National Guidelines for Digital Modelling: Case Studies

CRC Construction Innovation
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Foreword

These *National Guidelines* and *Case Studies for Digital Modelling* are the outcomes from one of a number of Building Information Modelling (BIM)-related projects undertaken by the CRC for *Construction Innovation*. Since the CRC opened its doors in 2001, the industry has seen a rapid increase in interest in BIM, and widening adoption.

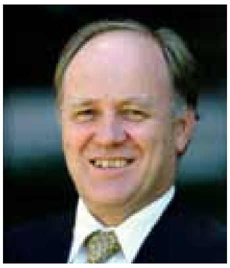
These guidelines and case studies are thus very timely, as the industry moves to model-based working and starts to share models in a new context called integrated practice. Governments, both federal and state, and in New Zealand are starting to outline the role they might take, so that in contrast to the adoption of 2D CAD in the early 90s, we ensure that a national, industry-wide benefit results from this new paradigm of working.

Section 1 of the guidelines give us an overview of BIM: how it affects our current mode of working, what we need to do to move to fully collaborative model-based facility development. The role of open standards such as IFC is described as a mechanism to support new processes, and make the extensive design and construction information available to asset operators and managers. Digital collaboration modes, types of models, levels of detail, object properties and model management complete this section. It will be relevant for owners, managers and project leaders as well as direct users of BIM.

Section 2 provides recommendations and guides for key areas of model creation and development, and the move to simulation and performance measurement. These are the more practical parts of the guidelines developed for design professionals, BIM managers, technical staff and ‘in the field’ workers.

The guidelines are supported by six case studies including a summary of lessons learnt about implementing BIM in Australian building projects.

A key aspect of these publications is the identification of a number of important industry actions: the need for BIM-compatible product information and a national context for classifying product data; the need for an industry agreement and setting process-for-process definition; and finally, the need to ensure a national standard for sharing data between all of the participants in the facility-development process.



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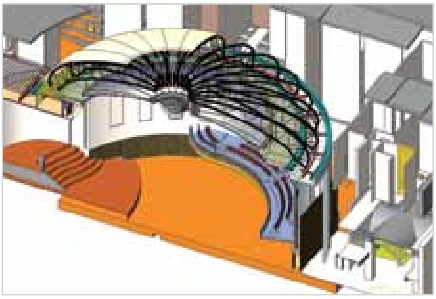


Case Study 5: Joint Contact Centre Zillmere Queensland

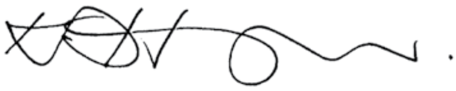
Case Study 6: 8 Chifley Square

Preface

Since 2001, the Cooperative Research Centre for *Construction Innovation* has been committed to leading the Australian property, design, construction and facility management industry in collaboration and innovation. We have been dedicated to disseminating practical research outcomes to our industry — to improve business practice and enhance the competitiveness of our industry. Developing applied technology and management solutions, and delivering education and relevant industry information is what our CRC is all about.

We look forward to your converting the results of this applied research project into tangible outcomes and working together in leading the transformation of our industry to a new era of enhanced business practices, safety and innovation.

John V McCarthy AO
Chair
CRC for *Construction Innovation*



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Chief Executive Officer
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The CRC for *Construction Innovation* provided the major funding, industry research leadership and coordinated the development of *National Guidelines for Digital Modelling* and accompanying *Case Studies*.

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Association of Consulting Engineers Australia
Australian Institute of Architects
Australian Institute of Building
Australian Institute of Quantity Surveyors
BuildingSMART Australasia
Facility Management Association of Australia

The project participants

Industry

Government

Research

Our thanks go to all those who attended and contributed to the success of this publication through their participation in the workshops held in Sydney, Melbourne, Brisbane and Perth.

Construction Innovation also wishes to thank and acknowledge Colleen Foelz (*Construction Innovation* and edenink) for managing the production of this publication, as well as Sue Ferguson (itzdesign) and Gail Cartwright (wordwright) for their design and editing respectively.

Case study 1:

North Lakes Police Station

North Lakes Police Station – external perspective

Images Case Study 1 courtesy Queensland Department of Public Works (QDPW)

This case study explores the collaborative process used to test the possibilities of Building Information Modelling (BIM) while delivering a quality project on time. The process was challenging, but also generated much valuable experience for future projects. The case study is an overview of the experiences gained by many stakeholders involved in the planning, design and construction of the new North Lakes Police Station in northern Brisbane.

A primary objective for the project was to generate an integrated multidisciplinary 3D model for the project, and enable the model to be shared with the contractor and subcontractors to better inform the delivery of the project.

Project overview

Design process

Introduction

The project is located at North Lakes, a staged ‘green fields’ residential and commercial development near Mango Hill. It sits between the Bruce Highway and Anzac Avenue, some 20 kilometres north-west of Brisbane’s central business district. The North Lakes area is part of the wider local government area controlled by Moreton Bay Regional Council. Area details are available at a community website.[1]

North Lakes Police Station – 3D render showing building footings

The project and its stakeholders

Major stakeholders in the North Lakes Police Station project are:

- **Queensland Police Service —** client
- **Project Services**[2] — design and documentation — a commercialised business unit within the Queensland Department of Public Works[3] providing professional services across all disciplines.
- **Northbuild Construction Pty Ltd** — contractor — a privately owned commercial construction company, with offices in Brisbane and the Sunshine Coast.

A note on planning

Planning and design for a police station in Queensland is subject to a Police Service Building Code, which sets out definitive and detailed procedures based around staffing estimates and operational issues. These guidelines prescribe the accommodation, communications and security levels, and details for interior layouts, room sizes, area adjacencies, visibility, sightlines, circulation and other spaces.

1 See http://tinyurl.com/NorthLake
2 QDPW Project Services, refer to http://tinyurl.com/ProjectServices Queensland
3 Department of Public Works (QDPW), refer to http://tinyurl.com/AboutQDPW

The use of BIM on North Lakes Police Station has been driven by Project Services (PS). The Architectural Group within PS has around 75 architects, and is divided into four teams for management purposes.

According to one PS staff member, the decision was made at a management level that BIM is the future, and that they should get there as fast as possible. In the architectural area of PS, the mix of software use is around 75 per cent Autodesk® Revit®[4] and 25 per cent Graphisoft® ArchiCAD®.[5] However, at the time this case study was conducted, there was a renewed drive to increase the adoption of ArchiCAD®, driven by its potentially better support for interoperability through Industry Foundation Classes (IFC).[6]

The initiative

A decision was made by senior management within PS to deliver the North Lakes Police Station project using BIM tools and principles for sharing information between various disciplines. The project was chosen for its typical complexity, as PS undertakes as many as 15 similar police station projects in a given year. The project had to be delivered on time and on budget, yet allow the investigation of innovative approaches to model data management.

As an additional self-imposed constraint, PS aimed to test the use of non-proprietary interoperable file formats — mainly IFCs — wherever possible within the project’s life cycle. This was based on a strategic decision to test and support the proliferation of IFC-based processes within industry; a decision that ultimately informed the selection of software used and processes applied within this pilot project.

Project workflow summary

In general terms, the project’s workflow was as follows.

Project initiation and schematic design

The client supplied a design brief to PS detailing its spatial requirements for the police station project.

At Schematic Design Stage, an object-based model was initiated by the architectural team using an IFC-capable architectural package (ArchiCAD®). The model was generated

4 Autodesk® Revit® Architecture, refer to http://tinyurl.com/RevitArch
5 Graphisoft® ArchiCAD ®, refer to http://www.graphisoft.com/products/archicad/
6 Industry Foundation Classes, refer to the International Alliance for Interoperability: http://www.buildingsmart.com

with the aim of providing the initial plans, elevations and views needed for design discussions and approval.

PS quantity surveyors derived their first estimates directly from the brief and project footprint. At a later stage in schematic design (identified to be the most important phase from a cost planning perspective), quantity surveyors verified the design against the brief 'visually' through a dedicated IFC model viewer (DDS® CAD Viewer).[7] Services engineers provided their own separate cost estimates to the cost planners.

The structural engineering team within PS did not initially model its requirements, but provided its input verbally to the architectural documentation team. Selection of column sizes, trusses, purlins etc. were shared with the documentation team, which then generated the objects within the main model.

The mechanical, electrical and hydraulics teams within PS initially defined project requirements through 2D CAD drawings.

Design development until tender

The 3D model was further progressed by a more specialised downstream documentation team. More objects were modelled and design details were added.

PS preference was to use Tekla® software to model the structure for the building because of its perceived compatibility with ArchiCAD®. Tekla® is not current PS software, and is not yet widely used with structural engineering consultants.

