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The Place To Be

Emerging Building Information Modeling/Management Technologies used in the Building Design Industry

Rosetta Di Giangregorio
Michael Goss
ISS Institute/TAFE Fellowship

Fellowship funded by the
Office of Training and Tertiary Education (OTTE)
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Executive Summary

In Australia today, building designers are in high demand and this demand continues to grow. The industry is currently undergoing a period of transition and discourse is taking place regarding what skills will be needed to ensure demand from the marketplace is met. Central to these discussions is the issue of Australian building designers increasingly looking to extend the scope of their practice by tendering for overseas projects. The notion of a global economy is fast becoming a reality for industries in Australia and the AEC (architectural, engineering and construction) industries are poised to leap into this economy. Australian building designers will need to have the capacity, skills and knowledge to compete and/or collaborate with leading local and international architectural practices to be part of this global economy, and more so, be adequately positioned to ensure continued innovative development in the Australian marketplace. Designers will need to explore and engage in process innovation, afforded by advances in technology (ie BIM systems) to better manage systems and adopt effective delivery process for building design and documentation, to provide clients with what they want and more so, what they expect.

The Fellows' current observation of the Australian context suggests that the industry is still faced with delivering a rapid response to clients and developers in a competitive market both locally and internationally which is demanding new forms of cooperation and communication through advanced design-build models, more sophisticated forms of internet project management and teaming models. BIM systems and the skills to fully utilise their potential will make our local industry competitive and viable.

The aim of the Fellowship was to provide the opportunity for Di Giangregorio and Goss to develop a comprehensive understanding of how others throughout the world are responding to, and implementing, the emerging building information and modeling systems that are now available for the design and documentation of building projects. With the study tour including visits to Singapore, Dubai, London, Greece and Venice - Italy, Di Giangregorio and Goss:

- Scoped the various systems that are being used in the design and documentation process for building projects, together with the degree of connectivity and integration with consultants to the project, such as engineers.
- Identified and assessed various approaches being employed by individual architectural/ building design practices looking in particular for innovative solutions and best practice.
- Liaised with professional associations to gauge how they are responding to the knowledge development requirements and training needs relating to BIM systems for the architectural and building design profession that they service with continuing professional development programs.

The investigation was conducted using the following methods:

- Contacting and interviewing aligned and comparable building design professional associations, practicing architects, building designers and training providers engaging with BIM systems.
- Viewing the application and implementation of BIM on current, live projects in Singapore, Dubai and London.
- Attendance at the 2006 eCAADe (Education and research in Computer aided Architectural Design in Europe) conference titled 'Communicating Space(s)', at the University of Thessaly, Volos, Greece, with a view to engaging with, and learning from leading practitioners, academics and trainers from around the world.
- Attendance at the 2006 Architectural Biennale in Italy to view and gain a perspective of the world practice and the positioning of BIM systems on a truly international level.

Executive Summary

The challenge was to establish, develop and implement a model of training that would be best practice and produce world standard graduates who will be both experts and leaders in using building information modeling/management systems for the building design and documentation industries. The Fellowship experience identified the need to:

- Provide a direction for curriculum revision and development for building designers at TAFE/VET institutes and promote and deliver professional development training for practitioners in industry.
- Create a momentum for implementing change at the National Curriculum Forums and through industry representative bodies to lead toward implementing integrated practice strategies and BIM training frameworks.
- Source funding to implement transitional development from current programs with the intent to pilot BIM training.
- Lobby for the development of a research practicum laboratory to further investigate and develop a best practice approach for the paradigms embracing BIM frameworks.
- Participate in national forums exploring BIM technologies for AEC industries.
- Investigate programs to engage in a sabbatical of industry release for Fellows who have participated in this study.

Following an overview of the international Fellowship experience, the report identifies a series of activities to be undertaken to optimise knowledge transfer and concludes with a comprehensive series of recommendations pertaining to Government, industry, the business sector, professional associations, education and training providers, the broader community and the ISS Institute.

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Abbreviations and Acronyms

AEC	Architectural engineering and construction (industries)
API	Application programming interface
BIM	Building information modeling and management BIM, in the context of this report stands for building information modeling and management. The building information model (BIM) is a system that produces and manages a database of information developed and maintained throughout the life cycle of a building project. It is also the process of generating and managing a building information model.
CAD	Computer-aided design Computer-aided design is the use of a wide range of computer-based tools that assist engineers, architects and other design professionals in their design and documentation activities. It is the main geometry authoring tool within the building documentation lifecycle management process. Current packages range from 2D vector based drafting systems to 3D parametric surface and solid design modellers. The acronym CAD is sometimes translated as 'computer-assisted' or 'computer-aided drafting', or a similar phrase. Related acronyms are CADD, which stands for 'computer-aided design and drafting', CAID for 'computer-aided industrial design' and CAAD, for 'computer-aided architectural design'. All these terms are essentially synonymous, but there are some subtle differences in meaning and application.
CNC	Computer numeric controlled (manufacture)
eCAADe	Education and research in Computer Aided Architectural Design in Europe
ISS Institute	International Specialised Skills Institute
IFC	Industry foundation classes
IT	Information technologies
ICT	Information communications technologies ICT includes technologies such as desktop and laptop computers, software, peripherals and connections to the Internet that are intended to fulfil information processing and communications functions.
TAFE	Technical and Further Education Post secondary school education and training at tertiary level with a prime focus on the development of advanced skills for a vocational outcome. TAFE works on a State and/or National level covering four levels of Certificate, Diplomas and Advanced Diplomas and delivery of Associate Degrees within the Australian Qualifications Framework.
VET	Vocational Education and Training VET is a national system designed to skill workers to work in particular industries eg plumbing, retail, etc. VET is underpinned by a National Training Framework which comprises two components: National training packages and the Australian Quality Training Framework. VET works on a nationwide level, covering four levels of Certificate, Diplomas and Advanced Diplomas within the Australian Qualifications Framework. Some VET programs can be delivered at secondary school level.

Acknowledgments

Rosetta Di Giangregorio and Michael Goss would like to thank the following individuals and organisations who gave generously of their time and their expertise to assist, advise and guide them throughout the Fellowship program.

Awarding Body - International Specialised Skills Institute (ISS Institute)

We know that Australia's economic future is reliant upon high level skills and knowledge, underpinned by design and innovation.

The International Specialised Skills Institute Inc (ISS Institute) is an independent, national organisation, which has a record of nearly twenty years of working with Australian industry and commerce to gain best-in-the-world skills and experience in traditional and leading-edge technology, design, innovation and management. The Institute has worked extensively with Government and non-Government organisations, firms, industry bodies, professional associations and education and training institutions.

The Patron in Chief is Sir James Gobbo AC, CVO. The ISS Institute Board of Management is Chaired by Noel Waite AO. The Board comprises Franco Fiorentini, John Iacovangelo, Lady Primrose Potter AC and David Wittner.

Through its CEO, Carolynne Bourne AM, the ISS Institute identifies and researches skill deficiencies and then meets the deficiency needs through its *Overseas Skill Acquisition Plan (Fellowship Program),* its education and training activities, professional development events and consultancy services.

Under the Overseas Skill Acquisition Plan (Fellowship Program) Australians travel overseas or international experts travel to Australia. Participants then pass on what they have learnt through reports, education and training activities such as workshops, conferences, lectures, forums, seminars and events, therein ensuring that for each Fellowship undertaken many benefit.

As an outcome of its work, ISS Institute has gained a deep understanding of the nature and scope of a number of issues. Four clearly defined economic forces have emerged out of our nearly twenty years of research. The drivers have arisen out of research that has been induced rather than deduced and innovative, practical solutions created - it is about thinking and working differently.

A Global Perspective. 'Skills Deficiencies' + 'Skills Shortages'

Skill deficiencies address future needs. Skill shortages replicate the past and are focused on immediate needs.

Skill deficiency is where a demand for labour has not been recognised and where accredited courses are not available through Australian higher education institutions. This demand is met where skills and knowledge are acquired on-the-job, gleaned from published material, or from working and/or study overseas. This is the focus of the work of ISS Institute.

There may be individuals or firms that have these capabilities. However, individuals in the main do not share their capabilities, but rather keep the IP to themselves; and over time they retire and pass way. Firms likewise come and go. If Australia is to create, build and sustain Industries, knowledge/skills/understandings must be accessible trans-generationally through nationally accredited courses and not be reliant on individuals.

Our international competitors have these capabilities as well as the education and training infrastructure to underpin them.

Addressing skill shortages, however, is merely delivering more of what we already know and can do to meet current market demands. Australia needs to address the ***dual*** challenge – skill deficiencies and skill shortages.

Acknowledgments

Identifying and closing skills deficiencies is vital to long-term economic prospects in order to sustain sectors that are at risk of disappearing, not being developed or leaving our shores to be taken up by our competitors. The only prudent option is to achieve a high skill, high value-added economy in order to build a significant future in the local and international marketplace.

The Trades

The ISS Institute views the trades as the backbone of our economy. Yet, they are often unseen and, in the main, have no direct voice as to issues which are in their domain of expertise. The trades are equal, but different to professions.

The ISS Institute has the way forward through its 'Master Artisan Framework for Excellence. A New Model for Skilling the Trades', December 2004. The Federal Government, DEEWR commissioned ISS Institute to write an Australian Master Artisan School, Feasibility Plan.

In 2006, ISS Institute Inc. set up a new ISS advisory body, the **Trades Advisory Council.** Members are Ivan Deveson AO; Martin Ferguson AM, MP, Federal Labor Member for Batman; Geoff Masters, CEO, Australian Council of Educational Research; Simon McKeon, Executive Chairman, Macquarie Bank, Melbourne Office; Richard Pratt, Chairman, Visy Industries and Julius Roe, National President Australian Manufacturing Workers' Union.

Think and Work in an Holistic Approach along the Supply Chain - Collaboration and Communication

Our experience has shown that most perceive that lack of skills is the principal factor related to quality and productivity. We believe that attitudes are often the constraint to turning ideas into product and a successful business; the ability to think laterally, to work and communicate across disciplines and industry sectors, to be able to take risks and think outside the familiar, to share – to turn competitors into partners.

Australia needs to change to thinking and working holistically along the entire Supply Chain; to collaborate and communicate across industries and occupations - designers with master artisans, trades men and women, Government agencies, manufacturers, engineers, farmers, retailers, suppliers to name a few in the Chain.

'Design' has to be seen as more than 'Art' discipline – it is a fundamental economic and business tool for the 21st Century

Design is crucial to the economic future of our nation. Australia needs to understand and learn the value of design, the benefits of good design and for it to become part of everyday language, decision making and choice.

Design is as important to the child exploring the possibilities of the world, as it is to the architect developing new concepts, and as it is to the electrician placing power points or the furniture designer working with a cabinet-maker and manufacturer. As such, design is vested in every member of our community and touches every aspect of our lives.

Our holistic approach takes us to working across occupations and industry sectors and building bridges along the way. The result has been highly effective in the creation of new business, the development of existing business and the return of lost skills and knowledge to our workforce, thus creating jobs - whereby individuals gain; industry and business gain; the Australian community gains economically, educationally and culturally.

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Fellowship Sponsor

The Victorian Government, Office of Training and Tertiary Education (OTTE) is responsible for the administration and coordination of programs for the provision of training and further education, adult community education and employment services in Victoria and is a valued sponsor of the ISS Institute. The Fellows would like to thank them for providing funding support for this Fellowship.

Employer Sponsorship

The Fellows would like to acknowledge the support of the School of Design (TAFE), RMIT University for providing the time and the additional funding required to undertake the Fellowship and associated activities.

