (to a lesser or greater degree) to all.

KEY FINDINGS OF THE DSCCA PROJECT

1. Most sectors believe the road construction market will grow in the next five years by between 10 per cent to 20 per cent.
2. Availability of resources is seen as having a degree of risk or the potential for risk in the future. These resources include transport, labour (particularly in skilled and professional labour), steel and quarry products, and precast concrete products. Private sector firms described 'resources', 'over commitment' and 'staff availability' as the main risks in the marketplace. However, local authorities flagged 'staff availability' as its main risk.
3. The private sector firms are willing to undertake work for QDMR. The department is seen as an attractive customer to almost all suppliers. In particular, QDMR is seen as a 'good payer' ensuring continuity of cash flow for these suppliers.
4. Despite QDMR being seen as an attractive customer, many suppliers were able to pick and choose projects and even whether or not they took on QDMR projects. This is due to the current market situation where suppliers have a smorgasbord of projects to choose from. The current state of the market has created a significant problem QDMR because although there is potentially additional capacity that can be directed towards QDMR projects, this additional capacity only becomes available if certain market conditions are met. Whilst this is the situation in the south-east of the state and the larger regional centres, the more remote districts are not experiencing these conditions.

   Several suppliers indicated they were quite comfortable in their market segment and did not believe there was a need to pursue a greater market share by increasing their capability or capacity. Conversely, many suppliers indicated that they would be very interested in undertaking QDMR projects if QDMR were able to package or unpackage projects to suit suppliers' position in the market in terms of a firm's size, financial capacity, risk profile and location. Suppliers were very interested in providing greater commitment if QDMR were able to provide certainty of projects over a period of time from two to seven years. QDMR should be able to match capacity and capability of its suppliers with their geographical location. Many smaller suppliers were keen for QDMR to ensure prompt payment.

   Some suppliers believe that communication problems need to be resolved between the parties. Documentation was also an issue. For example, the tender documentation was seen as over-complex and confusing. Revising and simplifying tender documentation and contract conditions would assist suppliers (and the department) in dealing with each other. This would lead to savings in costs and time for both parties. There would also be savings in costs and time if the over specification of the department's requirements was addressed.
5. Labour was seen generally as being freely available in most districts outside the south-east of the state. Even so, the quality and experience of that labour was seen as problematic. Despite these findings, the ongoing record low levels of unemployment across Queensland of around 3.8 per cent (Queensland Treasury Corporation 2007) are making the overall

[7] RoadTek is a government business within the Queensland Department of Main Roads. It is a major provider of road construction and maintenance services throughout Queensland.

labour market very tight. The buoyant economy, record spending on infrastructure development and a booming mining sector has made the overall labour market very tight. Both local government and private sector employers in the south-east and in the larger regional centres have experienced significant problems in recruiting suitably qualified and/or experienced candidates to fill the vacancies.

The availability of professional, skilled and supervisory staff was seen as one of the most pressing factors affecting the ability of suppliers to keep up with demand for services now and into the future. Professional and trade positions are the most difficult to fill. The skilled labour supply market will not be sufficient to meet the demand for the anticipated roadwork projects planned for the south-east of the state as well as the larger regional centres. Roads activity is expected to be at historically high levels throughout the next decade with the peak of the activity occurring approximately in 2011–2013 as the maintenance and construction roadwork intensifies (BIS Shrapnel Report 2006).

6. Both the private and local government sectors expect that the growth in the road construction market will be 30 per cent to 40 per cent over the next three years. They expect that the road construction market will maintain this level of growth over the next five years.

   RoadTek however, expects that their segment of the road construction market will stabilise or decline slightly within the next three- and five-year periods. It expects that the decline in the road construction market will be 10 per cent over the next three years and remain this way over the next five years.

   As indicated earlier, all of the suppliers indicated that they would like to observe a long-term plan and project commitment from QDMR, such as a program of works. This would provide certainty, reduce costs and would have a positive effect on workforce stability. In addition, the long-term commitment will enable all suppliers sufficient time to better plan their projects and allocate the proper resources.