However, it is used by some steel detailing companies including BDS Group[8] (now operating as BDS Vircon), which was engaged as a specialist sub-consultant to the PS structural engineers to provide modelling services for the project. This service was provided both at the BDS office and by co-locating the modeller with the structural engineer in the PS office.

The cost planners performed the second costing exercise. At this stage, the team tested the model 'semantically' (i.e. object properties were interrogated), as well as visually. The third and final costing exercise within the project used a well detailed architectural model which included an IFC version of the structural steel model prepared in Tekla® Structures[9], and some mechanical, hydraulics and electrical information. The cost team inspected the model through walkthroughs within DDS® CAD Viewer, and queried the architect for clarifications where necessary. These virtual inspections allowed the cost planners to identify unclear or expensive details, and then request changes to satisfy budgetary limits already set during the Schematic Design Phase.

The landscaping and civil teams within PS generated a 3D landscape topography using a specialised application (12d Model®[10]). Software incompatibility prevented the topographic and drainage models from being incorporated directly into the architectural model. The information had to be exported as 2D drawing files then used as CAD underlays within the tender documents.

The mechanical services design was performed using non-BIM methods during the earlier Schematic Design Phase. At the later stage, the mechanical team modelled the requirements using DDS® HVAC modeller — a tool chosen for its availability within PS and its IFC compatibility — while the electrical and hydraulics teams modelled their requirements using Revit® MEP. This exercise proved instrumental in generating multiple technical and procedural lessons for the team.

The structural design was progressed through a joint effort between the structural engineer and the documentation team. The architectural design model was exported — in IFC format — for use by the modelling consultant, BDS Group, which imported the 'architectural' IFC model into Tekla® and generated its own structural members. These were later re-exported — as a 'structural' IFC file — and embedded into the architectural model. This process was repeated a number of times until all design and constructability issues were resolved. At this stage, the IFC model generated by BDS replaced the steel elements generated by the PS architectural and structural teams.

The tender documents consisting of numerous highly detailed 2D drawings were then produced. They included many which were directly exported from the 3D models (e.g. steel details were a direct export out of the Tekla® Structure software).

An integrated 3D model was made available to the tenderers and to the contractor to assist in pricing the project and for construction planning purposes. It was not a formal contract document, although this is a goal for the future.

7 Data Design System® CAD Viewer, refer to http://www.dds-cad.net
8 BDS Group, refer to http://www.bdsglobal.com/
9 Tekla® Structures, refer to http://tinyurl.com/TeklaStructures
10 12d Solutions® 12d Model, refer to http://www.12d.com/model/

Model-based collaboration

Documentation and modelling

An ArchiCAD® model was used to resolve the architectural design of North Lakes Police Station. The initial modelling was performed by the principal consultant, who used it mainly to generate 3D visualisations. Subsequently, the same model was used by the project's documenters throughout the Design Development and Construction Detailing Phases to generate the necessary 2D drawings. The documenter had only to adjust — not re-create — the model to allow accurate output of plans, details and joinery drawings.

Modelling practices

The model was primarily intended to generate accurate and integrated 2D documentation, and allow clash detection and collaboration with the structural modeller. The modelling processes employed did not favour the automatic generation of quantities or the sharing of the model with parties outside PS. Information generated and sent through the firewall mainly comprised 2D AutoCAD® drawings and partial IFC models to be inspected using lightweight viewers on the construction site. As a case in point, and to allow adequate IFC translation of structural elements, some objects had to be modelled as two separate elements — structural elements and architectural skin.

These and other practices highlight the relationship between the intended deliverables out of the model and the way in which they will inform the modelling practices. It also underlines some of the differences between 'collaboration-driven' and 'quantification-driven' models. To explore this point a little further, below is an example of the modelling practices employed to favour 2D documentation and speed of delivery over the automatic generation of quantities out of the object-based model:

- Wall lining was neither modelled nor drafted; lining properties were referred to through textual notes.
- Some modelled walls used 'custom profiles' to generate roof facias and gutters. These objects will neither schedule correctly nor export as an IFC wall.
- All walls were modelled generically using different sizes, but without defining their internal composition or materials used.
- Wall notations were text objects, not parametrically linked to wall properties.
- The standard details were taken out of legacy CAD and not derived from the model.

The North Lakes Police Station (NLPS) model was used as a base for multiple collaborative efforts, including those between the designers themselves; between the designers and cost planners; and between designers and contractors/subcontractors.

The design–detailing link

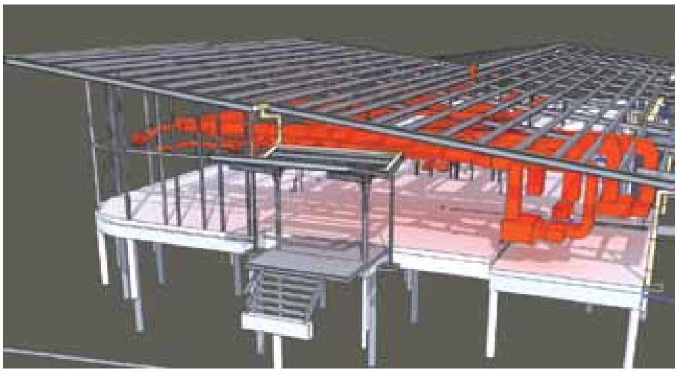
One of the more important facets of model-based collaboration was explored in this pilot project. The model was used as a collaborative medium between the building consultants to test the efficiencies of BIM processes. This collaboration was further tested and augmented by the physical co-location of both parties for a number of weeks; a co-location that allowed the efficient resolution of many constructability issues.

BDS Group: an introduction

BDS Group, the company chosen for its specialised model-based abilities to handle steel structure design and detailing, prides itself as being one of the first companies to adopt Tekla® Structures in Australia, and has been using it for nearly 11 years. BDS Group has eight offices worldwide using a total of 160 BIM licences — 40 of which are deployed in Brisbane.

BDS and Project Services

North Lakes Police Station was the first direct contract between BDS and PS, and it came about as PS was investigating companies using IFC-compatible software to establish a collaborative model-based relationship. BDS's manager acknowledges that its expertise in Tekla® played a major role in its selection by PS and the subsequent novation to Northbuild, the project's general contractor.



North Lakes Police Station – steel structure – view 1

The collaboration process

To increase collaborative efficiency, a steel detailer from BDS Group relocated to PS during an early stage of the project and was provided with an office area and a computer (BDS provided the Tekla® licences). This embedding of a steel detailer into other collaborating organisations is not uncommon for BDS, and around 15 per cent of its experienced staff are typically located outside its office. However, this is the first time it has had such an arrangement with a consulting architect. According to BDS, the close physical proximity of collaborating partners 'has enhanced the communication between designers and detailers'.

BDS noted that its involvement minimised the role traditionally played by the structural engineer on such projects, and brought the steel detailers closer to being part of the project's design team. It is BDS' understanding that such early collaboration between architects and — usually downstream — construction players is 'more efficient' and allows fast-tracking through 3D modelling. BDS also prefers steel detailers to be brought into the design process before the commencement of HVAC design because 'ducts follow structure, not the other way around'.

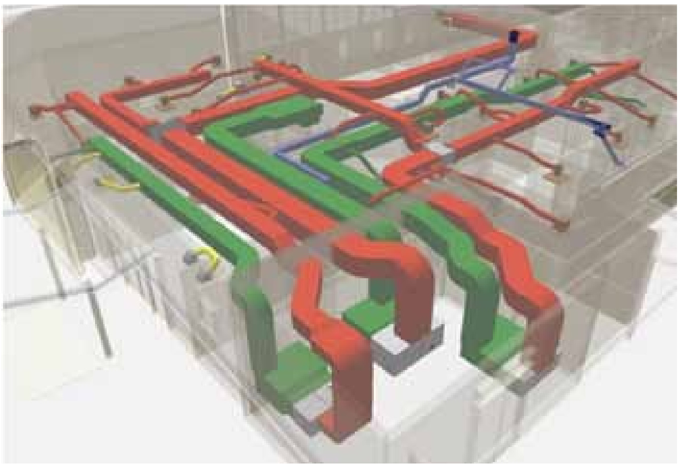
North Lakes Police Station – steel structure – view 2

A risk for PS at North Lakes was the integrity of the structural model. Effectively, the consultant provided the contractor with the shop drawings for the structure, and there may have been issues if the model subsequently proved to be inaccurate in any material respect.

This additional risk was accepted by PS for this project, and was mitigated by the additional care with which the accuracy of the model was checked before issue.

Internal collaboration: architects and services engineers

The model allowed different parties within PS to collaborate more efficiently. This included using the model to check for clashes between architectural elements (like rooms and separation walls) and service requirements (like duct and pipe routing).



North Lakes Police Station – mechanical clash detection

Heating, ventilation and air conditioning

The mechanical design for NLPS was first documented in 2D CAD. After it changed hands between two engineers, the project was modelled in 3D using the 2D as an underlay. The intention of the modelling was not to resolve the design, but to exchange 3D data with the structural engineer, as there was an issue with heights and clearances.