RMIT University, School of Design (TAFE)

- Alan Cumming, Pro Vice-Chancellor, Design and Social Context Portfolio
- Hendrikus Berkers, Head, School of Design (TAFE)

Fellowship Supporters

Australia

Building Designers Association of Victoria

- Brian Morison, Executive Officer
- Giselle Grynbaum, Executive Officer

Autodesk Australia

- Annette Brooks, Channel Sales Manager, Australia/New Zealand

Michael Ellis, Architect

- Michael Ellis, Principal Architect

Singapore

Autodesk Singapore

- Tom Joseph, Business Development Manager, Education

Dubai

Mohammad Al-Mojil Group

- Mr Adrian Vinck, Vice President Projects
- Franco DiStefano, Architect

London

ARUP and Gehry Technologies

- Alvise Simondetti, Foresight and Innovation Director, Research and Development

Greece

University of Thessaly, Volos

- Vassilis Bourdakis, Conference Chairperson

Acknowledgments

Peak Organisations and Key Representatives

The following organisations and bodies will be the beneficiaries from the findings of the study program.

Industry and Professional Associations

Building Commission Victoria

The Building Commission is a statutory authority that oversees the building control system in Victoria, ensuring the safety, liveability and sustainability of our built environment.

The Building Commission is the governing body responsible for the registration of building design practitioners in Victoria. The commission will determine the academic requirements to be written into legislation along with the industrial experience deemed necessary in order to be eligible for registration to practice in Victoria.

Australian Institute of Architects

Australian Institute of Architects is the association that supports some 9,000 members and the architectural profession and with practice assistance and continuing professional development programs.

Building Designers Association of Victoria

The Building Designers Association of Victoria Incorporated (BDAV) is an industry association, which represents building design and drafting professionals. Founded in 1983, the BDAV is a non-profit organisation registered under the Victorian Associations Incorporation Act to promote and advance the profession of building design and currently has approximately 1,000 members.

The BDAV provides a structured continuing professional development and education program to enable members to continually improve their knowledge on issues relevant to building designers and draftspersons.

Education/Training Organisations

Higher Education Providers – Universities

Providing programs for the architectural and construction industries.

TAFE Institutes

Providing training for the building design and construction industries.

Private Training Providers

Providing programs and training for the architectural and construction industries often on location in the workplace.

Business and Commerce

Software Developers

Organisations that have developed and currently have BIM software in the architectural and construction marketplace that is not being used to its full potential should benefit from the findings of the study program in regard to training of graduates and professionals who have the skill to fully utilise the full range of feature and functions the software can provide.

Providers of Continuing Professional Development

The report should inform providers of continuing professional development and training programs for the industry as to a preferred, or a range of best practice training methodologies for the application of BIM systems for the design and documentation of buildings.

About The Fellows

Fellow 1: Rosetta Di Giangregorio

Qualifications

- Certificate of Technology (Architectural Drafting), RMIT 1985
- Associate Diploma in Architectural Technology, RMIT 1985
- Diploma of Teaching (Secondary and TAFE sectors), University of Melbourne 1993
- Graduate Diploma in Information and Communications Technology Education, University of Melbourne 1995
- Recipient of E-Learning Leader Scholarship, RMIT University, 2006
- Masters of Education in Workplace Education, RMIT University (thesis to be completed)

Memberships

- Member of the Building Designers Association of Victoria
- VISTA – Victorian Association of VET Professionals
- E-Learning Association of Victoria

Over a career of more than twenty years Rosetta Di Giangregorio has practised as a building designer and technologist, with specialisation in ICT and CAD implementation and management areas. Di Giangregorio has gained a breath of experience in the digital documentation and facility management of residential, commercial and industry type projects. Di Giangregorio is a senior teacher and course coordinator in the Building Design and Technology Program for the School of Design (TAFE) at RMIT University. She is responsible for the CAD/BIM and ICT areas of the programs.

Di Giangregorio is committed to developing innovative and technology assisted work simulated teaching and learning environments, and developing e-learning paradigms that provide holistic but inclusive digital environments to address learning styles for graduates and the design industry. She is also committed to the development of simulation models that integrate collaboration technology and information modelling systems through web based design platforms.

Throughout her career Di Giangregorio has continued to build her industry partnerships, networks and built on her expertise in the CAD/BIM specialisation and in E-teaching and learning. Di Giangregorio enjoys perpetuating the vision that innovation in TAFE/VET is the springboard to new practice and innovation in the building design industry.

Away from this, Di Giangregorio's interests are spending time with her sons and husband, gardening, designing, reading and playing with all things computer-ish and being a cyber junky.

About The Fellows

Fellow 2: Michael Goss

Qualifications

- Certificate of Technology (Architectural Drafting), RMIT 1977
- Diploma of Technical Teaching, HIE, 1985
- Bachelor of Architecture (Distinction), RMIT University 1988
- Certificate in Business Workplace Training, RMIT University 1999

Memberships

- Corporate member of the Building Designers Association of Victoria
- Co-chairperson of the Victorian Advanced Building Studies Network Group
- National Trust Victoria

Over a career of more than twenty years Michael Goss has practiced as a draftsperson, building designer and architect. He has gained a breadth of experience in the design and documentation of residential, commercial and specialist buildings including prisons, health and educational facilities etc. Goss has recently assumed substantial responsibility as a Cluster Manager in the School of Design (TAFE) at RMIT University where he develops, directs and administers programs including Building Design and Technology, Furniture Design and Technology and Product Design specialising in the delivery of design education.

Goss's approach to education is to create integrated and holistic models of learning that simulate industry practice, applied to all levels of engagement from pre-trade, trades and professional fields of endeavour.

Throughout his career Goss has continued to build partnerships and strategic alliances within industry, education and training institutes, Government agencies, professional associations and community groups in Australia.

Away from this, Goss's interests include travel, architecture, the arts and design. On weekends he can be found tending his rural property in the centre of the wine growing region of the Yarra Valley in Victoria.

The Fellowship Program

The objective of the Fellowship program was to undertake an overseas study program to gain a comprehensive understanding of skill training in BIM (building information modeling and management) which includes design variations, energy performance and calculations, site management and localised impact projections.

Aim of the Fellowship

The aim of the Fellowship was to provide the opportunity for Di Giangregorio and Goss to gain a comprehensive understanding of how others throughout the world are responding to, and implementing, the emerging building information and modeling systems that are now available for the design and documentation of building projects. Over the course of the study trip the Fellows:

- Scoped the various systems that are being used in the design and documentation process for building projects, together with the degree of connectivity and integration with consultants to the project, such as engineers.
- Identified and assessed various approaches being employed by individual architectural/ building design practices looking in particular for innovative solutions and best practice.
- Liaised with professional associations to gauge how they are responding to the knowledge development requirements and training needs relating to BIM systems for the architectural and building design profession that they service with continuing professional development programs.

The investigation used the following methods:

- Contacting and interviewing aligned and comparable building design professional associations, practicing architects, building designers and training providers engaging with BIM systems.
- Viewing the application and implementation of BIM on current, live projects in Singapore, Dubai and London.
- Attendance at the 2006 eCAADe (Education and research in Computer aided Architectural Design in Europe) conference titled 'Communicating Space(s)', at the University of Thessaly, Volos, Greece, with a view to engaging with, and learning from leading practitioners, academics and trainers from around the world.
- Attendance at the 2006 Architectural Biennale in Italy to view and gain a perspective of the world practice and the positioning of BIM systems on a truly international level.

The challenge will be to establish, develop and implement a model of training that will be best practice and world standard producing graduates who will be both expert and leaders in using building information modeling/management systems for the building design and documentation industries.

The intention is also to share the findings as widely as possible with TAFE, and other providers of training for the building design profession, the construction industries and the general community.

Whilst the prime intent is to develop training strategies to address the skill deficiencies for building designers to utilise the sophisticated BIM technology the training will also be required by and bridge a range of disciplines through the necessity of common platforms and language for communication that would include builders, structural engineers, land surveyors, electrical and other service consultants, tradespeople, fabricators and building suppliers who will find it necessary to use the system.

Once the optimum training methods are developed and established the need to commence would be immediate given that new graduates would be two years in training and that gap training of practitioners would need to occur to fill the void.

The Skills and Knowledge Gaps

The technologies and methodology for the design and production of documentation for buildings has evolved and advanced at a rapid rate in recent years. Sophisticated software developments driven by powerful and flexible/portable computing hardware systems has dramatically changed the way in which the traditional draftsperson both designs and documents a building project.

The traditional 2D method of documentation for buildings is being replaced by initially generating a responsive 3D model with capabilities that include immediate feedback on 'what-if' alternatives and comparisons ie solar heat load together with the capacity of generating documentation drawings together with materials and services information schedules. Productivity inherent in the technology affords the capacity to electronically share, import/export information and communicate drawing files between allied consultants, tradespeople, fabricators and suppliers.

The skills and knowledge gaps that currently exist for building designers relates to their extremely limited ability to engage with sophisticated building information modeling and management (BIM) systems that afford advanced features of simulations for design review.

Training is required to produce graduates with the knowledge, skills and ability to intelligently utilise, integrate and coordinate the range of dynamic functionalities that the new building information modeling/management (BIM) systems afford, such as continuous and responsive alternative scenario feedback for design variations, energy performance simulations and calculations with a view to responsible and sustainable building design, lighting quality analysis, site management and localised impact projections.

By investigating the overseas models both in the South East Asian region and Europe, the Fellows aimed to be able to return to Australia equipped with the knowledge, ideas, innovative practices and training methodologies which would enable them to advise, instruct, promote and improve the overall acceptance of BIM systems and the benefits they afford the profession.

It has been perceived by many that education is the way to advance the application of this emerging technology. There is an enthusiastic and interested core group of people and industries in Australia who need the direction, information, and the support from the experience of other countries and organisations that have taken an innovative approach to the application of BIM systems for design and building management.

The Australian Context

Increasingly Australian building designers are looking to extend the scope of their practice by tendering for overseas projects. The notion of a global economy is fast becoming a reality for industries in Australia, and the AEC (architectural, engineering and construction) industries are poised to leap into this economy. Recent examples include a Victorian delegation of building designers to Dubai to present proposals for several large projects. Sponsored through the BDAV and Austrade, delegates participated in the Cityscape Dubai exhibition and conference, one of the biggest exhibits of international building design in the United Arab region. This venturing into new markets will continue to increase in the near future as massive development programs such as those proposed for Abu Dhabi and Asian markets like China also eventuate.

Australian building designers will need to have the capacity, skills and knowledge to compete and or collaborate with leading local and international architectural practices to be part of this global economy, but more so to ensure continued innovative development in the Australian marketplace. They will need to explore and engage in process innovation, afforded by advances in technology (ie BIM systems) to better manage systems and adopt effective delivery process for building design and documentation, to provide clients with what they want and more so, what they expect.

Another example of building designers strategically seeking out opportunities to practice offshore recently occurred when key members of the Building Designers Association of Victoria travelled to tsunami affected countries to offer expertise in rebuilding for the future. Building modeling and management systems that communicate in the international environment facilitate such initiatives. This suggests that this type of technology can act as a vehicle for more collaborative opportunities bringing expertise to the most needed areas of the world.

One way of examining building information modeling and management within the context of the Australian building industry is to view it through a SWOT analysis framework that explores strengths, weakness, opportunities and threats to map out the current situation and identify opportunities for building designers in the future.

The Australian building industry has been experiencing a period of economic growth. However, due to the recent fluctuations in the world's financial markets, it is yet to be seen what the flow on will be to the Australian building industry. The market is beginning to respond to the current situation and there has never been a better time for architects, building designers, contractors and developers "to work together to re-invent and streamline building design and delivery process. The remaining question for architects and building designers is simple: Will you lead or will you follow?"[1] If we view this period in time as an argumentative strength for the industry, do we have the skills to implement and lead the change that will benefit the industry in the future?

Building designers are in high demand at the current time and demand continues to grow. The industry is currently undergoing a period of transition and discourse is taking place within the industry regarding what skills will be needed to ensure demand from the marketplace is met.

Building designers were slow to adopt 2D CAD technologies through the early 1980's to 1990's, but client demand for digital documentation, and the availability of cheaper computer platforms ensured a growth in the use of digital tools for cost effective delivery of design and hence the growth of training and skill development to cater for this need.