7. Many of the private sector suppliers stated a preference for entering into a more relational style of contract arrangement with QDMR. They see the advantages for this arrangement as risk sharing between the parties, providing incentives for innovation, better quality work through resource and knowledge sharing and representing better value for money in the longer term. Suppliers indicated that there are significant gains and savings to be achieved through earlier contractor involvement and resource sharing where appropriate. They are keen to participate in these types of activities and better working relationships will create benefits for both parties.

   The suppliers indicated that they find the proposed packaging or unpackaging of projects or greater QDMR commitment over a 2–5-year and 5–7-year period attractive and beneficial as the long-term commitment levels the peaks and troughs over a period of time. This will have a positive effect on workforce stability by providing their workforces with certainty and therefore improve the chances of retaining skilled staff for longer. It would have the added benefit of improving the relationship with QDMR's suppliers. Significant time and resource savings can be achieved in 'go to market activities' by adopting a tailored procurement strategy that suits local market conditions.

8. Private sector firms flagged the following issues (in rank order) as having a substantial influence on their ability to undertake work for the department:
   i. Lack of resources to compete in and enter the market
   ii. Lack of staff availability
   iii. Perception that the process of obtaining the status of a prequalified supplier is not a fair process
   iv. High levels of QDMR specifications
   v. Stringent government policy impacting their entry
   vi. Lack of knowledge or experience of QDMR as a customer; they have not had a chance to deliver for the department before
   vii. The form of contract is seen as overcomplicated, cumbersome and a hindrance
   viii. Freight costs
   ix. Fuel cost.

INNOVATIVE APPROACHES TO UNDERSTANDING SUPPLIER CAPABILITY AND CAPACITY

PPD's approach to seeking knowledge of suppliers' capability and capacity across the state has been an innovative approach for public sector procurement in Queensland. This is seen as first step in obtaining detailed intelligence on the department's suppliers and the supply market. The DSCCA process has enabled PPD to provide the department for the first time with a 'snapshot' of the supply market, its capability and capacity at a state and district level. This enables QDMR to better understand how the geographical influences impact the supply market and provides information to assist bundling of projects not only at the district level but across districts.

PPD is able to contribute to better processes that more efficiently and effectively deliver the roads program and gain consistent information at the statewide and district level to inform program development and delivery decisions and support better outcomes. This in turn leads to better relationships with suppliers and a better understanding how to best optimise the viability of the supply sector. It puts the department in the position of an informed buyer which is able to make better 'value for money' decisions.

FUTURE DEVELOPMENTS

As indicated above, the DSCCA is seen as a first step on the way to the department having a full and complete understanding of its suppliers and supply markets both at a district and state level. There are a number of projects scheduled to commence in early 2008 which will build on the information gathered in the DSCCA Project and deliver to the department the information it needs to make fully informed procurement decisions. It will also enable this intelligence to be used in formulating the RIP each year and in delivering the roads program across the state. The more important projects are outlined below.

Significant purchase plans

The concept of procurement planning is not a new one. The State Procurement Policy regards procurement planning as ‘an important preliminary part of the deliberative process of achieving the objectives’ of the policy. There are two specific types of planning referred to under the policy. These are annual corporate procurement plans and significant purchase plans. The former is a strategic plan that sets out the objectives to be achieved through the agency’s purchasing activities consistent with the objectives of the policy. The latter is undertaken when purchasing goods and services that have been identified by the agency as being of high relative expenditure and/or for which supply is difficult to secure

The Queensland Government Chief Procurement Office (Department of Public Works 2007) provides agencies with guidance on the significant purchase planning. The plan sets out the objectives to be achieved from the purchase and specifies how the purchase supports the achievement of the department’s purchasing objectives. It provides QDMR with an evaluation of potential buying strategies, identifies the preferred strategy and then specifies contract/supplier management arrangements. Lastly, it specifies how the achievement of the objectives of the purchase will be measured.