The modelling was mostly intended for training, and for presentation as a pilot project for both internal and external forums. It is worth noting that the architectural model was generated in ArchiCAD®, and brought into Revit® MEP through IFCs. The IFC model needed some manipulation as it did not include any rooms (these had not been defined by the architects).

Model-based construction

Electrical engineering

The electrical engineer at PS used Revit® MEP and IES[11] for electrical modelling and analysis. This modelling was mostly geometric and used the more advanced capabilities of software employed. For example, all lights were modelled in 3D, but without using the photometric attributes (e.g. volts and watts) within the 'families' — Revit®'s parametric objects. Also, only a couple of circuit systems were created within Revit®. Systems are a parametric compilation of objects — an electrical circuit or an HVAC unit with its ducts and diffusers — allowing load calculations. These systems do not currently translate into the IFC format.

North Lakes Police Station – 3D section

Training, support and documentation

Both the mechanical and the electrical engineers working on NLPS have received training from IES and the Autodesk® resellers. This occurred at PS (Brisbane), and four staff members currently working on Revit® projects were involved in this initial training. The PS team emphasised the need for training and support to be adequate for the effective use of the software.

Processes were not documented because of the 'pressures of time' and — since experimentation was still ongoing — the PS team preferred to finish investigation and then start documenting the processes. In principle, PS is intending for each discipline to have its own modelling manual. This will then *form part of* PS guidelines (including 2D manual, layers and folder structures), *which is influenced by* 'guidelines for staging and how to talk to each other — testing data transfers' — the expected deliverable of the National Guidelines Project.

11 Integrated Environmental Solutions (IES), refer to http://www.iesve.com/content/default.asp

Northbuild has its head office in Brisbane with ~300 people. The Northbuild project manager is Sunshine Coast-based, and that office takes all work north of the Pine River. Informal feedback goes to the Northbuild project manager from the Northbuild project supervisor, and then formally to monthly strategy company meetings.

North Lakes Police Station site – before and at the start of construction

The Northbuild project supervisor (a qualified quantity surveyor) was keen to be involved in 3D and BIM as an alternative approach to 2D drawings.

North Lakes Police Station site as at mid-August 2008

The contract nominated BDS for structural steel detailing, and indicated that shop drawings would be provided as part of the tender package. Also, the contract stipulated that 'all steel must be cut and fabricated using CNC (Computer Numeric Control) technology'. At the time of the contract, one such company in SE Queensland had the capability to fabricate using these CNC files and also undertake steel erection. However, soon after the tender process had been finalised, the steel company ceased steel fabrication and focused on steel erection. The contractor was thus forced to subdivide the steel contract into two packages where separate companies (OneSteel[12] and BrownSteel[13]) could perform the steel fabrication and erection respectively.

It is worth noting that not all subcontractors were using BIM-enabled technologies. For the NLPS project, and in contrast to Design Phase players, most construction players were still relying on printouts of typical CAD files.

12 OneSteel, refer to http://www.onesteel.com/default.asp
13 BrownSteel, refer to http://www.brownsteel.com.au/

Model-based cost planning

Workflow

The PS quantity surveyors who were working on the NLPS project consider schematic design to be the most important project stage for cost planning. Similar to the architectural team on this pilot project, the cost planners also had two targets: to deliver an accurate cost estimate on time, and to test BIM concepts. With respect to experimentation, the cost planners worked closely with a development/beta version of CostX® from Exactal.[14] The new software allows two cost estimating approaches — a manual mode allowing quantification using standard DWG™ files, and a more automatic mode based on IFC models (was not yet ready under the reported beta conditions).

The cost planning exercise started by reviewing the 'project brief' — which included space allocations and other client requirements — then generating the project's first cost estimate. The second estimate depended partially on the visual analysis of a basic 3D model (ArchiCAD®), accessed through a viewer. The third cost estimate exercise was performed after the architects generated a more detailed model, which included the structural steel (as done by BDS) and some mechanical, hydraulics and electrical information.

This detailed model allowed the cost planners — using ArchiCAD® and an IFC model viewer (DDS® Viewer) — to cut sections and perform visual checks where needed.

In other words, the final cost estimate still depended on computer-enhanced technologies and did not depend on the model to automatically generate quantities. The cost database (Rawlinsons[15]) did not integrate into any of the software used, but values were applied manually. Cost estimation of some specialised services — such as security systems — were also performed independently, then provided to the cost planners.

The cost planners indicated that they require much more detail at Schematic Design Stage if they are to fully benefit from the BIM model. They argued that the availability of construction-level details early on in the project's life cycle will allow a two-stage only cost planning (at Briefing then Schematic Design). This holds true for projects of similar briefing, size and complexity. However, if the project is more complex, then cost planning will need to occur over more stages accordingly.

14 Exactal, refer to http://www.exactal.com/
15 Rawlinsons Australian Construction Handbook, refer to http://www.rawlhouse.com/ACH.htm

On discussing model-based cost planning, the following issues were highlighted for particular attention:

- Two risks were identified that prevented the cost planners from relying more heavily on the model —
  - the risk that some building objects are not actually modelled and will not be counted
  - the need for different modelling practices to allow accurate estimation (e.g. walls need to be modelled, not as single objects, but as multiple objects built up along tradesperson lines).
- There are issues with intellectual property when it comes to Australian classification systems and cost databases. PS cost planners are currently trying to add parametric information to elements based on the AIQS Standard Elements system. This system, based on the classification agreed on by the National Public Works Conference in 1979, is owned by AIQS[16], and does not connect to any cost databases, which in turn are considered the intellectual property of individual companies.
- Elemental requirements for 4D planning (spatial 3D + time) and 5D (4D + cost) may go beyond current subdivisions of the IFC schema.
- The Queensland State Government is mandating that all public buildings must achieve 4½-star energy rating. The cost planners believe that to meet government Environmentally Sustainable Design (ESD) requirements, more details will need to be included within the models, and the designers will be forced to choose materials early during the Schematic Design Stage. Including materials in models at the Schematic Design Stage will meet cost planners requirement for more details, as 'once they select the materials, that's most of the details needed'.

Software exploration

PS cost planners tested, and continue to test, many cost-planning software systems. Their investigation included Synchro[17], A3D[18] and Innovaya.[19]

Specific training

PS cost planners received no specific training on software or on collaboration, but were supported by internal and external talent working on the project.

16 The Australian Institute of Quantity Surveyors (AIQS), refer to http://www.aiqs.com.au/
17 Synchro Ltd, refer to http://www.synchroltd.com/
18 Advanced 3D Technologies (A3D), refer to http://www.a3duk.com/
19 Innovaya, refer to http://www.innovaya.com/

Focus on project services

The following sections highlight some important aspects of BIM-related activities at QDPW Project Services as seen through the NLPS project. The analysis is drafted from three perspectives: technology, process and policy.

Technology: focus on software

Software selection

Professional Services Portfolio is a multidisciplinary technical consulting team of around 250 staff members (with 75 or more architects) within PS. It maintains expertise in ArchiCAD®, Revit® Architecture and AutoCAD® across its multiple groups. Also, in groups outside the architectural domain — spanning structural, mechanical, civil, electrical, estimating and fire services groups — an array of other software is also deployed. This includes Revit® Structure, Revit® MEP, 12d Model®, CostX®, DDS®, Solibri[20], Riuska™[21], IES and a series of specialist software packages. These applications are selected from general-use modelling and simulation software, plus those specifically chosen for their unique deliverables or ability to interoperate with other packages.

Interoperability

PS has made a strategic decision to evaluate and use where possible software that supports the IFCs — the non-proprietary interoperable schema developed and maintained by the International Alliance for Interoperability (IAI)[22], as a part of the development of its modelling capability.

This decision was made by senior management in an effort to allow design, analysis and simulation packages to leverage off one another, generating added benefits from data exchanges between various packages.

At current schema and software maturity levels, many software packages implement the IFC standard, yet generate results of varying quality. As an example (at the time of conducting this investigation), the (unique) global user identifier (GUID) attached to each model–element is not always maintained by applications as they generate new file versions. The ability of an element to maintain its GUID across project phases is fundamental to maintaining modelling integrity in versioning and analysis. Also, PS had to depend on labour-intensive techniques and the assistance of external specialists to map and translate objects from one application to another. Some of the many issues identified are:

- the inability — or lack of expertise — to generate an IFC file from the steel detailers application (Tekla® Structures) to match standard layers within the architects model (ArchiCAD®)
- the inability of Revit® Architecture (2008 version) to export a subset of the model to the IFC format. This is now believed to have been remedied in the latest version
- the inability to import/export 'type of material' properties and other element metadata between different applications without significant loss of information.