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[1] Sanders, Ken FAIA. Architectural Record, Digital Practice Feature, September 2004, *Why building Information modeling isn't working…yet.* (Page 4) http://archrecord.construction.com/features/digital/archives/0409feature-1.asp

The Australian Context

The weakness in this period of adaptation was that building designers did not leap into or lead the process. The process was wholly demand focused rather innovative. In fact, the process was selective toward the 2D technologies and not toward the intelligent 3D modeling technologies of the time because these introduced a new element of risk and area of unfamiliarity. The paradigm that intelligent 3D models could be used to communicate design and guide construction has in fact been used in the industry for over 27 years, but the return on investment of the technology and the specialised expertise was often too far out of reach for most design professionals and was only ever explored by a small number of larger architectural and engineering practices in Australia and overseas.

As the technologies have become cheaper and the computer platforms have become more intuitive and evolutionary across all industries, we are now witnessing a social, cultural and generational shift toward information technologies. The expectation is that the AEC industries are automated and clients have a broader demand on the type of deliverable that building designers can produce and the benefits this can bring to their projects.

A weakness to the generalisation that information technologies contribute to automating industries is based on comparing rather than distinguishing the needs and effects of technologies on specific industries. For example, to compare the building design industry to automotive design would suggest that the building industry could streamline processes to enable more cost effective production on mass. However, although the automotive industries use similar technologies in design they do so to produce product for a mass production market and, therefore, a different economy of scale to building designers who custom design their product. Arguably, some building components can be mass produced, but the building design intent, in general, is to produce a custom product for a very specific locale and legislative codes, not a mass produced one. The interesting lesson here is that building designers can learn from the automotive industry paradigm, for more collaborative design processes to produce a more cost effective product. Building information modeling tools and the skills to effectively use these across collaborative teams would be one way of exploiting these lessons.

The opportunities for building designers to adopt technologies that will enhance collaborative processes and promote innovative development are key perquisites to achieving more with digital technologies. However, this also implies that professional cultures need to change to value add to the opportunities and benefits that building information modeling technologies can bring. Organisational transformation can be a painstaking and sometimes a costly road. Building designers need to decide whether they leap, or transit slowly and this often means bringing in skilled staff to commence the transformation while still maintaining some operation in traditional 2D mode.

Are the opportunities that building information modeling and management can bring only in the development of new technology skills, or are they also about leveraging the integration of design and construction to offer new solutions in design and address unpredictability in traditional design to build process? Is the development of a collaborative design paradigm something that should be built into the skill capacity of future building designers to ensure a closer connection between design and construction? Are building designers of the future, the virtual builders of the future?

If BIM technologies can be used to leverage a transformation of the building design industry, how is Australia placed to lead this change? This study's aim was to explore if, in fact, Australia is placed to lead change, or if in fact, we will follow. Will we discover that providing building designers with the skills to use building information modeling tools and to engage in a collaborative design paradigm for the industry is what the industry really wants? Does client advocate for this change already exist in the industry globally?

The Australian Context

The Fellows' current observation of the Australian context suggests that the industry is still faced with delivering a rapid response to clients and developers in a competitive market both locally and internationally. This is demanding new forms of cooperation and communication through advanced design-build models, more sophisticated forms of internet project management and teaming models. BIM systems and the skill to fully utilise their potential will make our local industry competitive and viable.

International Context

The overseas program was purposefully designed to explore the identified skills and knowledge gaps and obtain the information necessary for the Fellows to return to Australia equipped with the knowledge and ideas to enable them to advise, instruct, promote and improve the overall acceptance and application of BIM systems for building design.

Program Content: Destinations and Objectives

The study program was designed and developed to include a range of activities that when completed should achieve the aims of the study program.

Visits resulted in discussions with practitioners working on both large and small projects currently being developed using a variety of BIM systems including Singapore, Dubai and London examples. Challenges with implementation, training and application of the systems were explored along with any benefits the systems have yielded to date.

The visit to ARUP and Gehry Technologies (ARUP-GT) was a highlight as they are the world leaders in this field. ARUP-GT work collaboratively to supply the technology and expertise necessary to lead, manage and deliver the virtual building process. ARUP-GT creates the virtual building as a process by which design, construction and operational problems are visualised and solved using computer simulation. Simulation makes it possible to assess alternative solutions more quickly and accurately than traditional methods.

ARUP-GT explained that it enables project teams to quickly and accurately communicate design forms, functions and behaviours to other team members and the broader collection of stakeholders. The system provides an environment where team members can share and coordinate project information quickly and efficiently. Advanced facilitating analysis tools are capable of projecting capital construction throughout the lifetime of the facility, thereby developing solutions that meet both short and long term performance goals.

eCAADe Conference

A four day conference was attended at the University of Thessaly, Volos, Greece, ‘eCAADe 2006 Education and Research in Computer Aided Architectural Design in Europe’.

The intention was to gain a comprehensive understanding of the strategic direction and approaches that educational and training providers are putting into place to address the training requirements for the emerging BIM technologies. Comparative analysis was undertaken to identify and assess best practice as might be appropriate for the Australian context whilst maintaining capacity for international collaboration.

Venice Architectural Biennale

This exhibition enabled Di Giangregorio and Goss to view and assess cutting edge architecture and the application of BIM technologies in the projects being presented by a range of countries from around the world. The advantage of the exhibition was the coming together of so many countries to a single venue displaying their most impressive works in an atmosphere of cooperation.

University IUAV of Venice

This visit was the fourth visit to an educational institution, in this case with a specific architectural focus. The intention was to gain a comprehensive understanding of the strategic direction and approaches they are adopting to address the training requirements for the emerging BIM technologies and to observe how BIM training is being integrated into the wider program structure that they offer.

This fourth visit to an educational institution provided a comparison and contrast of the approach taken of the training for the application of BIM systems by the University of Thessaly, the National University of Singapore, and the Singapore Polytechnic (visited earlier in the study program).

Findings & Outcomes: Singapore Investigation 1

National University of Singapore, School of Design and Built Environment

21st August 2006. Interview with Professor Stephen Wittkopf, through introduction facilitated via Oki Purwanto, Autodesk Education and Business Development Manager ASEAN, in association with Tom Joseph Education and Business Development Manager Asia Pacific.

The National University of Singapore, School of Design and Built Environment was selected as a case study example for this Fellowship because it provided synergistic context in relation to the Australian academic environment. The teaching and learning paradigms embody a constructivist methodology focusing on project centre approaches to learning through research and development of conceptual design solutions. Design is facilitated through technological enabled analysis of data, which consequently empowers the designers to make appropriate environmental and sustainable choices of materials for building construction. University website: www.arch.nus.edu.sg

Associate Professor Stephen Wittkopf, Department of Architecture, National University of Singapore is the Chair for the IT Committee and specialist researcher in the areas of building performance and daylight analysis. These roles place him in the unique position to provide valuable experiential reflection on the benefits of exploring BIM and other software programs that exploit the way in which designers approach design. Associate Professor Stephen Wittkopf was quoted as saying *"BIM can change the way we design"*.

Without having a particular focus on the brand of BIM technology used, the Professor explained that there was sensitivity toward single product use that suggested bias by association to commercial software enterprise in education. The university's policy was to openly invite innovative software solutions as an offering of technological aids to undergraduates that wanted to use these tools to explore and apply detailed computational analysis in their design studio work. Therefore, undergraduates are able to use a variety of platforms dealing both visualisation and documentation that ranged from CAD to 3D and building information modeling (BIM).

The National University of Singapore offers the only programs in architecture in the country, therefore the School of Design and Built Environment is strategically responsible for providing architecture graduates to the industry. This is also a significant advantage for the school because it can have an influential narrative for the design and technology in the industry. As the sole provider of degree, masters, PHD in architecture for Singapore, NUS has selectively propositioned a strong design research paradigm rather than a technical or professional training emphasis. They feel a strong sense of responsibility toward the education and training of 'designers' of the built environment.

The technology aspect was seen as an underpinning skill set and, therefore, offered to students as a range of training that presented technical tutorial based modules, often structured by the software developers and providers in small blocks of training. These underpinning skills then supply students with the tools to compliment the main design based project based studios.

Interestingly, the school also had a policy of no computer training/production for first year students, choosing to develop design cognition through manual applied skills such as drawing, sketching and model making to provide holistic design dexterity.

Undergraduates in later years were given a choice of the technological tools, many choosing the AutoCAD 2D or Microstation platforms, because they recognised this to be the market preference in industry. In studios investigating form modeling, students chose to use Sketchup ahead of REVIT or ArchiCAD, because it was more intuitive and fun to use. Graduates believed that if they were proficient in AutoCAD or Microstation skills they would be guaranteed work, although provided with the choice students were unlikely, in general, to experiment with alternate software platforms unless their design studio focus warranted an alternative tool set.

In one of Professor Wittkopf's studios called 'building performance and daylight simulation analysis', there was an expectation that students could explore and develop new investigative standards rather than using existing standards to evaluate the effects of daylight on the building and spaces. The software tools offered for analysis work included Lightscape, Energy Plus and thermo simulation software.

Resources and Infrastructure

The School of Design and Built Environment offers the following platforms across these select programs:

- Architecture – AutoCAD, ArchiCAD, REVIT and 3DViz, Rhino, Lightscape, (digital portfolios packaged using Flash), Energy Plus and thermo simulation software.
- Industrial Design – Rhino, Solidworks, 3D Scanner – Modella, 3D scene scanner (ie: a spatial scanner capable of scanning an entire room.
- Urban Design – building and real estate programs accessed the same platforms as the groups above.

The Department of Architecture provides 600 students with 300 desktops, providing a 2:1 ratio of available technology for students to use in-house. These computers are maintained on a two to three year replacement cycle and are owned by the university. Wireless infrastructure across the School of Design and Built Environment provides the supplementary access to web based resources. The university has negotiated laptop subsidies to students, for dual core technologies with expressed interest in Apple. MS XP Professional is the preferred operating system, with Dell, HP, Sun Systems, and Apple as the preferred contracts to the PC technology.

Security issues for the network licenses impact on the way students use the software. Professor Wittkopf commented that some universities overseas, eg Oxford, had gotten around the problem by instigating a licenses borrowing system. This means students could be provided with software licenses outside of scheduled class times. In comparison, NUS were bound by inflexible software licensing agreements that did not provide equal cost per capita benefits, for example – ArchiCAD software was offered as an unlimited site license and free to students compared to Autodesk suites which are offered as restrictive numbered licenses and with student versions which were not free. This observation was reflective of those licensing conditions faced by Melbourne Universities and TAFEs at present.

Both the program structure and applications for architectural design were accredited by the Royal Institute of British Architects (RIBA). NUS was focused on trying to provide a 'dynamic work environment' in response to the preferred way students wanted to work now and in the future. This was described as 'anytime, anywhere access' eg hotspot facilitation of spontaneous working groups, sharing project work (ie data sharing).

The architecture qualification at NUS is a four year bachelor degree and one year masters program. All year four level students are obliged to work on housing based projects, which is a project orientation influenced by the HTB (a housing industry authority in Singapore).

International Context

Seventy percent of all study modules in the degree are undertaken with the department. Undergraduates are able to take up to 30% of (courses) study modules outside the faculty and from sister departments. This is to encourage students to view their studies with the opportunity to expand into a multi-disciplinary skills base. Real estate and building are examples of skill migration.

Undergraduates also have the opportunity to advance their research through the Centre for Advance Studies in Architecture (CASA). Industry was desperately seeking graduates with technology skills, eg technology assisted analysis, building science and computer skills. Particular demand was for people with computer skills to run predictions and simulations.

Despite the innovative academic approaches to training and technological research, Singapore architectural practices are conservative in that they select one prime software package as their underpinning production platform. Singaporean professionals were still using the 2D software because this simplified their approach to compliance requirements, such as those required by the national energy rating system (called the Green Score System). This system is applied to projects as a 2D performance-based assessment tool.

One of Professor Wittkopf's areas of research specialisation is the eco-productive and energy saving system offered through photo-voltaic systems. At present, these systems are not openly encouraged in design and construction, as they fall within the fourth scale of the Green Score System, which is tagged as innovative practice rather than within the first three which are required to meet the compliance ratings.