PPD has taken the concept of the significant purchase plan one step further in applying it to QDMR’s procurement requirements. A significant purchase plan will be prepared for each district as a way to better plan procurement for district projects and help QDMR deliver its RIP. When undertaking a significant purchase plan, PPD will analyse the district’s supply market, develop an understanding of the purchasing needs of the district and develop situation-specific strategies for procurement and project delivery. This process has taken the significant purchase plan to a whole new level. It is not just focusing on a significant purchase in terms of particular commodities, rather it is focusing more holistically on coming up with a plan to tackle the purchasing requirements for an entire district.

Supply market analysis

Currently a number of the commodities required in road construction projects are proving difficult to secure within the required timeframe and/or budget. Increased competition for resources impacts upon various levels within the supply chain: from raw materials to production and logistics. Environmental factors are also adding stress to an already stretched industry that relies on natural resources for many critical materials. Current water restrictions and long-term water efficiency plans are having an effect on the production of certain materials. Water is also required in the road-laying process.

Many of the supply issues associated with increased demand, and competition for resources and environmental constraints, are impacting upon other public infrastructure delivery organisations. Furthermore, the effects associated with supply risk are ‘flow on’, meaning that problems are produced throughout the construction process. For suppliers, uncertainty of supply can make the task of pricing works very difficult. For QDMR, this means exposure to contracting risks such as inaccurate estimation (by principal and contractor), budget and timeframe overruns and numerous contract variations.

The shortages of critical commodities in the supply market are occurring now. If this situation continues or worsens there is a very real potential for serious delays in delivery of the commodities. This would severely disrupt the department’s ability to deliver the program of works and this would have serious ramifications economically and politically. PPD will be undertaking a supply market analysis for all of the department’s critical commodities in January 2008. It is imperative that the department has up-to-date knowledge of market conditions and its suppliers to ensure that it makes fully informed and sound sourcing decisions.

The Significant Purchase Plan Process is an extension of the DSCCA process. A significant purchase plan has already been trialled in the Peninsula District and it has been adopted into project management. This trial process has been an outstanding success. The district has reported that it has used the demand and supply market analysis to solve a number of problems by mapping capability, increasing the supplier base and freeing-up resources.

One example that came from the Peninsula District illustrates the success of the plan. The district was struggling to deliver some projects using the existing supplier base. After consulting the significant purchase plan, the district contacted a supplier that had been identified as a potential supplier in the plan. This firm had the capability and capacity to complete a project on the Peninsula Development Road. As a result of efficiencies in location and process the firm was able to deliver the district a saving of \$800 000 on the original budget estimate.

The district was able to engage this firm on the basis of a sole invitee without the need to go to the market. The reason for this was that the plan was able to provide information on the marketplace and the suppliers with capability and capacity. This builds excellent relationships with suppliers and saves significant time and costs.

CONCLUSION

One of the main lessons learnt from the DSCCA Project and the trial of the significant purchase plan in the Peninsula District is that early involvement of PPD in the procurement process, research and planning has a positive effect on the success of delivery of the roads program projects.

The DSCCA experiment served to focus the department on a statewide approach to its procurement planning rather than the fragmented approach based solely on districts operating independently for their own purposes. Suppliers could see that the department was interested in engaging them and improving its relationship with them. For the department’s part it learnt that it needed to communicate with its suppliers and work cooperatively on solutions that benefited both parties.

For the first time QDMR had a statewide picture of its supply base and it could determine suppliers’ capability and capacity in meeting its roads program. The department cannot rest now as the market is continually changing, and undertaking the significant purchase planning process in 2008 will build on the work already done to provide the department with an evaluation of potential buying strategies and identifying the preferred strategy to engage the market. The supply chain analysis of critical commodities will also contribute to providing the department with vital data it requires in making important procurement decisions.

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Part 9
Benefiting from Innovation

CHAPTER 39

Key Lessons and Conclusions

Keith Hampson
Kerry Brown
Janet Pillay
Peter Brandon

INTRODUCTION

The construction sector offers a productive environment in which to develop a greater understanding of the ways in which innovation can make a difference to an industry sector. Construction practice has been hampered by an inability to innovate and importantly, a lack of innovative capacity especially in light of the fragmented nature of most construction work leading to inability to create collaborative effort (Nam and Tatum 1997). This volume demonstrates that the construction industry has, over time, been able to develop and harness novel ideas, implement innovative policy and new initiatives to benefit the sector. Traditionally, the construction sector has been known for its lack of innovation and problems with establishing a culture of innovation. However, the research put forward in this volume is testimony to the developing innovation agenda in construction.