Dependence on 2D deliverables

Many PS staff currently use modelling — mainly ArchiCAD® and the many Revit® 'flavours' — to design, analyse and document, but still generate all their contractual deliverables in DWG™ and PDF, the de facto file exchange and printing formats. This holds true for the NLPS tender set, which was shown to be compiled of 2D drawings, schedules and specifications collated from the multiple disciplines and sub-disciplines. These 2D deliverables, although exported from 3D object-based models, assume the 'master set' name, and overtake the model in importance and reference. It also generates a strong internal demand for 3D to 2D data translation, satisfied through built-in and purpose-written (XML) translators.

Integration

There are early efforts within PS to test and use 'model servers', a network-based solution to integrate multiple BIM models. In testing this type of technology, PS is communicating with a Brisbane-based company developing a model server solution called ActiveFacility.[23] As part of its approach, ActiveFacility provided an FTP link to PS to upload its project files, and then mounted the information onto the server. Although data could then be 'pulled back' when requested, direct access to the model server by PS or its external partners did not materialise and so the system — at the time of this investigation — was used more as a storage system than as a model server. In 2008, PS looked to trial the EDMServer™[24] (a model server solution from Finland) with the assistance of an external expert from the Queensland University of Technology. The investigations were still at an

20 Solibri, refer to http://www.solibri.com/
21 Granlund Riuska, refer to http://tinyurl.com/GranlundRiuska
22 International Alliance for Interoperability; refer to buildingSmart at http://buildingsmart.org.au/
23 ActiveFacility, refer to http://www.activefacility.com/
24 EDMServer™, refer to http://www.epmtech.jotne.com/products.41332.en.html

early stage, and it is difficult to establish in this report whether the solution has been successfully employed and whether benefits to PS and its collaborating partners have been identified.

Network communications

During the design phase of the North Lakes Police Station, the architectural, structural, mechanical, electrical and civil/landscaping teams were co-located within the head office in Brisbane. Even one of the external project collaborators (BDS Group – steel detailers) worked at that office and shared modelling data through the local area network (LAN), unimpeded by firewalls or security considerations. After tender, the building contractor and their subcontractors — relatively new to digital workflows and BIM deliverables — initially had some difficulty handling and transmitting the larger IFC files generated by the design team. These stakeholders have since acknowledged the significance of accessing these files and the value-adding that model visualisation brings to the construction process.

The issue of network bandwidth has proved challenging even behind the PS firewall. As an organisation characterised by its spread over major centres in Queensland, PS uses a wide area network (WAN) to connect all offices and share a permission-controlled set of folders. Although the speed of this network is comparatively high (up to 10 Mbps), it may be less than required for the rapid interchange of large model files. Depending on software systems and processes employed, large amounts of data need to be moved across the network repetitively to allow model-based collaboration. This may not be an issue for projects with small file sizes, but as the projects increase in size, the impact of relatively slow networks can be significant. At PS, this has manifested itself at times in users opting to use email to exchange files between offices rather than depending on the shared folder structure. This, of course, threatens scalability of model-based projects, and a technical resolution is being investigated by the Information Technology group within PS, in liaison with application managers and external network providers.

Process: focus on training

Training strategy

CAD and BIM training within PS is responsive to need. That is, staff members may approach their manager and request specific training, or the manager may request up-skilling of staff members in preparation for a pending project.

With large staff numbers, multiple project types and a geographical spread over many offices, PS has implemented many overlapping software packages — for example, ArchiCAD® and Revit® Architecture — each with its own application manager responsible for training and support.

Training methods

In addition to training undertaken internally, PS also uses originating software companies or their local distribution channels for training. In-house training also focuses on teaching best practices for these toolsets. This in-house training provides information about computer directory structures, basic file-naming conventions, sample project templates, and how to set up projects to achieve best practice and uniformity across the organisation. In addition, some software tools and specific processes may be developed by PS, and users will then receive customised training to increase efficiency and productivity, and align processes and procedures.

A specialised training facility with 16 CAD-enabled computers is available at the Brisbane head office. The above training approach appears to have been adopted for the main BIM productivity tools deployed at PS (ArchiCAD® and Revit® — all types). However, the mechanisms for training on 12d Model®, CostX®, DDS®, Solibri, Riuska™, IES and other tools have not been formalised, and may still be need to be investigated and evaluated.

Support

Application support for distributed users is typically provided by experienced application users from their work area, or from the ArchiCAD® or Revit® managers based in head office. Using a 'train the trainers' approach, selected individuals in regional offices (e.g. Townsville, Toowoomba) have also been extensively trained, allowing decentralised training.

Policy: focus on guidelines

PS has developed and continues to maintain a detailed set of CAD layering standards, allowing it to streamline its CAD-based design and management processes. At head office, the ArchiCAD® manager has been appointed to maintain these CAD standards — which are also partly applicable within ArchiCAD® — with the aim of progressively adding 'best practice' manuals covering the implementation, deployment and use of BIM by various disciplines.

A final note

To support BIM education and training, PS also has a basic intranet site containing a selection of training topics and a project showcase. There is also an internal ArchiCAD® users newsletter distributed monthly, describing new tools and sample projects. It also acts as a motivator by highlighting a selected user and their BIM work.

In addition to the above, PS is currently and actively pursuing a series of model-related guidelines focusing on workflow optimisation and data exchange mechanisms.

In summary

The PS organisation is characterised by its spread across six or more regional offices in major centres throughout Queensland and a large head office in Brisbane. This geographical spread and multidisciplinary environment presents itself as both an opportunity and a challenge. The co-locational variety allows the innovative alignment of varied disciplines around BIM using the same physical infrastructure, organisational hierarchy and project processes. The close proximity of staff wearing different hats is a boon to model-based collaboration, as it allows quite rapid response times between different designers, engineers, documenters and other project participants literally under the same roof. It is also quite challenging, as the multiplicity of disciplines and sub-disciplines, each honing a different set of practices and software tools, can generate an intense demand for workflow optimisation. Data exchanges and flows become of utmost importance in this partial microcosm of the AEC industry. Interoperability between all the applications used is prioritised, as it cannot be assumed to be 'someone else's problem' because that other player is the engineer sitting five seats away from the architect. PS, through a considered strategic decision, has not only tried to streamline the data flow, but opted to test non-proprietary interoperable formats (namely IFCs) as a medium for that flow — an approach that generated as many solutions as challenges to all those involved in the model-based workflow.

How all these challenges will be addressed is not yet clear, but this is not stopping PS and its collaborating partners from committing themselves to more challenges in the immediate future.

The North Lakes Police Station project has provided its stakeholders with ample opportunities to investigate Building Information Modelling as a set of technologies, processes and policies. This pilot project has informed the activities of project stakeholders to try other, even more ambitious, BIM undertakings.

Case study 2:

Queensland State Archives Extension Project

State Archives Extension Project – 3D view

Images Case Study 2 courtesy Queensland Department of Public Works (QDPW)

This case study discusses some of the many experiences gained by participants involved in the project for the extensions to the Queensland State Archives at Runcorn. It explores the potential benefits and challenges of deploying Building Information Modelling (BIM) and 4D solutions for collaboration across design and construction. Many of these experiences are further elaborated on within the Lessons learned section of this report.

Project overview

The State Archives Extension Project started in June 2005 on a site located next to the existing Queensland State Archives building at Runcorn, Brisbane. The new building is a four-storey structure totalling around 11,000 m^2 (AUD$52 million gross cost), and aims to double Queensland State Archives' storage capacity through the addition of nearly 54 kilometres of shelving, plus public use and administrative spaces. The complex, which will house microfilm, audiovisuals and digital archives, is designed to withstand extreme conditions including earthquakes and cyclones. The archiving requirements elevate the internal environmental conditions to paramount importance. The extension project is a substantial undertaking in many respects.

Existing Queensland State Archives building

The State Archives Extension Project was designed and documented by Project Services (PS)[1] for the Queensland Department of Public Works.

The project reached practical completion in July 2008. Further details about the Queensland State Archives are available on its website.[2]

1 QDPW Project Services, refer to http://tinyurl.com/ProjectServices
2 Queensland State Archives website, refer to http://www.archives.qld.gov.au/qsa2.asp

Case study participants

Four interviews were conducted with members of the project team: the project manager, architect, contractor and modelling services provider.

Project manager at Project Services

The project manager selected for the State Archives Extension Project was responsible for managing the performance of the consultancy team and ensuring that the client's requirements and the project brief were met. During the tender process, the project manager typically became the first point of contact for all enquiries, and was responsible for evaluating tender submissions in accordance with the Queensland State Purchasing Policy.

After acceptance of a tender, the superintendent administered the contract and the project manager filled the role of client representative.

Architect at Project Services

The case study included an interview with the principal consultant for the State Archives Extension Project, who worked closely with the project manager. As principal consultant, his role revolved around design, and managing the documentation team. (For more information about PS, please refer to *Case study 1*).