This generated some concern regarding the uptake of innovative development or training that did not have an immediate demand in the marketplace, because it influenced the choices undergraduates made for their specialisations.

Aside from specialisations, the notion of collaborative practices was discussed, in relation to the use of technology to achieve collaborative project solutions. Work had been undertaken in collaboration through Microsoft net-meeting software. This took place with universities in USA and New Zealand, and varied in the degree to qualitative success. On both occasions, groups experienced time zone problems, and the use of different tools (eg preference was software named Irradiance) was also problematic. In these activities, one group acted as designer and the other as technological consultants. Although an exciting opportunity for applied practices, there did not seem to be market for this outside of major organisations that were required to work within their own multi-national internal structures. Problematic file transfer was also an issue, not simplified through early attempts at using REVIT (before its introduction of Vault file transfer capability), and there was also a question of security around who holds ownership of the edits and the model when these system were used in the case examples.

The future of BIM was still very tentative as a future focus even in academia, because previous work on IFCs generated by ArchiCAD with commercial simulated engines had provided unanswered questions regarding the multiplicity of data distribution that needed to be captured by digital models for them to be effectively used through multi-disciplinary areas of the building design and construction areas, without engaging enormous resource costs in the technology needed to create, collate, use and distribute the data.

There was still peripheral interest in the BIM developments, in particular Professor Wittkopf suggested investigating work in Sheffield academic institutions, and developments in Sydney University which were currently forming a super faculty structure which brought together engineering, IT and architecture, and had the potential to develop innovative BIM applications across the disciplines by bringing like minded interests together.

Case Examples

Public Housing and Design Computing

A look at student work (viewing digital compositions on screen) through the NUS website. Project title: *Public Housing and Design Computing*. Three teams of students in consecutive years worked on the project. The first two year levels had six weeks to complete work, and the remaining year worked on the project for one semester.

Group 1: Existing conditions – simulation to analysis the model.

Group 2: Landscape, low rise and tower areas of the project. This group provided a number individual solutions as potential re-designs of the tower.

Group 3: Worked within the envelope to totally re-design the site with all the environmental constraints and sustainability requirements based upon the experience gained from the previous studies.

AutoCAD 3D was used exclusively, creating a project management approach to facilitate file collaboration and drawing standard and then used X referencing and block functionality.

Light Guide Project as Case Studies

The effects of light on the existing structure were mapped as a thermo coloured pattern on the building façade which was then developed into a design concept/process through the investigation of fenestration, particular considerations where required for opening sizes and shading devices, with different densities.

Professor Wittkopf was interested in developing a potential workshop, or symposium using the Light Guide Project as a case study in project centred learning (shared project in building service ESD/BIM project).

Autodesk Perspective and Strategy to Extend the Use of BIM in the Market

Oki Purwanto noted, *"to promote the implementation processes for REVIT in industry Autodesk was sponsoring resellers to train graduates, so that they could sell the product with the graduate – with the potential of the graduate to retain ongoing employment and to ensure the technological transition from 2D to BIM".*

Resource: Folio 5 publication, first published July 2003. Focus on 5 distinct folio presentation themes (as per handbook), Department of Architecture, University of Singapore.

Findings & Outcomes: Singapore Investigation 2

Singapore Polytechnic School of Built Environment

22nd August 2006. Interviews with Madam Chan Choy Ling, Deputy Director and Goh Siak Koon, Section Head, Division of Architecture. Program area – Diploma of Architecture, a three year program of study with approximately 80 students per year level.

The Singapore Polytechnic School of Built Environment is responsible for providing the majority of the paraprofessional architectural design and technology graduates to the industry. They are also the only school that has an articulated pathways program for graduates applying for architecture at the National University of Singapore. Graduates applying for the architecture degree are judged on their academic merit and are provided with at least one year of credit transfer into the program.

The Singapore Polytechnic School of Built Environment also provides training in the building and civil streams however, the school's Diploma of Architecture stream was the

primary focus of this interview. Hence, facilities visited included the model making studio/ workshops, which was where students in the program developed cognitive skills in design by manually constructing models of 'design primers'. Design primers applied the principles of form modeling with material and spatial exploration for first year students before students dissected these principles further in to graphical formats. These studio spaces were also supported by a technical resource centre and e-labs. E-labs were the primary computer rooms, and consisted of approximately 44 PC's in each of the in the current spaces. These spaces usually required two teachers to work with groups at any given time. Moves were in place to reduce these spaces to rooms of no more than 20 terminals, to improve the workflow spaces, reduction the effects of radiated heat and improve mobility and access spaces in the rooms.

To situate the context of the Polytechnic's technological foci, Madam Chan Choy Ling, Deputy Director, and Goh Siak Koon, provided a brief history of the technology starting with the introduction of the first Integraph mini computer platforms in the 1980's. These systems, although effective at the time became too expensive to maintain and were superseded by PC's. The PC hardware platform brought with it a transition to AutoCAD and DrawBASE software and until the mid 1990's these were the primary platforms. However, the school moved to Microstation on PC because distributors could offer an attractive package both on price and support. The offering included initial license cost and with free licensing for students. Microstation software was used primarily for 2D production and although the school looked at Triforma (from Microstation suite) as a 3D platform, they opted for 3D studio Viz for 3D presentation.

The interview revealed that industry primarily uses AutoCAD for 2D work, and the institute found that the transition from Microstation to AutoCAD created little problems. However, they conceded that students did have the option to use any software, and in fact selected AutoCAD for 2D, Viz for 3D and some were engaging with Sketchup for design presentation work.

To facilitate the student demand for the Autodesk products, floating AutoCAD licenses are made available across the Polytechnic. Engagement with BIM products was not a school initiative at this stage as the market was not driving a substantial change however, a transition to REVIT was mainly initiated by the students themselves seeking to experiment with a more sophisticated 3D modeling platform.

In the main, feedback to the institute indicated that industry was seeking 2D documentation skills. Goh Siak Koon suggested that 3D presentation was often farmed out to someone other than the architectural professional or paraprofessional rather than handled in the architectural firms themselves.

One of the reasons behind the reluctance to move beyond the CAD platforms in industry seemed to stem from the industry standards and regulatory frameworks. Singapore Institute of Architects (SIA) had created a customised AutoCAD package template with all industry CAD standards built in to support CS 2200 (CAD package layering/line weight and block library standards of architectural and consultant streams). This was widely distributed across the industry. SIA's role is to support and represent industry as a semi institutional advisory body and industry association, therefore they have substantial influence in the shaping of work ethics and practice, contributing to competitive enterprise and training demands.

Both the Registration Board of Architects (RBA) and the SIA had a substantial influence in shaping industry practice and training needs, even though in context, the SIA was principally an association and the RBA was the industry governance body. As a Government funded training institute, Singapore Polytechnic was influenced by these organisations and found that students too were aware of the industry preferences that these groups mandate.

First year students were introduced to technology and manual skills in parallel. Manual orthographic production was also taught manual production and design proposition.

Photoshop and Powerpoint were taught and used for presentation. The presentations were sometimes done digitally, but mainly requested as hard copies. Sometimes students used 3D Studio Viz for a short pathed animation walk-through. Students are provided with computers, but were starting to purchase their own laptops. Students are subsidised by the Government for study fees, and also can pick up extra subsidies for equipment.

Student demographic is towards lower income, low socioeconomic groups within the ages of 16 to 18 years, coming from year 10. There was an Industrial Technical Education program (O levels plus two years – similar to TAFE) available. If there were high achievers then they could study at the Polytechnic at the point of mature age entry (18 years). Students are trained to be work-ready, but the majority have ambitions to be architects. The student can pathway in the university with a one year credit and then be admitted into the second year of the degree program. Selection is by merit and is not automatic.

The school has the latest software, but the interviewees made the comment that the students are very resourceful in obtaining free software.

The Polytechnic has wireless 10MBs. The labs were timetabled, not open access labs. There was an open access centre, but this has now closed. This centre had a 10pm lock-up time for staff and students.

The overall technical support was outsourced by contractors. The school itself had minimal local technical support.

Industry

To involve industry the institute has industry critiques of student work. Industry is also involved in course review every five years, which involves an external panel, made up of a university, industry and governance body.

Another way the institute engages industry is through the development of externally designed examination. Every year an external examiner group (which sometimes included Australian university representation) is engaged to develop and conduct these assessments. These results are also benchmarked across industry surveys and primary feedback, particularly in regard to evaluating the need for AutoCAD skills.

The institute also runs an industry attachment program for second year students. Students participate in a ten week program undertaken during the holiday period at the end of the academic year. Staff have to visit groups of two students and monitor progress, however, a centralised unit manages the attachment program itself. The attachment program has an assessment linkage to more than one unit of study in the program that picks up various competencies in these units.

For the attachment program, students maintain a log book and staff manage the data entry process. The staff visit the student in the workplace to monitor and sign off on progression of each competency completed while participating in the program. Students often gain employment as a result of participating in the attachment program.

Student competitions are conducted, for example the Youth Exchange competition design of a room for budget accommodation (international competition for 3rd year students).

The first year student work is mostly digital and they do not use drawing boards, and by third year all work is digital.

Singaporean students who study in Australia have provided feedback suggesting that their experience in Australia has provided them with a high level of proficiency in digital presentation.

Students are encouraged and allowed to use any software to promote their exposure to a variety of platforms. Layering standardisation was used and encouraged by governance bodies as these were deployed as official standards across all consultancies. A heavy emphasis was put on this enterprise approach to training students in the CAD areas.

SPRING Singapore, the Standards, Productivity and Innovative Board, is a member of the Global Excellence Model Council which supports small and medium enterprise and is the Government agency for standards and providing online standards on the websites (http://www.spring.sg). Along with SIACAD Pty Ltd[2], these organisations have a lot of influence on the way CAD curricula is developed and taught in the institute. They also ensure that enterprise in Singapore practices are not comprised by the cost of having to continually upgrade their legitimate software licenses, so they often use an older version to avoid upgrade costs while still being able to implement uniform regulated standards.

Industry training was mostly provided by the sellers of the software, and there was no evidence of demand from industry to the Polytechnic for PD training. They undertook outsourcing of drawing to China and India.

Collaboration with other institutions is generally not pursued, because this Institute is the only one to offer a Diploma of Architecture in Singapore.

The Singapore Polytechnic School of Built Environment is also investigating the Chinese standards for students and graduates to adopt in their projects work that encompasses regional partner requirements.

One of the most recent innovations in the institute was the global e-studio, which is considered an emerging future direction, simulating the studio environment. The idea was born from the fear of the possible pandemic effects of Sars and avain flu which also directed the paradigm around e-learning. Up until this point the institute did not see the LMS (Blackboard) as an e-learning system for off-site clients. This was predominately because the countries' broadband capacity was problematic due to 10 MegaBit transmission capacities; therefore little had been developed in this area in the graphic or design streams.

Blackboard was used as a repository of lectures (distributed learning system) for students on campus. Work had been done to investigate e-learning opportunities through Educonnect (http://www.educonnect.com/), an American school management software company, and Roger Edmonds, who runs e-schooling services and is a cutting edge e-learning expert from Adelaide, Australia.

Tour of the Facilities

A tour of the facilities concluded the visit at Singapore Polytechnic School of Built Environment and helped to illustrate the current technology focus for the institute and the direction for future innovation and development of technologies, particularly in the area of maximising computer facilities for multi-platform use. Although the areas visited did not reveal a directional focus toward the development of BIM technologies, the institute was aware that adoption of these platforms was important to at least provide well rounded technology exposure to students seeking to use them in their studies or for future application.

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[2] SIACAD is a subsidiary company formed by the Singapore Institute of Architects in 2000 to enhance the productivity and effectiveness of their members, who also provide a website with customised blocks. See 'Attachments' chapter, *SIACAD Product Profile Brochure,* or http://www.siacad.com/

To this end the institute provided the e-lab program which provided specific groups with limited licenses for CAD and other dedicated software required in the training courses. Students also had an opportunity to use facilities in a shared lab – a multimedia centre with a full number of studio suite software.