BENEFITING FROM INNOVATION: KEY LESSONS

Clients Driving Construction Innovation: Benefiting from innovation has outlined and examined a broad range of research and findings that have the potential to offer leading-edge practice. The key lessons situate the client as occupying a critical place in the innovation system. Seadon and Manseau (2001) offer that the owner of the building is the 'ultimate' construction client and these authors suggest that a range of tasks and responsibilities accrue to owners as specifiers of projects and, further, that these elements work to drive the innovation process. However, public sector clients are also highly significant as this group forms the largest group of construction industry clients and, collectively, the public sector shares both procurement and delivery of construction projects (Lennard et al. 2005). It is suggested that public sector clients are unique as they also hold policy and regulatory power to shape the character and features of the different aspects of the construction industry and accordingly also have a stake in driving construction innovation. The link between innovation and the client actions, interactions, roles and responsibilities is the focus of this edited volume.

Clients driving construction innovation

The first chapter of this work – *Clients Driving Construction Innovation* – presents the nine themes around which it is written. The key lessons are summed up by Brandon in Chapter 2. He outlines the possibilities for a new site of emergence for innovation and explores the nexus of construction management, information technology and sustainable development which form a triad of innovation domains.

Meeting clients' needs

In Chapter 3, O'Brien uses a case study of an innovative project alliance to test whether alliances can deliver better outcomes *and* value for money. Typically alliances are used when there is technical complexity, a challenging schedule, unknown risks, need to bring capability or add external resources to a project. However, a potential problem is the lack of transparency due to the sole-select arrangement of the participants. This chapter demonstrated that potentially conflicting outcomes can be managed in an alliance. Purdey and Luther extend this evaluation to the area of workplace performance, and consider objective and subjective assessment approaches in Chapter 4.

Furneaux et al. examined ICTs to deliver an innovative framework for meeting clients' needs in Chapter 5. The case study analysed a streamlining of development assessment (DA) in local governments in South-East Queensland. Increased harmonisation of previously disparate processes was achieved in the project. In Chapter 6, Backhouse and Coster take on the challenge of designing a workplace that aligns with client values. The case study examines a novel approach to workspace that blends open plan with closed office spaces. Oyegoke et al. continue this client focus in Chapter 7 where they consider whether client expectation can be satisfied through an innovative procurement route.

Procurement and risk management

Novel procurement models are examined in this section along with the highly complex issue of risk management. McDonald examines project alliances in terms of their ability to deliver value for money. A program for choosing the appropriate procurement strategy in the Netherlands, KOSMOS, is described and evaluated in Chapter 9. The system has delivered critical savings especially in keeping highways open under conditions of maintenance. The utility of including leveraged social outcomes in contracts is assessed by Austen and Seymour in their chapter. Next, Scott emphasises the need for effective relationship management in projects. Methods for monitoring supply markets from a procurement risk management perspective is explored in Chapter 12. Following this, Rowlinson and Cheung discuss the nature of alliancing in Australia.

Improving efficiencies through information and communication technologies

ICTs are at the forefront of delivering innovation. The case studies in this section are testimony to far-reaching effects in the industry that ICTs can produce. The building information modelling techniques offer a highly integrated technical framework for creating, tracking and storing building information. The potential of these forms of data repository is significant. Perey describes the ability of a BIM system to improve the building by an innovative 'double skin' and then to monitor energy usage in the building. In Chapter 15, Tucker et al. use 3D CAD building models to improve air quality in buildings. Similarly, in Chapter 16, Yum et al. detail an innovative automated estimator for bridge design to reduce costs and improve efficiencies.