Construction project manager at Laing O'Rourke

Laing O'Rourke's (LOR) Building Group is an expanding construction company, with offices in many Australian cities, the UK and UAE. The construction project manager assigned to the State Archives Extension Project had no previous experience in BIM solutions, but was selected to lead this substantial construction project for his energy and enthusiasm to explore the possibilities of 3D, 4D and BIM. His role started after the tender process was completed, and he played a hands-on role in managing the construction activities both on site and through the virtual construction model.

Manager and local representative of Advanced 3D Technologies

Advanced 3D Technologies (A3D) was formed in 1999 and provides both 4D software and 4D modelling services to the industry. For more information about A3D (referred to as the modelling service provider or MSP in the remaining sections), please visit the company's website.[3]

3 Advanced 3D Technologies, refer to http://www.a3duk.com/2006/home.htm

Contractor organisation

LOR Building Group was awarded the contract to undertake the State Archives Extension Project. For general information about LOR, please refer to the organisation's website.[4]

Introduction of 4D

BIM has been introduced into LOR's workflow through a multi-directional push. This included a top-down innovation push from LOR's management, which 'understood the importance of 3D/4D', a technology which it had been actively deploying in its UK branch for the past eight or nine years.

In Australia, LOR's offices benefited from the experiences of their UK counterparts, who provided assistance and encouragement to adopt 4D. As part of this assistance, an engineer was despatched from the UK, conducted presentations and shared his knowledge with a group of senior staff in Australia. This encouragement, coupled with experiences gained through the State Archives Extension Project, has resulted in a strategic commitment to implement 3D/4D technologies progressively. To keep abreast of pertinent changes, LOR's management set up a committee to investigate future technological solutions including BIM/4D. It has seen the benefits of 4D and has already taken the strategic decision to deploy 4D whenever possible.

4 Laing O'Rourke, refer to http://www.laingorourke.com.au/

The interviewee reported that LOR will be moving to adopt Autodesk® Navisworks® as a preferred 4D solution, after testing a few 4D solutions, including the one used on this project. This has been apparently driven by the UK branch's recommendation, which found Navisworks® models less demanding of its hardware. It has also been reported that LOR will be increasingly augmenting its 4D abilities through outsourcing some modelling capability to an affiliate company in India.

Communication between offices

LOR staff use an intranet solution called iGate (by Eigen Technology Services[5]) to share project news, but does not currently include any training or documentation/workflow guidelines. The intranet is complemented by a document management system (DMS) called TeamBinder[6], used by LOR for email communications, document sharing and similar activities. TeamBinder is used internally within LOR, as the organisation will regularly adopt whichever DMS is selected by its clients. For example, and for all projects relating to PS, LOR uses eContractAdmin[7], and for all IKEA projects, it uses CTSpace[8] (formerly Citadon).

5 Eigen Technology Services, refer to http://www.eigen-tech.com/index.html
6 TeamBinder, refer to http://www.teambinder.com/teambinder/Home/
7 eContract Admin, refer to https://secure.publicworks.qld.gov.au/msgs/
8 Citadon CTSpace, refer to http://www.ctspace.com/

Image showing existing building (left) and new extension of Queensland's State Archives

Project workflow and processes

Training and training culture

When LOR started working on the State Archives Extension Project, two of its key staff were provided a half a day of on-the-job training from the novated MSP (A3D), which brought in a trainer from its main offices in the UK. With the exception of training received for this project, and at the time of conducting this case study, local LOR staff had no formal 4D or BIM-specific training program. In contrast, LOR has a structured training regime covering scheduling, communication, negotiation and contract law topics, provided by both internal and external trainers. Also, and in a wider context, LOR Australia provides scholarships to tradespeople (the interviewee was a recipient of such a scholarship) and works with universities (previously QUT[9] and currently UQ[10]) to develop and deliver relevant educational material.

It is beneficial to note that LOR does not currently employ engineers in-house in its Australian offices, but relies on what it terms ‘service coordinators’ with specialised trade-based expertise. However, and as a consequence of potential benefits from BIM/4D implementation, LOR is now looking into hiring engineers and architects to augment its deliverables and provide a more complete service to its construction clients.

State Archives Extension Project after practical completion, September 2008

9 Queensland University of Technology, refer to http://www.qut.edu.au/
10 University of Queensland, refer to http://www.uq.edu.au/

The design process

PS developed the project briefing document with the client over a period of six months, and included spacing requirements, circulation and the like.

The starting point for the brief was a requirement that the new State Archives building should double the existing size and cost around AUD$50 million. This briefing or conceptual design period followed an Environmentally Sustainable Development assessment, and included a massing model done in ArchiCAD®. This early model had three options, which were then used to run a value management exercise to determine the best possible design and cost options.

This value management exercise, run by an outside facilitator, included the consultancy team and ran for a day or so. The early model was then used to generate areas which were compared manually with the brief, called the project definition plan. After that, the model then started to evolve through the addition of walls, windows and contextual design relationships between the new site and the older building. Design decisions were then made about the character of the building, including materials, wall types and roof pitches.

The design team, which included four staff members — a recent graduate, a student, a highly experienced detailer and the principal consultant (the interviewee) — used hand-sketching then ArchiCAD® to model the building and generate plans, sections and elevations at a large scale (1:100 and above).

When it came to documenting at smaller scales, parts of the model were extracted and details were generated using 2D AutoCAD®.

The role of value management in State Archives design process

The value management process was instrumental in optimising the design of the State Archives Extension Project. One main result of this process was a reduction of building height from four to three floors, based on an exercise involving the whole team working on the project (within PS), with a material handling specialist providing input towards the end of the Schematic Design Phase. The specialist consultant (from Sydney) analysed the storage systems requirements and optimised the design with respect to storage, accessibility, security and other relevant criteria.

Views inside the new building after practical completion

Working through the 2D floor plan documentation, he provided his recommendation back to the designer, instigating a significant change in building design and a substantial reduction in cost. Although similar services are available through major shelving companies like Brownbuilt , PS opted to use an independent consultant to avoid nominating specific brands of shelving and storage components early on in the project.

State Archives storage systems

The design team at PS then used the specialist's layout and equipment heights to model storage units (shelves and other elements) on a typical floor. The modelling was done generically and was used to visually coordinate services and make sure mechanical, electrical and fire services were well located and coordinated using information provided by PS engineers.

This modelling effort was undertaken by the architectural team, as the engineering team had no modelling capacity at that early BIM adoption stage (2005). When the modelling capacity changed at a later stage, services were remodelled later by the mechanical engineers using ArchiCAD® Ductwork.

Services resolved: as built piping and ducting which were coordinated through the 4D model

The 4D process

PS initiated the adoption of a 4D model and construction program for the Queensland State Archives Extension Project. PS mandated 4D delivery as the deliverable/process, and also novated the MSP for engagement and services on the 4D aspects of this project.

Introduction of the 4D model

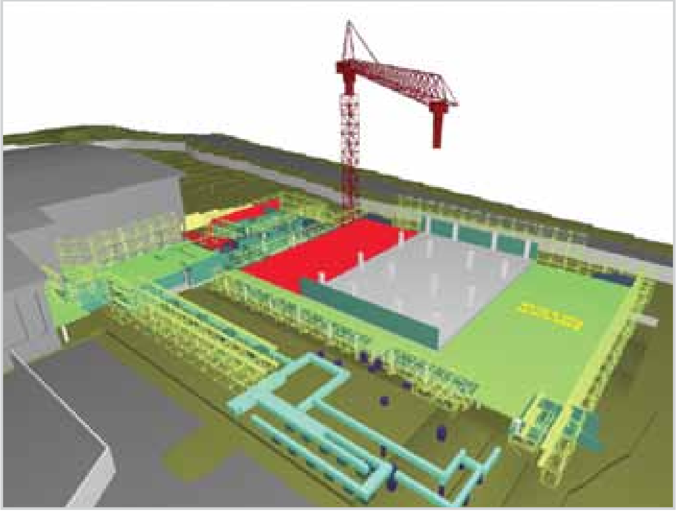
The decision to adopt a 4D model for the project was taken by PS and the Department of Public Works to evaluate the effectiveness of the methodology and to promote it to industry. The initiative to experiment and innovate may have been more difficult without the department's commitment to promote more effective methods to the building and construction industry at large.