In the main similar project progress as that mapped in Victorian design and technology programs were developed in this institute, such as small scale domestic (two storey) in the first year, commercial high rise and retail in the second year, and complex residential or condominiums in the third year. Each course required at least 75% attendance and a requirement with 2.5 days a week in the e-labs (which housed 44 terminals and two staff). Students paid for all their materials and a printing hub separated the two e-lab studios.

The institute has proposals to expand the IT facilities because of the greater technology focus in the programs, however, the proposals were dependent on Government initiatives for resource allocation. Computers were obtained on a national level tender and then allocated to institutes. The individual schools had an opportunity to state the specification of the machine, but not the brand.

Findings & Outcomes: Dubai Investigation

Mohammad Al-Mojil Group

24th August 2006. Wayne Edgtton, Vice President, Mohammad Al-Mojil Group (MMG). AK Design & Architecture and Interior Design.

Sequence of Events

Preliminary discussion:

- Went to building 6 DICF
- Visited to AK Design office
- Property development advertising suites for the competitor's development

As the most prominent of all construction groups in Dubai, the Mohammad Al-Mojil Group is at the forefront of construction development and design in this region. It is also an organisation that values the benefits of productivity and its effective application in all aspects of its ventures.

Through the Fellows' contact Adrian Vinck, Vice President Projects, at Mohammad Al-Mojil Group (who is also an expatriate Australian), they were able to organise a meeting with Wayne Edgtton, Vice President at Mohammad Al-Mojil Group, to discuss their experience with BIM implementation and the perceived benefits for the organisation.

In general discussion about various programs used in the design, AutoCAD was revealed to be used for production, while REVIT was still being used by a few personnel who had been recently trained. Also discussed was if this program was still being considered as training 'investment'. 3D Viz and Maya platforms were used for concept stage and form modeling development. There was a tension between training the staff and realising the benefits of the training, because there was pressure to meet current project deadlines. Most new employees come with CADD background and knowledge and adopt office standards regardless of the CADD application they could use, ie AutoCAD users used AutoCAD and Microstation users used Microstation. This meant that work could be continued without perceived disruption to workflow, but inevitably meant that output rather than platform uniformity, or file protocols and ICT standards could be managed well.

The design office generally produced initial concepts in AutoCAD software and used 3D Viz for the form modeling that was created from the AutoCAD base drawing. There was difficulty in the transition to 3D conceptualisation or visualisation and staff grappling with this in both 3D Viz and REVIT were trying to work through skill deficits and transitional changes. They had previously used Architectural Desktop, but found it cumbersome (using this for three to four years and only using part of its capacity). They also trialled and used ArchiCAD.

Upon reflection, these problematic issues facing the design office were addressed and a training plan had been considered to achieve a balance in the skill gaps. It was identified, however, that given current workloads that this would happen over a lengthy period of time. This would then spotlight issues around the REVIT platform and provide a greater focus on developing the BIM usage.

With few staff trained to use the REVIT software, 3D models were created, but details were extracted and returned to 2D documentation in the AutoCAD and Microstation platforms. Since they did not fully understand the potential of using REVIT (ie the BIM software) in a manner that would allow them to integrate third party software, they actually transferred the detail breaking any link to developing a fully integrated building information modeling system. In turn, their perception was that producing a 3D model in REVIT means working with other packages to produce high resolution renderings of the model.

Contextual Impressions (Key Observations)

In Dubai, environmental issues were low on the priority list with speed of construction and return on investment high on the list. The following observations were made:

- Cheap labour market – imported and unskilled, which influenced construction methodology, and an abundant low grade gas supply generated the power supply economy.
- Desalination plants ensured an abundance of water with excess pumped back into the gulf. Chilling plants and water storage were used as portable and temporary infrastructure systems, while project estates were under construction.
- Sociological and cultural issues contributed to a hierarchical structure that determined levels of remuneration against people with qualifications in different positions.
- The sheer volume and pace of construction was staggering, particularly in reference to the magnitude of the sites under development, eg The Green Project, which involved the development of an entire financial precinct that consisted of 32 high rise buildings, a coastline of residential development and the biggest shopping mall in the world.
- It is not usual for construction work to have interrupted workflows where buildings are often taken to shell completion and then tenanted or sold. This often meant that construction workflows could recommence works previously completed at the point of sale, and core structure and services redesigned and redirected to suit the new tenant.
- The company outsourced all structural and mechanical engineering services with consultants all working on AutoCAD and none in the 3D environment. This simplified the use of the digital information and meant that there were no complications when converting 3D geometry systems to flattened 2D layered systems. Further to this, the lead team architect coordinated the consultants and location of services in projects and directed issues around the layering systems to be used and sheet systems and these were given as templates to the consultants.
- Franco Di Stefano, a Melbourne architect and expert in BIM implementation, has delivered a REVIT training program to a group of senior personnel with the intent to promote the implementation processes through the office. Despite this, the design office was still failing to convince the clients, whose view was that the benefits of having a BIM model to express the project was not understood from a 3D perspective, because

the contractual obligations required both 3D visualisation but often 2D input only from consultancy services. Discussion with consultants in regard to working with REVIT, revealed that there is a continued preference for and reliance on AutoCAD. However, even with a heavy reliance on AutoCAD, consultant information was being produced in release versions that could be as far back as release 14. Autodesk is providing REVIT with the purchase of AutoCAD, but there was no ongoing support at all and, therefore, a reluctance to fast track its take-up.

This was a very fragmented view of the BIM capacity or potential, demonstrating that the design team may not have understood that the BIM methodology was different to the old CAD technologies and could eliminate duplication of processes. However, their previous experience with CAD training was viewed as separate to implementation processes in the office, and clouded their understanding of how another type of technology could require such disparate methodologies to what they understood through CAD applications. Consequently, they conferred that to implement REVIT there are providers that undertake two to three week training programs and then the offices generally train the staff themselves. As such there appears to be a lack of understanding that the type of skills required to implement the full benefits of BIM methodology could not be delivered through software training alone, but also required a project centred approach to implementation.

- There were almost no tertiary qualifications locally in the building design streams, or professional development training centres and candidates would travel to Australia and other countries for training, eg Jalal Almasoodi.

Mr. Edgtton offered to provide an introduction to the Head of Architecture at King Saud University (http://www.ksu.edu.sa) which was the only college offering architecture and building studies in Dubai. The other prominent training institute was the University of Wollongong in Dubai (refer to http://www.uowdubai.ac.ae/) although the campus in Dubai did not offer the courses outside of Australia. In the context of the educational deficit, they were sourcing Australian and UK graduates.

The profile of specialist skills meant that senior positions are held by experienced European professionals and the skill base for middle level positions often come from Asia and South East Asian nations. The staff consisted of a range of architects, interior designers and CAD operators. They needed construction and science/technology knowledge and most came with a Diploma of Engineering background. Overall they had 15 staff and had identified the need to expand and engage more skilled staff to meet the demands of growing development work in the company.

Implementation of BIM to Facilitate to Construction Point

The REVIT training experience did reveal that the design team had an inclination toward in situ training with a preference to engage an expert trainer to work along side the project team to train and apply best practice and productivity. However, the potential to deliver a cost saving at the construction point was what interested Mr Edgtton about the proposed implementation of BIM in the design processes.

Client presentations were still handled as hard copy, not digital, as these were preferred for the client to take away. Some digital presentation was occasionally implemented for clients, but it was preferred not to give digital copy away. A hard copy was always produced to accompany such presentations.

Digital transmission of data was a concern, and currently this transfer of information was handled by using locked PDF with consultants and Xref (X referencing[3]) internally.

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[3] X referencing is a file referencing system that allows native drawings files to reside in secure repository areas, while a non editable reference view of the file appears in specific drawing locations to ensure a building project is viewed in context.

Serpentine Gallery Pavilion Project

Findings & Outcomes: London Investigation 1

ARUP and Gehry Technologies, London

30th August 2006. Interview conducted with Alvise Simondetti, Foresight and Innovation Director, Research & Development

Sequence of Events

- Visited to ARUP design office including project presentations and discussions
- Visited local architectural exhibition

General discussions commenced in regard to interesting architectural events that were currently occurring around London, specifically the 2006 Serpentine Gallery Pavilion Project in the Kensington Gardens that used CNC pattern cutting. ARUP has always been involved in the pavilion projects, working as part of the integrated design team. Refer to Pavilion information details in the 'Attachments' chapter or visit http://www.serpentinegallery.org

Following the general discussion Simondetti provided a general overview of the ARUP organisation.

ARUP Organisational Overview

ARUP is a global firm of designers, engineers, planners and business consultants who are dedicated to providing an integrated approach to design problem solving by offering a full compliment of skills that represents a concentration of technical and strategic knowledge. They have up to 10,000 projects running concurrently at any one time, and comprise 9,000 staff working in 82 offices in 32 countries worldwide with an annual turnover exceeding £430M (US $804M).

The key aims of visiting ARUP were to:

- draw from their experience of integrated design practice and see what role BIM had in the organisation, and
- identify what particular skill sets ARUP were seeking for practitioners to work in the building information modeling systems and determine if these were critical within the values of integrated practices.

Alvise Simondetti identified that a number of ARUP's successful projects had used the principles of building information modeling to demonstrate the feasibility of the project through a coordinated analysis of the structure, the effects of different material usage, the integration of multidisciplinary services and the potential for realising the most creative and environmentally sustainable of projects. He also noted that most of this work was integrated at the design stage and then segmented from the model to refine in the discipline streams such as in the engineering of the projects. Examples of projects developed using these methodologies include the following.

Galleria Fashion Store, Seoul, Korea UN Studio Lighting Design

This project incorporates the innovative use of over 5,000 LEDs (light emitting diodes or glass disks) that wrap around the building like a fluid and dynamic media skin. The illumination and both reflective and refractive nature of the building surface could not have been designed and analysed without integrated use of technologies to test the effects of the interactive skin, both as a dynamic media skin on the façade of the building and the internal conditions created by enveloping the building in this sinuous context.

Further information: http://www.arup.com/netherlands/projects.cfm?pageid=6675

International Context

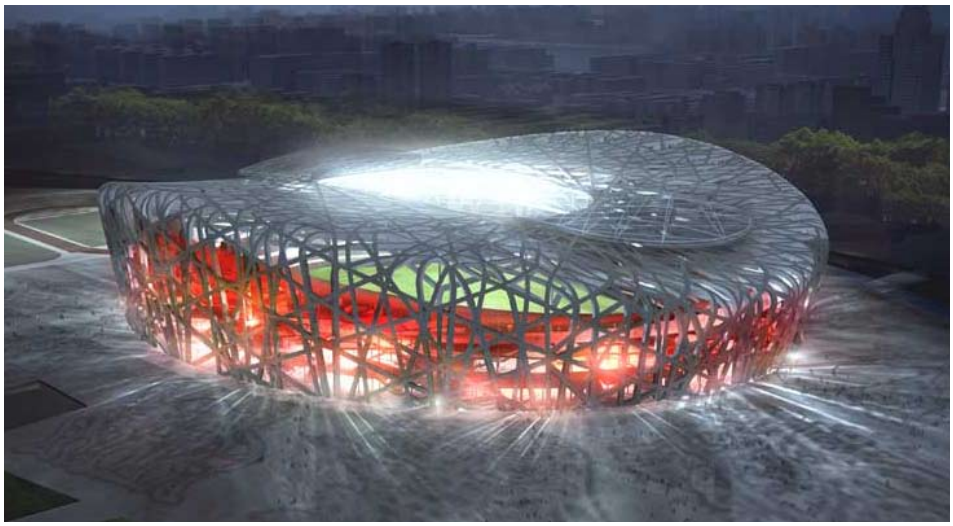
Galleria Fashion Store, Seoul, Korea

Three of the most interesting projects currently in progress are as follows.