Construction health and safety

A continuing critical issue for the construction industry is occupational health and safety. The benefits of innovative OHS contribute not only to wellbeing in the industry, but the reduction of hazardous and dangerous conditions for employees. The focus of the chapters on this theme is on attitudes and the workplace environment, and how critical they are to this endeavour. Tom Fisher leads the section in Chapter 17 to describe the role of the Federal Safety Commissioner in promoting construction safety by working through culture and leadership. Sokolich highlights the role of developers in leading safety, and, in Chapter 19, Pillay discusses current government initiatives aimed at facilitating harmonisation, and improving OHS in Queensland-based construction accreditation schemes. Brown et al. continue the harmonisation debate with an evaluation of three harmonised initiatives. The next three chapters provide frameworks for facilitating a safety culture in the construction industry. Chapter 24 concludes the section by reporting on the implementation of applied research in industry as it relates to a CRC for *Construction Innovation*-sponsored project focusing on developing a practical guide to safety leadership.

Facilities management

Facility management has emerged to become a major activity within the business support sector. This is highlighted in the Sydney Opera House case studies in Chapters 25 and 26. Ventkatisan et al. (Chapter 27) use an innovative fuzzy logic technique, adopted in a previous research effort for determining major distress mechanisms in concrete bridges, and have shown this to also be applicable for timber bridges. This modelling technique can also be applied in many other fields. Likewise, effective condition monitoring and assessment also have a range of applications, and Chapter 28 considers how this can lead to sophisticated asset management systems.

Industry development

Improving the capacity of the industry sector is an important endeavour. Initiatives that increase organisational and industry knowledge flow may include insourcing knowledge through innovative means such as project alliances rather than though the more long-term and inflexible option of development of internal labour markets as found in the research of Galvin et al. in Chapter 29. SMEs are the focus for Hardie and Manley in Chapter 30 who investigated flexibility and adaptability as a precursor to innovation. Close links with industry associations and ties to research bodies were found to assist SMEs to be innovative. Panuwatwanich et al. continue this discussion to consider the effect of the climate on innovation diffusion, and business performance. In Chapter 32, Thorpe et al. also concentrate on SMEs and their approach to sustainability in order to initiate industry-wide options for engaging SMEs in sustainability measures.

Sustainable construction for the future

The emerging topic of sustainable building has evidenced several innovative approaches. Tools to encourage sustainable building options have been a start; however the potential of ICTs and new materials to offer sustainable building solutions is enormous. Chesser et al. outline the potential of a sustainability checklist to offer development options for environmentally friendly initiatives. In Chapter 34, Glad considers the impact of social sustainability. In their chapter, Lim and Yang offer frameworks and processes to enhance sustainability deliverables, and in Chapter 36, lifecycle assessment is presented as a sustainability power tool. Widén et al. discuss partnering as a form of innovation in Chapter 37. Bateman concludes the section with a new methodology for analysing industry capacity for public road infrastructure development.

CONCLUSION

Construction 2020 (Hampson and Brandon 2004) outlined a vision for the construction sector that had as its hub the interaction of industry and researchers to produce innovative world-class research with high impact and relevance for the construction industry as a whole. The chapters in this volume seek to contribute to realising this vision. Undertaking robust and rigorous research and disseminating the results to industry, is of itself an innovation. The cataloguing and generalising of industry best practice, in order to ensure that the sector has the opportunity to capitalise on the innovation, however, also requires an implementation strategy.

The key themes outlined in this book have foreshadowed new areas of research and opportunities for construction-related practice to lead the construction sector into greater productivity and performance. New contractual arrangements based on relationships and partnerships, advances in ICT and regulatory reform are radically changing the construction industry. The challenge is ensure that innovation and innovative practices are widely disseminated throughout the entire industry and take-up of innovations is widespread rather than remaining in isolated pockets of the sector or being utilised only by large firms without shifting downstream to subcontractors or small- and medium-sized enterprises. The interest in SMEs in this volume indicates a previously untapped area of research that has possible traction for developing an innovation agenda.