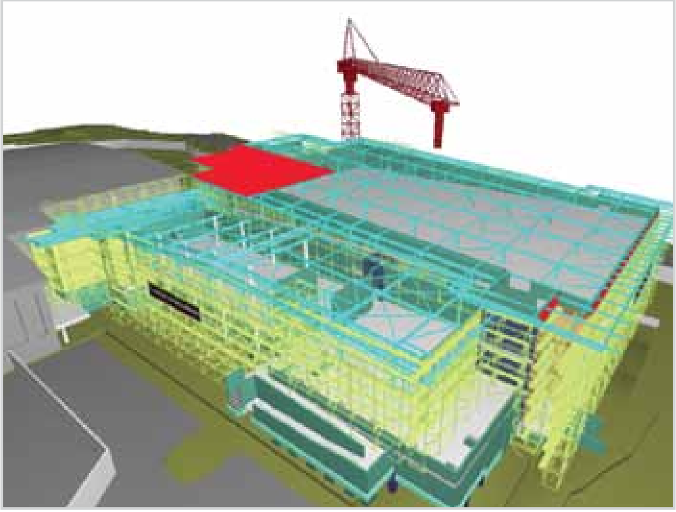
To support the initiative, the department contributed to the cost of preparing and maintaining the initial base model, which was not expected nor intended to be sufficient for construction planning and control purposes. A more detailed model was subsequently developed with the contractor and used for construction management

Using 3D modelling with an elemental approach (object-based modelling), the model has the ability to provide some surety about project costs, provided enough pricing information is embedded into the model.

Process of generating the 4D model

The 4D model was generated and maintained by the MSP rather than through the purchase of a dedicated modelling software package. Project stakeholders were provided access to it through a dedicated model viewer. Although a basic architectural model was developed at PS during the early design phases, it was not adequate for the MSP's purposes. PS then provided the MSP with 2D CAD drawings of all required structural, mechanical and hydraulics information, and the MSP remodelled the whole building using its own 3D DWG™-based application. This was linked to a dedicated MS Project file, and the 4D file and a dedicated 4D viewer — called PAL viewer — were provided to the architect, project manager and contractor. All modelling was done by the MSP, a process that took some time to complete. Both LOR and PS received some deliverables within the first month, while the more detailed Level 3 model (refer to *Modelling details* below) was completed. During the construction process, and as modifications to the model were needed, the MSP would then remodel the needed parts and upload changes to the web.





State Archives Extension Project – 4D model view

Modelling details

Each object inside the 4D model was linked to a task/activity within the Gantt chart by the MSP, using MS Project to manage the tasks and their relationships. The separation of objects within the model followed the MSP's three different service/modelling levels: Level 1 is the most basic separation of construction objects, while Level 3 subdivides the model into much smaller parts, each linked to its own task. As discussed, initially the MSP was contracted to provide the most basic integrated model (Level 2), and was then engaged to subdivide the model into smaller parts (Level 3) after the contractor was appointed.

To understand these modelling detail levels better, at A3D's Level 1, columns are modelled as a single group (single task), at Level 2 they are modelled independently (number of tasks equals number of columns), while at Level 3 each object may have more than one task assigned to it. It follows that the higher number of tasks/objects created within the 4D model, the more it lends itself to be managed flexibly. For example, it is more flexible to manage each column at ground floor as an independent task rather than all columns at the same floor as one object or task. It is even more flexible to add three different tasks/states to each independent column and allow these to change appearance according to each state. At the MSP's highest modelling level, elements will change colour according to their state on site: columns will be a certain colour if they are being 'formed'; another for 'steel has been added'; and a third for 'concrete poured'.

To shed more light on the 4D process, below are a few more details.

- The contractor (LOR) first prepared a detailed construction program based on the contractual agreement/program signed with the client.

- The MSP (A3D), after receiving LOR's program, generated its own program, which is even more detailed than LOR's. For example, LOR had subdivided 'slabs' into three separate ones (A, B and C) and assigned a single task (FormReoPour) to each of these slabs. A3D's program will break the FormReoPour task into three subtasks for each slab: FormSlabA, ReoSlabA and PourSlabA. This caused the number of scheduled tasks to triple in number: LOR's program had an average of 4000 tasks, while A3D's had around 12,000 tasks. According to the contractor, 'even the banding of polished concrete blocks' was represented in the 4D model/program.

- The 4D model included some of the civil earthworks. For example, the 'fill' was modelled as an independent element/task so it could be removed as a whole once the actual excavation had been performed.

- Plant and equipment like cranes and scaffolds were modelled and listed as tasks like any other building element.

- No human activity (e.g. location of human assets, circulation, OHS) were represented in the 4D model.

- As the building was being constructed, PS needed to change the building design by subdividing the new extension into two levels and extending vertical circulation. The 4D model was updated to reflect the design and program changes.

- At that 4D experimentation stage, elemental costs were not included within the model, although technically, the modelled objects had custom fields to allow inclusion of cost data.

- The structural steel was modelled by PS, but not included or remodelled in the 4D model.

- One of the drivers for increasing modelling detail up to A3D's Level 3 was LOR's requirements to include mechanical elements, discover duct penetrations and perform clash detection between different services. It is important to note that both the mechanical engineer (PS) and the ducting subcontractor (James L Williams) generated their own 3D model. Only that of the mechanical engineer made it to the 4D model (refer to *Lessons learned* for more information).

Using the 4D model

The contractor took possession of the construction site at the same time as the MSP (A3D) was engaged to generate the 4D model. Both LOR and PS started sending the MSP the necessary 2D drawings as construction work was progressing. The contractors quickly realised (refer to *Lessons learned*) that generating the 4D model is better done well before taking possession of the building site to allow better construction planning.

As the model was being generated by A3D, LOR continuously communicated 'buildability' and 'sequencing' of construction elements to the A3D team. The 3D model was then linked to an MS Project file jointly developed by A3D's modellers and LOR's professional schedulers. These schedulers (or programmers) usually work alongside construction project managers and provide consultation on how to speed progress up and decide — if there is a problem with one of the activities on site — how to modify the program to stay within the critical path.

After the 4D model had been generated, the typical workflow for the contractor was to visit the construction site, identify built work (say columns), go back to the office, open the A3D model and select the same columns inside the model. The contractor would then use the 'Show me items' command and the program would identify the corresponding column activities, allowing the user to update the completion date. Also, the 4D model as developed by A3D has the ability to be displayed *as baseline* and *as actual*, which allows the comparison of as-planned and as-constructed respectively. In any case, the 4D model of the State Archives Extension Project was not developed to Level 3 until a little later in the construction period.

Issues identified within this project's approach to 4D modelling

Developing and maintaining the model through an external MSP presented the stakeholders with operational benefits and procedural challenges. On the positive side, neither the design nor construction teams needed to purchase specialised software or train their staff to generate 4D models. On the negative side, as the MSP was located within a significantly different time zone (UK), the window of real-time communication between the designer, contractor and MSP was very narrow (three hours). This was later remedied by the availability of an Australian-based MSP contact manager. Some of the other issues identified are listed below:

- Project stakeholders had to wait a significant amount of time between the 'end of design' and the availability of a detailed 4D model (refer to *Lessons learned*).

- The technologies used were disjointed and there were significant losses in productivity. For example, the software used by the designer (ArchiCAD®) was incompatible with the one used by the MSP (DWG™-based modeller). This meant that the MSP had to re-create the model from scratch and rely on 2D CAD drawings.

- Since no mobile 4D technologies were deployed, other inefficiencies were identified. For example, the contractor had to carry hard copies on site to highlight construction changes by hand, then return to the site office to digitally update the model and upload/email the changed model to the common store. It's worth noting that although LOR was contractually obliged to update the 4D model fortnightly, the contractor found benefit in updating it weekly, and even every few days.

- Ownership of the 4D model is not clear, as A3D owns the software used to generate the State Archives 4D model (technology based on the DWG™ proprietary format). A3D has also provided the 4D model as a service, while the model viewer was made available through a tightly controlled licensing arrangement. It is thus arguable that the model is owned by the MSP, while the construction program used to generate the tasks within the 4D model is arguably owned by the contractor. In summary, ownership of the model has not been stipulated in the contractual arrangements, and is therefore not clear.

Benefits, risks and needed calibrations of the 4D process

The principal consultant at PS indicated that visualisation — as a communication language — is one of the greatest benefits of 4D. This is evident in the 4D model representing 5000 lines of tasks in the Gantt chart, and allowing the comparison of projected progress against actual construction using colours and other visual attributes.

With respect to risks, there were some early pre-emptive discussions between PS and LOR to ensure that there were no contractual issues arising from using 4D technology. The adoption of these new technological and procedural solutions was made easier because the project was always running ahead of time.

With respect to possible calibrations of the 4D process, the principal consultant at PS identified that the 4D model used did not include all programmable information required to manage the project. For example, the 4D model did not show any information relating to off site activities like shop drawing generation, inspections, sample approvals and off site manufacturing. These activities — typically represented on the Gantt chart — were absent from the 4D model, which meant that consultants had to keep both programs (one within the 4D model and the other outside it) running concurrently, needing continuous manual coordination. Another possible calibration was identified by the PS project manager. He explained that setting up modelling protocols early within the 4D process is of paramount importance to reflect 'constructability'. Once constructability is established, other factors relating to planning and cost control should be added to enable analysis of cost claims, vet them against on-site progress and compare baseline costs to actual costs incurred.