Beijing National Stadium, Olympic Green

Design Consortium of Herzog and de Meuron Architeken AG, ARUP and China Architectural Design and Research Group ARUP developed computer software to define the geometry of the complex steel bowl structure from the stadium, whilst integrating other multidisciplinary services such as sports architecture, structural, mechanical, electrical and public health engineering, acoustics and fire strategy and sports lighting.

Further information: http://www.arup.com/eastasia/project.cfm?pageid=2184



Beijing National Stadium, Olympic Green

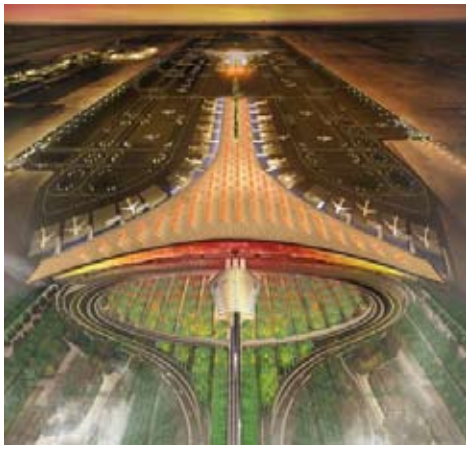
Beijing Capital Airport Terminal 3 Foster and Partners, Architects

This project similarly used the multidisciplinary services approach to build and integrate a design model of this structure, which at one stage had the original proposal using steel, but had to be re-calculated using concrete which was possible through the usage of the digital database that drives the building information model.

Although a number of software platforms were in fact used, the Beijing projects were scripted in the Bentley framework of BIM, which provided an orderly method of digitally managing the project – plotting queues – regenerative modeling processes.

Further information: http://www.arup.com/eastasia/project.cfm?pageid=597

International Context



Beijing Capital Airport Terminal 3

Beijing Capital Airport Terminal 3

Florence High Speed Train Station (Florence RFI Station) Norman Foster, Architect

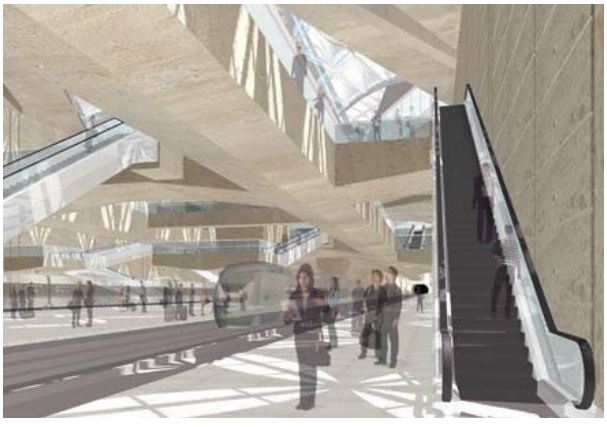
This is the first major contemporary architectural project undertaken in central Florence for many years. The station box is 450 metre long with platforms at 25 metres below ground designed to capture and funnel natural light to the station platforms.

The project employs innovative solutions for reducing energy consumption and pollutant emissions and uses renewable resources. The roof will also have a multilayered system in which each component plays a different role; a series of diaphragms of variable structure guarantees environmental and acoustic control, as well as air exchange, emissions control and natural lighting while a photovoltaic system will provide the production of electricity.

Software used on this project included 3D Studio Max, integrating real-time animation to sequence the actual data for simulations to be conducted in order to predict and conduct analysis of scenarios for natural light, fire and acoustics. All this data was essential to ensuring an informative design process, with an understanding of the most effective materials and construction technologies to achieve the final result. Note: Special mention was made of the software 'Irradiance' and 'Steps', evacuation software.

Further information: http://www.arup.com/projectmanagement/project.cfm?pageid=5908

Florence RFI Station



Florence RFI Station

International Context

Denver Art Museum Daniel Libeskind, Davis Partnership

This project was completed in October 2006. In this project ARUP's 3D work and computer models were shared by the entire project team. This streamlined the design and construction process through an informative methodology where data gathered in the simulations and analysis tools where used to evaluate the model.

Further information: http://www.arup.com/americas/project.cfm?pageid=7928

Denver Art Museum

Further to these projects, ARUP has been proactive in its technology and innovative strategy, drawing from its experiences and participation in the following events and community projects.

- **Practice 2020**

  Great thinkers were asked to place themselves on an axial diagram that examined innovative practice and research and initiating development. ARUP's focus around taking lessons learnt from this conference to its strategic planning for innovation.

- **2003 London Serpentine Pavilion** Toyo Ho

  No drawings were used, but innovative engineering and construction methodology enabled an exploratory process to achieve amazing results, notably collaboration on the 'Serpentine Gallery Pavilion 2006' by Alvaro Siza and Eduardo Outo de Moura with Cecil Balmond, ARUP.

- **Making of the Virtual Environment for Urban Roadway Project**

  ARUP have continued their research and development focus in exploring laterally across multi-disciplinary technologies to investigate urban infrastructure performance in digital simulation. Examining narrowband/wideband frameworks to combine within one simulation model a way of demonstrating processes such as emergency services access, fire evacuation and sound diffusion for communication, and traffic management and movements within the context of an urban roadway system.

The projects above were supported by software applications such as:

- **Master Modeller – Custodian (Young Demographic)** Hong Kong 3D Model (GIS)

  The understanding of multi-disciplines is required to be able to respond to press calls.

- **Toolmaker (Andrew Maher, RMIT University)**
  Writer of script
- **Math Modeller**
  - Extracts/cosine approximations
  - Geospatial mathematician

ARUP also fosters and embraces academic relationships in their research and development focus, encouraging their own staff to engage in projects that provide a synergy between current projects and exploratory practice. This includes fostering collaboration on projects such as:

- Use of 3D scanner to develop 3D spatial relationship models with Professor Mark Burry at RMIT University
- Development of a new simulation program that incorporates a games-based engine from off the shelf software know as 'Unreal'. Half a million pounds was offered to integrate this gaming rendering license into rendering software for architectural packages to develop virtual models depicting:
  - accurate lighting, accurate sound, and accurate architectural surfaces
  - accurate sound in relation to the position that you occupy within a room space

Simondetti stated *"the terminology BIM is relative"*, meaning that the focus is not on a specific type of software, but rather the management of information generated from a variety of platforms to produce an intelligent data set and subsequent responsive 3D model. Simondetti also stated *"his mission is to bring 3D up the chain"*.

Training

Simondetti identified that the implementation of training was most effective if it was project based and needs driven. Rhino training has been undertaken in ARUP's Glasgow and Melbourne offices where staff learn the principles of 3D modelling. He observed that *"there are similarities to the intuitive nature of the SketchUp Software"*. It was further noted that there is a gap in the training of architectural technicians who are specifically prepared to meet the current and emerging needs within the profession.

Findings & Outcomes: London Investigation 2

Visit to the Building Centre 26 Store Street, London

After the meeting with Simondetti, a visit was made to the Building Centre to view the giant model of central London incorporating new schemes that have planning consent with a diverse range of projects including architectural, transport and urban design projects in and around the city.

The projects on display represent the mega developments taking place across London designed to accommodate this growth. Many of the schemes are in locations identified as areas of opportunity in the mayor's London plan. Often they are located on 'brownfield' sites and will create new centres of activity; they will not only change the way London looks, they will change its fundamental structure. Many of the projects on display had used a variety of digital techniques to produce images to communicate the proposal to the mayor, developers, architectural professionals and the general public.

Findings & Outcomes: London Investigation 3

Markland Klaschka Architects and Designers, London

31st August 2006. Interview conducted with Robert Markland, Architect

Overview of the Practice

The practice was established in 2001 with the partners' background and expertise being primarily in the development of commercial scale projects. The practice currently acts as a consultant for the British Department of Planning to assist with the implementation of BIM and it was the London Muslim Centre project that was the catalyst for the visit. This project cost 10 million pounds and was the practice's first trial of BIM on a live project as other trails had been on competition projects.

Bentley Architecture V8 was only in the early stages of its development version 8.1 and as a result of using the software the practice has worked with Bentley Systems UK on their architectural advisory board.

Markland stated *"USA development is where it is all happening"*. The American Institute of Architects has commenced development of practice guidelines for the implementation of BIM technologies encouraging their members to evaluate their own current practices and look toward an integrated multidisciplinary approach to project work.

He also has an affinity with the parametric studio project headed by Steve Stevens, Product Manager, Architecture at Bentley Systems Inc, Huntsville, Alabama.

London Software Demographic:

Design Practice	Main Software Usage
Small	Microstation
Medium	Vectorworks
Commercial	AutoCad

The adoption of Bentley software is for a range of subtle reasons, ie less associative.

Robert Markland suspects that REVIT may be better for more orthogonal and repetitive structures and noted that whilst Bentley Systems UK is not particularly good at marketing and promoting the product Autodesk markets their products more aggressively.

The following points capture the essence of the Fellows' conversation with Markland.

- He expressed a concern regarding improvement in developing the relationship between architects articulating their needs and the software developers understanding the needs. An example is how moving a toilet wall in a large scale building relates to understanding building processes and their relationship to how the software handles these processes at a given point in the model development.
- He also expressed a concern surrounding the software interface, particularly what is referred to as the 'Dashboard approach' which facilitates the invoking of commands and facilitation of detailed data schedules. The schedules needed to have two-way responsiveness.
- He predicted that this sort of feedback would provide developers with an edge toward the next phase of the Bentley development which would form the backbone of BIM for this product.

- He suggested that the relationship between applications to project was more powerful than an academic approach and that software developers struggle to keep pace with industry and are a fair way behind the cutting edge.
- He gave a presentation on 'real world' workflow in BIM. The presentation was convincing and he has been head hunted as a consultant.
- He indicated that in the UK the industry is failing, in the main, in the implementation of BIM and had similar thinking to REVIT champions of BIM, in that this is a transition phase for the profession. The project approach to the implementation of BIM is preferred and would seem the most direct and successful methodology.

Markland's predictions for a scenario for the next five years are:

1. The application of BIM methodology works.
2. Similar event software vendors could collapse in, and we go back to 2D. Markland states *"Bigger practices are already alluding to this as an event"*.

When asked the question *"is there a future for multi-platform for BIM"*, Markland's reply was that it does, with a common file format. Markland noted that IFC vendor implementation was poor as it is not in their commercial interest to engage in interoperability at this point in time.

The role of the architect is a bolt on role to the engineering role in the context of the USA – quantity surveyors are the architects. UK design is led by architects and engineers who are the enablers, unlike the case is in the USA. Collaborative tools are focused on by the engineers, for example in the UK ARUP manoeuvre with the client to bypass the architect, hence there is an evolutionary battle going on.

In Markland's evaluation of the current Balfours project, he commented that there were good information databases on both sides, but no connecting flow between using PDFs. One way to rectify some of the problematic areas of this project approach was to provide a good briefing tool 'codebook' and digital template that could be made available over third parties.

Other key areas of comment by Markland included the following thoughts:

- Architects need to be aware of why they should choose a particular BIM system and the advantages that the system may afford them.
- A tool that assists in seeing where the mistakes are rectified could be implemented, similar to those tools game users encounter in software such as Prisoner's Dilemma, which reports on problem points.
- Generally the architect has to be clear and up-front with the contractors that data is good from a fully integrated 3D model raising concerns about the architects role.
- A combination of high tech equipment and highly skilled operators is recommended. For example, five staff were employed on the Muslim Center project. They were split between basic users working on the inside of the building and advanced users working on the external skin and outside of the building.
- Currently in progress is the development of training strategies with a preference for project based learning in-house. This will be useful for Markland Klaschka Architects and Designers.
- A model for team learning. It would be ideal to have a team of 3-4 people being trained together gradually improving and sharing skills that they developed. To do this we would overview skills, provide the tools and augment training with wikis that only key people can edit and use these for refreshing and coordinating the team's input. Teaching is on a more modular basis, related to where they are in the project and later can move on to other skills. A young versatile practice can take risks and lead vendors in where the software design and development goes.