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Index

3D CAD 89, 92, 94, 97, 98, 99, 166, 168
accreditation schemes 116, 117, 126
alliance 3, 13, 14, 15, 16, 17, 18, 19, 54, 55, 56, 84, 85, 86, 129, 130, 132, 133
asset management system 166
benchmark 17, 23, 24
bridge 17, 57, 58, 59, 81, 82, 101, 102, 103, 109, 131
budget 13, 14, 17, 19, 42, 45, 47, 57, 71, 77, 86, 102, 104, 124, 125, 126, 127
CAD 2, 10, 89, 90, 91, 92, 93, 94, 97, 98, 99, 107
client 2, 3, 5, 8, 18, 29, 39, 41, 42, 44, 45, 46, 48, 49, 55, 98, 99, 113, 128, 129, 130, 131, 132, 134, 167, 168, 169
client expectations 45
collaboration 3, 9, 15, 16, 18, 29, 30, 36, 39, 41, 84, 86, 103, 109, 117, 118, 129, 133, 134, 152, 161, 163
communication 3, 5, 7, 9, 10, 15, 16, 28, 29, 39, 42, 43, 46, 53, 59, 66, 67, 68, 70, 71, 72, 73, 84, 85, 86, 88, 111, 116, 117, 128, 129, 130, 131, 132, 133, 134, 135, 138, 140, 141, 143, 147, 151, 154, 158
competitive advantage 2, 40
concrete bridge 3, 101, 107
contracted out 53, 185, 186, 188
contractor 13, 46, 47, 48, 49, 52, 54, 55, 61, 82, 86, 87, 103, 113, 114, 115, 116, 117, 118, 130, 131, 132, 133, 150, 162, 165
culture 3, 6, 7, 11, 15, 19, 40, 44, 52, 53, 54, 67, 69, 84, 85, 86, 87, 111, 112, 113, 115, 128, 129, 130, 131, 133, 134, 136, 186, 187, 194, 195, 198, 199, 200, 202, 203, 204, 205, 216, 224, 244, 252, 253
design 2, 3, 5, 6, 7, 8, 9, 11, 13, 14, 15, 16, 17, 18, 19, 21, 22, 23, 25, 26, 29, 37, 39, 40, 41, 42, 44, 45, 46, 47, 48, 49, 55, 57, 58, 59, 66, 72, 74, 83, 85, 86, 89, 90, 91, 92, 94, 98, 99, 101, 102, 103, 104, 105, 106, 107, 108, 109, 112, 113, 114, 116, 129, 130, 131, 132, 133, 169, 174, 184, 185, 186, 187, 188, 194, 197, 198, 200, 201, 203, 204, 205, 207, 208, 210, 211, 212, 213, 217, 222, 224, 225, 226, 229, 231, 233, 235, 236, 241, 244, 253
design and construct 8, 46, 49
diagnostic process 169
eBusiness 2, 29
eGovernment 28, 29, 30, 32, 35, 36, 37
electronic document management 133
entreneurship 234
EnviroDevelopment 216, 217, 218, 219, 220, 221
environmental conditions 20, 26, 43, 172, 173, 184
environmental sustainability 206, 207, 208, 212, 213
facilities management 3, 89, 90, 93, 182, 229
fuzzy logic 169, 170, 171, 172, 173, 253
globalisation 207, 246
harmonisation 28, 31, 36, 118, 120, 122, 123, 124, 125, 126, 252, 253
hazard 112, 114, 117, 134
Horizon Alliance 13, 14, 15, 16, 17, 18, 19
Human resources 14, 16, 17, 40, 192, 194, 239
indoor air quality 21, 94, 95, 98, 99, 217
industry development 3
information and communication technologies 2, 3, 213, 253
infrastructure 3, 5, 9, 14, 18, 19, 54, 55, 56, 57, 58, 59, 60, 62, 72, 77, 82, 83, 85, 86, 90, 102, 129, 130, 167, 175, 182, 193, 203, 213, 220, 226, 228, 229, 230, 231, 232, 244, 245, 246, 247, 248, 249, 253
innovation adoption 204, 212
innovation systems 15
integration 18, 19, 47, 68, 78, 97, 103, 112, 116, 130, 175, 185, 186, 189, 200, 238, 243
key performance indicators 14, 23, 187, 230
knowledge management 3, 11, 33, 184, 188, 192, 196