In summary

Cost quantification, estimation and savings

The 4D model did not play any role in cost estimation and the payment process for this project. Even after deploying a 4D model to perform construction planning and reporting, claims were still based on 'percentage completed' documents submitted by the builder though the document management system. The quantity surveyor, part of the PS consultancy package/team, had to visit the building site, walk with the builder and assess construction works.

Although the model was not used for generating quantities, cost estimation or cost planning, it has shown a significant potential in judging cost claims. As a case in point, one delay cost claim was rejected by the project manager after comparing the actual task with the baseline program within the 4D model. However, another claim for additional costs was upheld, as the model identified the additional work needed and that it was due to latent conditions.

According to the principal consultant, PS used the standard schedule provided by the builder until the 4D model was generated. Once made available, 'the model *became* the contractual program'.

The 4D model was used as a communication and planning tool by the designer, project manager and builder during the post-tender construction process. The collaborative and visual nature of the 4D model allowed progress claims/reports to be assessed in a more rapid and accurate fashion. As for speed, it generally took only half an hour every week to update the 4D model to reflect actual on-site conditions. With respect to accuracy, the 3D model allowed different states to be reported. For example, the concrete columns were modelled to reflect three different states: 'formed', 'reo added' and 'poured'.

The simplicity of this process and the accuracy of the 4D model assisted the project manager to judge whether a progress payment was warranted or not. It also allowed the project manager to monitor progress 'by the element'. The benefits of the 4D model also extended beyond reaching the practical completion milestone (July 2008). The model is still occasionally consulted to check previous construction states (or 'time snapshots') and to review change logs.

In summary, it was not clear whether the client quantified any cost savings through using 4D, but Public Works has invested in research and development. The interviewees have all found 4D very useful in communicating constructability and allowing the builder to better coordinate site works, procurement and delivery. One interviewee — after working with the model and seeing the results — felt that the BIM, 4D and 5D route 'is the only way to go'.

Case study 3:

1 Bligh Street

3D render of 1 Bligh Street building within its context

Image courtesy Architectus and Ingenhoven Architects

This case study discusses the experiences of consultants and contractor as they undertake their first multidisciplinary Building Information Modelling (BIM) project.

The project is a premium CBD high-rise office building located in a top location in Sydney.

Project overview

1 Bligh Street is a 30–storey, premium CBD high-rise office building, located in a prominent location in Sydney. On completion, 1 Bligh Street will be a 42,000 m^2 development, with an estimated cost of AUD$230 million. The building has the potential to achieve a 5-star ABGR (Australian Building Greenhouse Rating) and 6-star Green Star Rating without sacrificing indoor environment quality.

1 Bligh Street is one of the first commercial projects in Australia to implement multidisciplinary BIM collaboration. BIM played an important role in the documentation and simulation of the project, which contributed to its distinctive design and ambitious performance. The use of BIM was set as a client requirement, and was included in the contract. Ultimately, the client plans to use the as-built BIM model for facility management purposes.

1 Bligh Street is located at the 'valley' created by the Macquarie Street ridge and the tall buildings in and around George Street.

The site context and its potentially wide range of far-reaching views were an important factor determining the elliptical shape of the building and its orientation.

Urban study

Image courtesy Architectus and Ingenhoven Architects

3D render of the main access

Image courtesy Architectus and Ingenhoven Architects

Case study participants

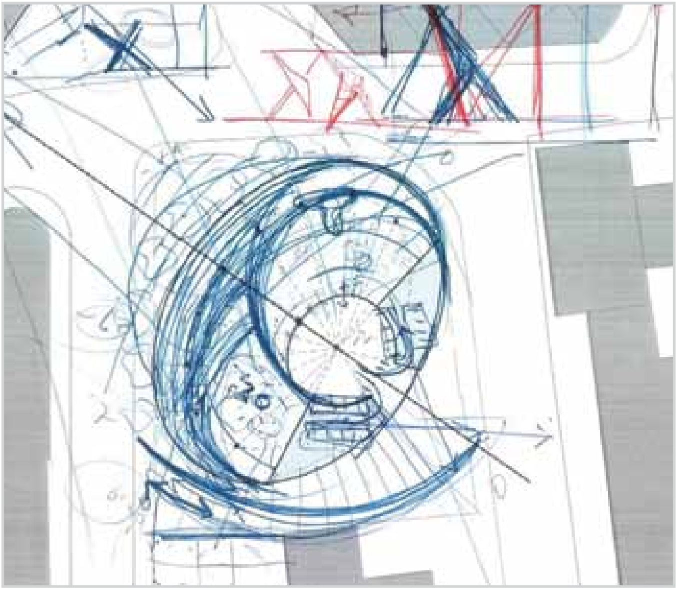
In this case study, 10 participants were interviewed across four companies. The interviews took place between June and July 2008, in Sydney and Melbourne. The interviews were concerned with a variety of topics within the process, technology and policy areas surrounding BIM.

The interviews focused on the architects as the consultants leading BIM in this project. Nevertheless, the consulting team and the contractor were also interviewed to document and analyse their experiences while collaborating with BIM.

Consultant	Interviewees
Architects **Architectus**[1]	Design Technology Director
	Design Director
	Project Architect
	Modeller
Structural Engineers **Enstruct**[2]	Director
	BIM Manager
Services Engineers **Arup**[3]	Director
	Modeller
	BIM Manager
Contractor **Grocon**[4]	Design Manager

1 Architectus, refer to http://www.architectus.com.au/
2 Enstruct, refer to http://www.enstruct.com.au/
3 Arup, refer to http://www.arup.com/australasia/
4 Grocon, refer tohttp://www.grocon.com.au/

The architects



Conceptual sketches of 1 Bligh Street building

Image courtesy Architectus and Ingenhoven Architects

A novel design proposal by Architectus and Ingenhoven[5] was chosen the winner (from among 12 submissions) of the DB RREEF/City of Sydney design competition for 1 Bligh Street.

As part of the design competition, collaboration between design firms was requested, and architects were asked to collaborate with other practices, particularly at the environmental level. As noted by the Architectus design director: 'we searched, found and selected Ingenhoven to collaborate with us primarily on the basis of their architecture, the compatibility of our organisations and our view, and their experience on double skin façades in particular'. Ingenhoven's experience with double skin façades was a success factor in achieving the high environmental objectives set for the project.

However, collaboration between the two companies needed to be carefully managed, especially when Architectus is located in Sydney and Ingenhoven in Dusseldorf, Germany.

Besides their geographic separation, the two companies also needed to manage the differences between their documentation methodologies. While Architectus had at the time completed six constructed projects using BIM and spent five years steadily perfecting its BIM procedures, Ingenhoven had little experience with BIM. Early in the project, it was considered that undertaking technology and methodology transfer from Architectus to Ingenhoven would have added problems and risks to the project, so the idea was discarded.

5 Ingenhoven, refer to http://www.ingenhovenarchitekten.de

The decision was taken that Ingenhoven would document 1 Bligh Street as it normally would, using Bentley Microstation®[6] (without a BIM approach), and forward it to Architectus. Then the latter firm would coordinate the documentation into the BIM model. Halfway into the documentation, Ingenhoven considered adopting BIM, but it was deemed too risky and the idea was abandoned for this project.

Since Ingenhoven was not the driver for BIM on 1 Bligh Street, it was not interviewed as part of this case study.

The transition from CAD to BIM

Although Architectus had a heavily customised CAD platform (still used in some projects), containing tens of thousands of lines of customised code, it was looking for a process to better document its projects and saw BIM as a way to achieve it.

The architects tried several applications, and even ran an entire project in Autodesk® Architectural Desktop® (ADT). While ADT was not regarded as proper BIM software by the design technology director, it was considered an evolutionary path into BIM. At the time, it was believed that a good (low risk) way to move from CAD to BIM was to adopt the CAD approach offered by ADT, and benefit from its already developed skills as high-end users of AutoCAD®. However, as commented by the design technology director: 'BIM requires a revolution, you cannot do it with evolution and if you attempt to incrementally adopt BIM in small steps you will not succeed in implementing it. Ultimately, BIM is a disruptive technology and you have to take the pain of the disruption at some point'.

Once the decision was made to go straight into BIM, the transition proved to be 'surprisingly easy' and smoother than an incremental transition through ADT.

Flexibility (being able to leave things behind), together with choosing the right staff and project, were identified as key to a successful BIM implementation.