- There are limitations noted on software that Markland is currently using:
  - Generative component Bentley part graphic/part geometry (internal scripting engine)
  - Live dynamic numeric response model developed with handles that calculate the effect of the external cladding/internal atrium; simple volumes only, rather than calculating daylight levels, etc
  - Reference form at interface of interior/external cladding
  - Bentley currently has no generative component control scheme
  - Analysis on a project-by-project basis of what needs to be parametric and what does not
  - Generative components are produced in an authoring environment. Currently the Bentley wall tool is basic and could become one tool
  - Data groups are named, but you can create your own. Pascal, own/edit brings together a catalogue of items at its heart and links items. This is used to defer decisions; an example could be a window and frame opening in a wall.

Muslim Centre Master Model Demonstration

At this stage of the conversation Markland gave a demonstration and commentary of the Muslim Centre BIM master model.

- Bentley 2D-3D option is not a good marketing option to bridge attitudes to use 3D. However, one aspect that can make it a useful tool is a 2D slice of a 3D model which cannot pretend that it is a plan.
- The multi-disciplinary nature of the building development has established traditional demarcation lines, yet it would be a huge advantage to all where a reference services model will junction and terminate points in 3D.
- The future success of BIM. Currently the basis is there, yet interfaces are too simplistic and one where the user is forced to hold the whole model in their head.
- There needs to be a release of API backbone for leaders to develop new tools that are required.

References Proffered by Robert Markland

- Data Visualisation – Edward Tuffe, The Visual Display of Quantative Information
- Contact in Greece – Peter Foutakis

Findings & Outcomes: Greece Investigation

eCAADe 2006 Conference, 'Communicating Spaces' Volos, Greece

6th - 9th September 2006. The eCAADe conference was jointly organised by the Department of Architecture and the Department of Planning and Regional Development at the University of Thessaly, Volos, Greece.

Presenters and delegates convened from all around the world to showcase, discuss and compare the very latest and emerging digital developments relating to both architectural education and professional practice.

Following the welcome and keynote address some 110 presentations were conducted over the three days. Generally topics with commonality were clustered together as bracketed sessions.

Fifty sessions were selected that had prime relevance, or connection to the focus of the area under investigation and to inform this report.

Attendance at the conference afforded three streams of advantage:

1. To observe and assess innovative practice being conducted throughout the world and to compare and consider the local situation in Australia as well as the other countries previously visited as part of this study.
2. To observe and assess teaching and training methodologies being used to develop architectural technicians with the capabilities required to realise and maximise the potential of the latest and emerging technologies for digital design, presentation and documentation of buildings and structures.
3. Attendance at the conference was the catalyst for interaction and connection with architectural professionals and educators from around the world. Becoming part of the eCAADe community has resulted in further post conference interactions and will be an ongoing source of continuing communication and linkage with other leaders and enthusiasts from around the world.

Findings & Outcomes: Italy Investigation

Venice Bienalle, Venice, Italy *10th - 19th September 2006*

The intention in visiting the Bienalle was to look more broadly at an international expose of the industry to capture at a point in time the ways in which technologies have impacted and influenced project development and delivery. This provided comparative observations and perspectives in relation to the previous places visited on the study tour.

The Bienalle focus was on technologies in an urban context where sustainability, energy and economics could be determined through investigation and technology assisted simulations.

This demonstrated how an information rich data set could enhance project feasibility and inform stakeholders and assist in targeting innovative design and construction practices.

Knowledge Transfer: Applying the Outcomes

The challenge will be to establish, develop and implement a model of training that will be best practice and produce world standard graduates who will be both experts and leaders in using building information modeling and management systems for the building design and documentation industries. The Fellowship experience identified the need to:

- Provide a direction for curriculum revision and development for building designers at TAFE/VET institutes and promote and deliver professional development training for practitioners in industry such as through the Industry Skills Councils.
- Create a momentum for implementing change at the national curriculum forums and through industry representative bodies to lead toward implementing integrated practice strategies and BIM training frameworks.
- Source funding to implement transitional development from current programs with the intent to pilot BIM training.
- Lobby for the development of a research practicum laboratory to further investigate and develop a best practice approach for the paradigms embracing BIM frameworks.
- Participate in national forums exploring BIM technologies for AEC industries.
- Investigate programs to engage in a sabbatical of industry release for Fellows who have participated in this study.

Recommendations

Government

Government can play an integral part in the development and transformation of the AEC industry, and in particular the building design sector. This can be realised in a number of ways including supporting educational training institutes to review and implement change in training programs to capitalise on the skill development of building designers:

- to create public sector awareness of the benefits of building information technologies and leverage the benefits through commissioning practices for Government contracts that advocate, promote and practice an integrated practice approach.
- to work closely with insurance providers and client groups to merge competing design-build agreements and dismantle legal and current institutional barriers that prevent integrated design and construction because of incongruent standards.

Industry

The building design industry has a responsibility to continue learning how to provide services in collaboration with those who provide service consultation and construct the designs clients demand. This study recommends that the industry works to:

- develop relationships that can only further the investment, reward all parties involved in projects and ensure an integrated solution with fewer elements of risk for all participants.
- promote using building information modeling and management technologies to leverage this collaborative development as an opportunity for building designers and builders of the future.

Business

As an activist for ‘developers or owners voices’ the business sector can be a powerful advocate for process innovation. Providing a strong financial and legislative support backbone to the AEC industries, it can be an influential catalyst for change. This study recommends that the business sector:

- work closely with financial organisations and insurance companies to look at the benefits of using an integrated practice approach though the implementation of BIM to lower risk, reduce error and value add to project outcomes.

Professional Associations

Professional associations support members by acting as voice for professionals in the industry informing them of industry innovation, providing practice guides and programs for continuing professional development. This study recognises the professional associations to be, in essence, one of the spring boards from which building designers can begin their journey into understanding the benefits of building information modeling and development of an integrated practice paradigm.

Education and Training

Education and training institutes have an important responsibility to be at the forefront of innovation and development. This study is a testament to the commitment to continue to research and work toward bringing innovation into the hands of future graduates. Consequently, this study recommends that the importance of building information modeling and management, integrated practice paradigm become part of the considerations in curriculum development for programs training building designers.

Recommendations

The Fellows will be available to meet and speak with representatives of Industry Skills Councils to (where appropriate) take their findings into the National Training System through nationally accredited training packages and into the curriculum at TAFE and university levels.

How the ISS Institute can be Involved

The International Specialised Skills Institute has the potential to utilise its many contacts to attract funding and work with Government agencies, universities, TAFEs, certification groups and professional associations to assist the growth of specialist skill development in this area. In most cases, the lack of funding is the main obstacle that needs to be overcome.

Further Skill Gaps

In a study with a specific focus, one tends to acknowledge many tangential questions that will arise as result of gathering the data related to the study aim. This experience will provide further opportunities or raise further questions. In this case, the study reveals a need for continued research into skills development for the building design industry.

Exploring the skill deficiencies associated with bringing building information modeling and management knowledge into the skill attributes for building design professionals also begs the questions associated with implementation of these skills into practice. Does current training embrace the integrated practice paradigm that suggests a closer relationship to the construction of projects, through the virtual construction model? Does current training address the collaborative processes involved in the shared model development? Does the current training support building designers' needs to understand the linkages between technologies that bring design intent in direct association with construction detail and interdisciplinary interoperability? Does the current training cover enough construction and materials technology, environmental sustainability, etc, and practicum to provide graduates with the skills they will need to work as part of an integrated practice?

These questions will provide researchers with many opportunities to investigate further skill deficiencies that will become evident through the transformative processes that the building design industry will face in the very near future.

References

Material Collected as Part of The Study Tour

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Transition, 2003/2005 issue

National University of Singapore
Folio 05 – Documents of NUS architecture, July 2003.
Folio is a publication of the Department of Architecture, National University of Singapore, ISSN Number 0219 – 7197, ISBN Number 981-04-9348-7

Raffles Design Institute, Singapore 11 Beach Road, 01-02, Singapore
www.raffles-design-institute.edu.sg
Raffles Design Institute – brochure

Adel Almojil Architects – Dubai United Arab Emirates
AK Architecture/Interior Design – corporate brochure

The Building Centre 26 Store Street – London WC1E 7BT

New London Architecture – brochure

Designs on Kings Cross – brochure

Argent Group PLC, Property developers, Albany Courtyard, London W1JOHF – brochure
www.argentgroup.plc.uk

Serpentine Gallery www.serpentinegallery.org / information@serpentinegallery.org
Diary of architectural exhibitions. Architectural Design, Rem Koolhass, Integrated Design, ARUP.

eCAADe Education and Research in Computer Aided Architectural Design in Europe Communicating Space(s)
Conference papers, edited by Vassilis Bourdakis and Dimitris Charitos Volos 2006

Venice Bienalle 2006 www.labiennale.org/en/architecture/
Citte Architecttura e Societa – brochure

Attachments

SIACAD Product Profile Brochure Refer to http://www.siacad.com/ for further information.

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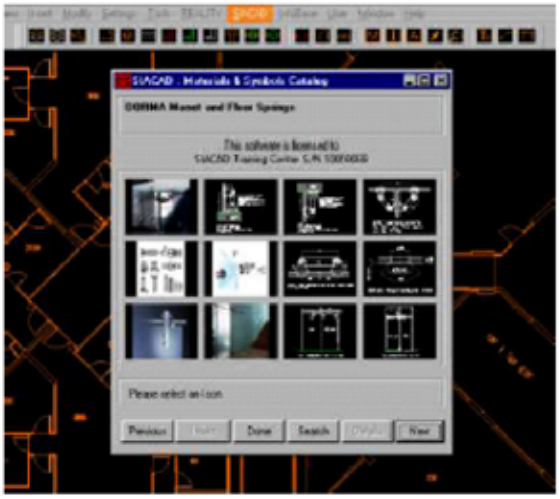

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The first step to achieving real productivity from your CAD system is to have a comprehensive Layer, Color, Linetype and Symbol Standard. **SIACAD** was first developed to manage the Singapore CP83 Standards. In fact, it's the most efficient solution to CP83. However, it's not limited to CP83. It can be easily customised to suit any other standard. **SIACAD** includes a complete set of functions for you to create and manage such standards.

Build Layer Name: You can easily create any layer name with the correct attributes such as colors and linetype. Currently, it handles the CP83 standard but it can be easily modified to handle other standards.

Layer Profile: Create as many "layer profiles" as required and apply them to your existing drawings. This will turn on only those layers required so that you can easily work with your drawings. For example, you can easily create profiles for ceiling layouts, structural plans etc. There is no need to painstakingly turn on or off individual layers.

Sort Layer Names: Convert existing drawings so that they conform to your preferred layer, color and linetype standard. This works even for entities within blocks and you can apply the same "dictionary" to other drawings. Indispensable when you need to work with drawings done by others who do not conform to any such standards.

Attachments

Additions & Alterations: Create your drawing using standard layers. Then apply our A&A tool to selected layers and choose whether you want them to be in the "demolished", "existing" or "proposed" layers. This automatically creates the correct layers in the correct color and linetype. It even allows you to revert back to your original layers.

CP83 Approved Symbols: The Singapore CP83 standards comes with a complete set of 650+ approved Standard Symbols for Architectural, Electrical, Mechanical and Landscape. Use our unique Catalog Viewer to search, select and insert these symbols into your drawing in the right layer and color.

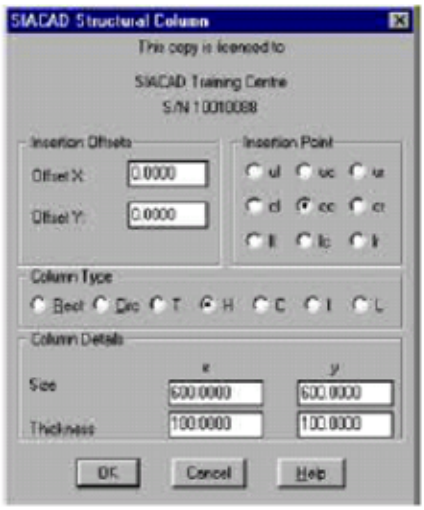
Manufacturers' Details and Specifications: Download our **SIACAD InfoBase** content library and make use of thousands of detail drawings, specifications and electronic brochures of building products. Use our search engine to locate your preferred product and insert them into the drawing..all in the right layer, color and scale.