knowledge transfer 184, 185, 186, 187, 188, 189
KOSMOS Programme 57, 58, 59, 60
legislation 36, 112, 116, 117, 121, 122, 123, 125, 126, 128, 130, 135, 181, 211, 212
life cycle 18, 46, 48, 49, 58, 102, 107, 108, 109, 175, 176, 177, 182, 198, 206, 207, 221, 225, 226, 235, 253
life cycle assessment 221, 2235, 253
manufacturing 5, 8, 10, 47, 49, 53, 76, 81, 83, 128, 136, 192, 206, 235, 238, 240, 242
model-based estimating 106, 107, 108, 109
motivation 40, 84, 87, 105, 111, 129, 198, 243
partnering 10, 18, 52, 53, 54, 55, 56, 84, 86, 87, 113, 133, 134, 135, 187, 195, 216, 218, 238, 239, 240, 241, 242, 243, 253
procurement 3, 10, 11, 13, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 74, 75, 78, 79, 80, 81, 82, 84, 119, 112, 117, 129, 134, 191, 213, 230, 244, 245, 246, 247, 248, 249, 252
productivity 2, 4, 15, 16, 20, 21, 22, 23, 24, 25, 26, 27, 40, 43, 71, 112, 120, 121, 122, 124, 125, 126, 127, 199, 205, 206, 207, 208, 210, 211, 244, 253,
project management 42, 45, 48, 67, 70, 102, 103, 130, 133, 223, 230, 249
public sector 13, 28, 29, 37, 38, 53, 54, 55, 62, 66, 74, 84, 87, 184, 186, 189, 197, 243, 244, 245, 246, 248, 252
regulation 2, 7, 28, 29, 30, 31, 32, 33, 37, 38, 61, 62, 63, 64, 65, 66, 118, 120, 121, 122, 123, 124, 125, 126, 127, 130, 133, 135, 188, 191, 194, 196, 207, 211, 212, 214, 216, 217, 222, 231, 232, 238, 243, 245, 248, 249, 250, 252, 254
relationship contracting 52, 53, 55, 84, 186
relationships 3, 5, 6, 15, 16, 18, 29, 32, 37, 41, 42, 46, 53, 54, 64, 67, 68, 69, 70, 71, 72, 74, 84, 85, 86, 87, 90, 91, 103, 114, 128, 129, 130, 131, 134, 136, 186, 188, 192, 193, 194, 195, 198, 199, 200, 201, 203, 204, 239, 245, 247, 248, 249, 250, 253
research and development 101, 193
risk 3, 13, 16, 19, 34, 46, 47, 48, 51, 52, 53, 54, 55, 56, 57, 67, 68, 69, 70, 72, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 86, 90, 112, 113, 114, 116, 128, 129, 130, 131, 132, 134, 175, 179, 180, 181, 184, 186, 191, 192, 193, 194, 195, 197, 200, 206, 207, 208, 211, 212, 225, 235, 239, 243, 247, 248, 249, 252
safety 2, 111, 116, 120, 122, 123, 128, 195, 196, 207, 253
safety culture 112, 113, 114, 115, 129, 130, 131, 132, 133, 134, 136, 253
safety leadership 131, 114, 253
safety performance 113, 115, 129, 130, 132, 134, 136
small to medium sized enterprise 291, 292, 293
social sustainability 222, 223, 226, 253
standardisation 18, 31, 32, 33, 36, 46
supply chain 2, 8, 45, 46, 49, 74, 75, 82, 83, 84, 86, 87, 130, 132, 195, 245, 249, 250

sustainability 3, 17, 84, 92, 192, 195, 206, 207, 208, 210, 211, 213, 216, 217, 218, 220, 221, 222, 223, 224, 226, 227, 228, 229, 230, 231, 232, 233, 234, 236, 237, 253
Sydney Opera House 253
technology diffusion 214
technology transfer 186, 197
total quality management 134
training 15, 41, 42, 61, 62, 63, 64, 65, 66, 71, 114, 116, 132, 134, 187, 194, 195, 206, 211
urban development 216, 232
value for money 13, 14, 16, 52, 53, 180, 189, 207, 245, 248, 252
value management 14, 15, 16, 18, 19