Automation

Doing CAD drawings can be a real drag. Basically, you use lines, arcs, circles etc. to build up your drawing. In **SIACAD**, repetitive tasks like these are automated. This enables you to achieve productivity gains not possible from your plain CAD engine.

Grid Lines: Instead of using a series of lines, circles, text and dimensions entities, you use our automatic grid line generator. Intelligence is built into this routine so that you won't make mistakes like having grid lines with confusing annotations such as "O" and "I"

Columns: Specify the size required and automatically insert Rectangular, Circular, Elliptical, "T", "I", "H", "C" and "L" shaped columns into your drawing.



Beams: Draw beams in "edge", "hidden" or "exposed" view. There is no need to manually draw lines, offset / trim them and then change the linestyle.

Walls: Draw all kinds of walls such as structural, parapet, partition etc. with your preferred wall thickness and offset.

Openings: Break openings in walls based on an offset distance from the edge of the wall or have the opening centralised.

Doors: Insert single/double swing, single/double leaf doors or sliding doors into your walls. This command also breaks openings in walls and clean up the edges.

Windows: Insert standard windows up to 8 panels or sliding windows into your walls. This command also breaks openings in walls and clean up the edges.

Attachments

Tools

SIACAD users know what they want. Beyond just Standards and Automation, they have requested for tools to help them with their day to day CAD drafting. Some of these tools are so useful that it makes you wonder why they don't come standard with most CAD systems.

Area Text: Pick any enclosed entity such as polylines, circles etc. and add or subtract their areas automatically. Then paste the area into the drawing as a text entity.

Text Case: Change existing text into uppercase, lowercase or mixed case.

Align Text: Align selected text to a point using left, center or right justification.

Replace Text: Replace phrases or words within text lines. Replace all text lines in the drawing or select only those you require.

Text Bubble: Draw annotation text inside bubbles such as circle, elevation, section, etc. Create or edit our predefined bubbles to suit your needs.

Running Numbers: Set a start number and an increment. Paste the text of these running numbers into your drawing. Excellent for car-parking lots, staircase runs etc.

Get Object: Pick on an existing entity or symbol. This then sets the layer, color and linetype to that of the selected objects. Next it fires up the command that is used to create the entity or object.

Search Catalog: Search for any symbol or detail drawing from the full range of Approved Symbols, Manufacturers' InfoBase and In-house details and specifications. Use Boolean AND to narrow down your search parameters or search by price range. Display the preview icons of the selection and insert the preferred symbol or detail into your drawing.

User Customisation

SIACAD is designed as an open system. You can easily customise it to suit your requirements. It is also very easy for system managers to create and maintain their own layer, color and symbol standards. These standards can be hosted on a server and shared by all workstations.

Get Layer Standards: Define the layer standards by editing our standard layer definitions. Select and use any standard you require.

Catalog Manager: Create your own symbol / detail library using our powerful Catalog Manager. This creates preview icons and enables you to define the layers for inserting the symbols or details.

In-house Catalog: Organise all your existing in-house detail library using our In-house Catalog system. There's no "programming" involved. Just organise your detail drawings into folders and drop them into the Catalog Manager. There is also no limit to the number of in-house catalogs you can define.

Attachments

Network Manager: Most of our users store their Manufacturers' InfoBase, Approved Symbol Catalogs and In-house Catalogs on a server. This can be any folder that's shared and available to all the CAD workstations. Each workstation then contains only links to the catalogs instead of the actual drawings or specifications. This enables you to easily maintain your catalog and library as you only need to update on the server and all the workstations have access to the same information.

System Requirements

The system requirement for running **SIACAD** is straightforward. If your CAD software is working fine, **SIACAD** will work on top of it.

CAD Platforms:
IntelliCAD
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AutoCAD LT **
FastCAD 32
VectorWorks (PC/MAC) **
MicroStation V8 **

Computer System:
Microsoft Windows 95/98, Windows NT 4.0,
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Minimum screen resolution: SVGA 800x600.
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**LT Version does not have LISP functionality. VectorWorks and Microstation versions do not have all the functionalities of the IntelliCAD or AutoCAD versions.

Attachments

Excerpt from http://www.serpentinegallery.org/2006/07/serpentine_gallery_pavilion_20_1.html

Serpentine Gallery

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Architecture
Education
Projects

Serpentine Gallery Pavilion 2006, by Rem Koolhaas and Cecil Balmond, with Arup

13 July – 15 October 2006

The Serpentine Pavilion 2006 was co-designed by Pritzker Prize-winning architect Rem Koolhaas and innovative structural designer Cecil Balmond.

The centrepiece of the design was a spectacular ovoid-shaped inflatable canopy that floated above the Gallery's lawn. Made from translucent material, the canopy was raised into the air or lowered to cover the amphitheatre below according to the weather. A frieze designed by Thomas Demand marked the first collaboration between an artist and the designers of the Pavilion.

The walled enclosure below the canopy functioned both as a café and forum for televised and recorded public programmes including live talks and film screenings in the Time Out Park Nights at the Serpentine Gallery programme.

The Pavilion also housed works by several artists participating in the *Uncertain States of America* exhibition.

Rem Koolhaas said: *The 2006 Serpentine Pavilion is defined by events and activities. We are proposing a space that facilitates the inclusion of individuals in communal dialogue and shared experience.*

Cecil Balmond said: *These Pavilions have evolved with various structural typologies and materials, provoking a debate on architecture; this year the exploration continues not only with typology and material but with the very definition of* Pavilion.

Each Summer, the Serpentine commissions an internationally acclaimed architect to design a temporary Pavilion for its lawn. The programme is unique worldwide. Conceived by Julia Peyton-Jones, Director, Serpentine Gallery, the project represents a rare opportunity for architects to create a more experimental structure in the United Kingdom, where none of those invited has ever built before. Those selected previously are Zaha Hadid, 2000, Daniel Libeskind with Arup, 2001, Toyo Ito with Arup, 2002, Oscar Niemeyer, 2003, MVRDV, 2004 (unrealised) and Álvaro Siza and Eduardo Souto de Moura with Cecil Balmond – Arup, 2005.

Serpentine Gallery Pavilion 2006 © John Offenbach

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Towards Integrated Practice – a Rapid Tour

2007 Royal Australian Institute of Architects (RAIA) Conference
Melbourne Exhibition Centre 20.04.07. Notes by Michael Goss from the presentation.

SESSION 1

Karl Fender and David Sutherland, Fender Katsilidis

The presentation centred around the Fender Katsilidis experience of implementing BIM on recent projects.

The presentation was segmented into the following areas:

- Current world and inadequacies
- Changing world
- New world

General statements made during the presentation included the following:

The practice had come to appreciate the nature of BIM as a collaboration medium and noted the extent to which it had an impact on the way in which the office practiced both in terms of internal collaboration within the design team and externally with consultants to their projects. It was not initially predicted when the decision was made to use BIM that the resultant benefits would eventuate.

Generally they would espouse that the profession should be engaging in BIM as the benefits that they have experienced would translate for all practitioners.

BIM has facilitated better ways of doing their work in what is often by its nature a fragmented design/construction world.

In a world that has a major focus on costs the value that BIM systems can afford both in the short and long term should be considered and evaluated.

Non standard formats have been a factor in the decline in productivity and the ease at which collaboration and sharing of information can occur.

In the past the design process has been a contributor to the resultant poor quality of construction but the BIM system has made significant improvements in this area as early collaboration and information sharing has resulted in gains that improve the quality of documentation, communication and the construction process.

Generally in the current climate there is a push to work more effectively and the productivity, communication and collaboration gains afforded by BIM systems is assisting to meet the demands.

The advent of BIM is in the context of a increasingly digital world that utilises virtual environments to advantage.

Whilst the reduction of paper based information and communication has been on the agenda for many years it seems that BIM is making significant inroads towards the reality of paper reduction.

The digital 3D model is data rich and able to be manipulated to respond with intelligence on anticipated performance.

AEC bytes website was recommended by the speakers as a reference to consider.

Attachments

The use of BIM systems results in a range of products and byproducts in new formats with improved functionality:

3D model + intelligent reporting system + computer technology

Costing/quality/performance inherent in building elements that are placed into the 3D model as the model is being constructed. Together with the building elements, space too can be defined and referenced.

The virtual building is developed from the componentry which is therefore data rich from the outset.

Behaviour and performance can be tested through the 3D model as it has been developed as an information rich and animated model.

The Eureka Tower project in Melbourne was the first major project undertaken by the practice and commenced in 2000 which marked the start date for using BIM in Fender, Katsilidis office.

Advantages discovered throughout the journey of implementing building information modelling:

Error checking functionality has resulted in a dramatic reduction in errors and request for information from the building contractor and consultants.

Example of a recent project using BIM:

The Adelaide Advertiser building – It was originally proposed that the structural system would be steel frame but it eventuated that the a concrete system would be used and the BIM system minimised the impact of the change.

Examples were displayed of 3D shop drawings prepared by the builder for the stairs in the project complete with detail through to the fixing bolts.

Drawings are still the product of BIM systems and drawings such as an information rich glazing schedule can be extracted from the 3D model.

Advantages

Better understanding of the design intent.

Better understanding by the design and documentation teams through early involvement in the design process and the development of the 3D design model.

The result was greater sense of being part of a team improved cohesion of the team, improved integrity and accuracy of the information input into the model and cooperation in error checking.

A comparison was made to the tower of Babel in that there are a multitude of systems and software applications currently available and in use that requires a common platform or conduit for communication with consultants to the project.

(Refer to the Building Smart website)

A Canberra Building project was referred to as an example at this point of the presentation to demonstrate the use of viewing software to read the BIM model. The software is free to download and assisted the collaboration with the services engineer to develop a plumbing model that was then imported back into the BIM model.

Potential of BIM

BIM could become the main hub for:

- Design and documentation production
- Dissemination of information on performance
- Vehicle for the assessment of the design success
- Simulation of behaviours

New ways of looking at BIM by the profession:

- Requires re-thinking of design process
- A cultural shift is required in the profession away from the reliance on 2D CAD drawings
- Adjust understanding of collaboration and how it is practiced
- Validation of the design intent through performance modelling

Conclusions:

- BIM is the way forward as a methodology
- An investment in software is required
- Leveraging off a sizable project can be catalyst for the initial implementation of BIM into a practice.
- A diligence and commitment is required to input the data and to maintain protocols.
- Drop 2D CAD
- There is a growing resource of trained graduates.
- Architectural practices are leading in the construction world at the moment closely followed by the engineers and this will change as the system is embraced more widely across the diversity of consultants to building projects.
- BIM facilitates cooperation and teamwork in general and makes the process more enjoyable for the individual designers as they are part of a richer team.
- BIM models are particularly good for presentations to client groups and authorities to gain the approvals required.

SESSION 2

What is Integrated Practice? RK Stewart, President of The American Institute of Architects

The introduction to the topic focused on the need to break down the traditional silos within the profession.

There is a need to improve communication and effectiveness of productivity across consultancy boundaries for the range of consultants involved in the procurement and development of a building project.

Integrated practice in America is being fostered by Government, especially in the case of Government projects. The engagement of architects and architectural consultants now requires information from BIM systems for its projects.

RK Stewart identified four key elements to increase the effectiveness of productivity

- Leadership by the owner of client
- Integrated project structure

Attachments

- Open sharing of information
- Virtual building models

At this stage of the presentation the following references were recommended:

- AIA website for papers – www.aia.org/ip
- 2nd White Paper
- 3xPT Strategy Group comprised of – AIA, AGC and CURT

Current practitioners leading in the use of BIM systems:

- Tom Mayne, FAIA
- Orcutt-Winslow Partnership

Related Resources to support the presentation:

- CD: Towards Integrated Practice – Additional reference material, RAIA and AIA