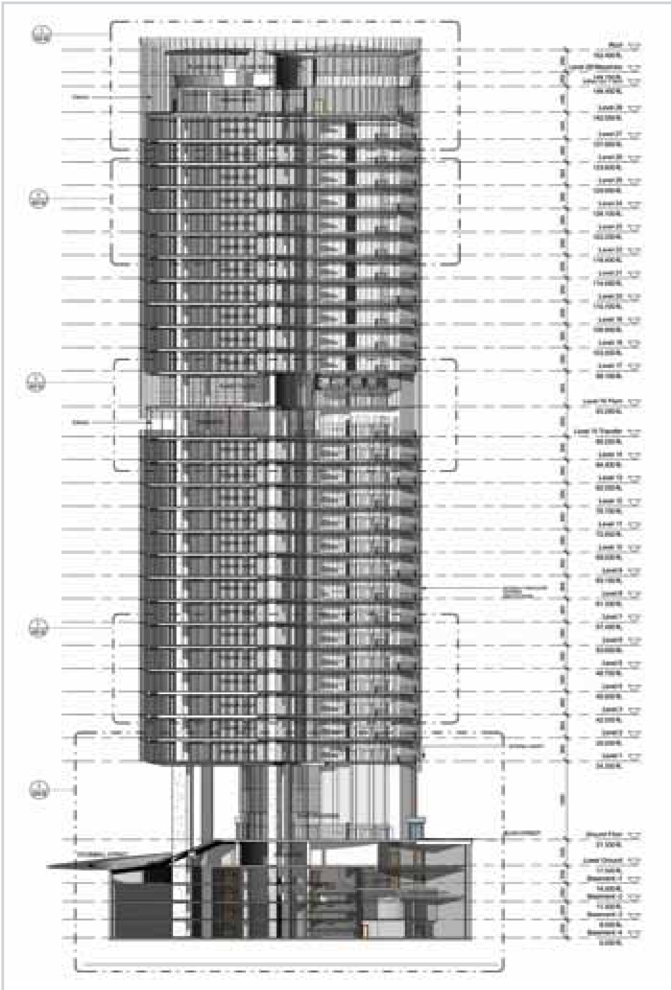
Choosing BIM software

From Architectus' point of view, there were few software packages that could be labelled as BIM applications: Autodesk® Revit® Architecture[7], Graphisoft® ArchiCAD®[8] and Digital Project™.[9]

Digital Project™ was regarded as niche market software that lacked the user base of more commercial systems, which could have an impact on the infrastructure of user groups, staff, training and content (families/libraries) which are available for other systems like Revit® or ArchiCAD®. It was also perceived that Digital Project™ was not conceived originally as an architectural design application (evolved from CATIA), and it was regarded as better suited for construction processes and manufacture.

On the other hand, the architects perceived that Revit® offered advantages to them over ArchiCAD® in that the former offered a complete suite of BIM applications for multidisciplinary collaboration (structural and services), and allowed them to stay within the range of Autodesk® products.

Architectus has fully adopted Revit® Architecture as its BIM solution, and used version 2008 to document the 1 Bligh Street project.



Section of 1 Bligh Street done in Revit®
Image courtesy Architectus and Ingenhoven Architects

6 Bentley Microstation®, refer to http://tinyurl.com/microstation
7 Autodesk® Revit® Architecture, refer to http://tinyurl.com/RevitArch
8 Graphisoft® ArchiCAD®, refer to http://www.graphisoft.com/products/archicad/
9 Gehry Technologies, Digital Project™, refer to http://tinyurl.com/DigitalProject

Although version 2009 was already available at the time of the interview, Architectus had not installed it yet. One of the major impediments for upgrading was reviewing the library content, a process overviewed by the design technology director and done prior to each upgrade. Nevertheless, the design technology director believes that, as opposed to CAD upgrades *'where the painful process of upgrading offers marginal value'*, there are always compelling reasons to move to a new version of any BIM platform, *'just because the improved features are worth having'*.

BIM benefits

Most of the BIM benefits experienced by Architectus are related to a better understanding of the design through 3D visualisation and fast access to accurate data.

> *Now that we are using BIM, I can say that the answer to 'why BIM?' is because it is a better process, more efficient, more cost effective, less prone to errors and has an enormous number of side benefits in terms of feedback loops, information that you get earlier in the project, [and] not going down the wrong path because everybody has the same understanding of what the design is. But all those benefits are not necessarily apparent when you are considering whether to move to BIM or not.*
>
> ***Design Technology Director, Architectus***

> *What BIM does for us is that it gives us more control architecturally. We know where everything is all of the time, in real time. That equals control, which equals accurate information back to the client or everybody else for that matter.*
>
> ***Project Architect, Architectus***

> *BIM improves the quality and coordination of documentation. Thus, we could create better buildings because we spend more time on important aspects of the building rather than on the mundane aspects.*
>
> ***Design Director, Architectus***

Following is a list of benefits experienced by Architectus as a result of implementing BIM on 1 Bligh Street and other projects. It is worth noting that 1 Bligh Street is the first project done by the practice using multidisciplinary BIM collaboration, thus the benefits of this type of collaboration are yet to be corroborated, and the following benefits are mostly related to BIM Stage 1 implementation.

Even if used without multidisciplinary collaboration, from an architectural point of view, BIM is a very successful way of documenting complicated buildings. As noted by the project architect, BIM 'helps the client quite quickly to understand the feasibility studies and what the full impact of those might be. It informs the decision-making process, so it speeds that up. Some of our clients might focus on the numbers, so BIM allows them to see their numbers in a third dimension and understand some bigger impacts. That helps us a lot. Architecturally, BIM is very successful'.

BIM can also assist in better understanding the scope of works and what people are required to do on site, which in return reduces waste and improves the coordination of trades working on site.

In the case of commercial buildings, like 1 Bligh Street, floor space area analysis is very important. With BIM, the architects are able to do FSA (floor space area) schedules and forward them to their clients with an accuracy and speed unmatched by traditional CAD systems. As noted by the project architect: 'I can create FSA schedules straight away and visually display those areas to the client, which improves the collaboration and relationship back and forth. Actually, I got good feedback from the client on 1 Bligh Street. He told me he has asked the same thing of other architects and it takes them a week to come back, because they do it on CAD'.

While the architects perceived that there is a risk in modelling every corner of the building, it also means that they can reduce the number of RFIs (requests for information) through better understanding and visualisation of the building. On another project (1 Bligh Street was not under construction at the time of the interview), Architectus was able to considerably reduce the number of RFIs because it 'modelled every corner that normally nobody ever sees, and we can chop it off and send it off. That improves the efficiency of the project. That could never be underrated, that is probably the best thing you get out of BIM. It is proactive, informative. Everything that you want for the guy on site'.

However, as noted by the design director, the benefits are not immediately experienced. They are the result of considerable investment and achieved over a long period of time. Another major problem with BIM still remains 'selling it' — getting the client to pay for it. The project architect believes that the best way to sell BIM is to make the client understand its benefits.

BIM training

The architects training approach is that 'you cannot learn Revit®, you need to experience it, you need to live with Revit®'. Architectus favours on-the-job learning over sending staff to training courses.

> *The best training is the one that gives you answers to questions you have right now on current projects. Also, the best person to assist you is the one sitting next to you provided he or she can help. It's a much better solution to rely on someone who knows the project and knows the deadline instead of sending someone to a (training) course.*
>
> ***Design Technology Director, Architectus***

Given that this training strategy requires a balance between people with good Revit® experience and less experienced staff (at the modelling level), Architectus' strategy has an impact on how project teams are put together.

The design technology director also stressed that BIM-oriented training is considered differently and handled differently to CAD training: 'With CAD you learn lines, arcs, circles; very simple; and everything else is built from it. In Revit®, you model components that behave differently, as their real world analogues do'. Thus, an understanding of how all the disparate building elements are put together is integral to learning BIM. As a consequence, training is not only limited to the use of the software, but to the understanding of building components. As declared by the leading modeller of 1 Bligh Street: '[With BIM] I have to constantly think about how things are being built, so I'm not just drawing some lines in 2D. I'm really understanding the way that the building has to work, so from an understanding point of view [BIM] is incredibly more beneficial than drawing in 2D'.

BIM manual

The design technology director has documented most of the office Revit® procedures, and has composed an extensive manual (370 pages) in PDF format which is accessible via the internal network. However, it is not expected that everyone reads this extensive manual. The architects consider the manual far from being a mere set of instructions put together to achieve something. It is considered an encyclopaedia which gathers know-how and solutions to previously encountered problems. People are encouraged to refer to the manual first when a problem arises.

As acknowledged by its author, the manual, despite its length, does not cover everything. According to the design technology director, the challenge of producing a good comprehensive manual is that BIM is non-linear and one thing relates to many others: 'If you start to write about something it goes all over the place. You can't consider areas without thinking about schedules, area plans, colour schemes, etc. But colour schemes could be related to views, not areas and so on'.

Even though the manual is regarded as a good starting point to troubleshoot problems, it is not considered a requirement for a successful implementation.

Technical support

When a Revit®-related problem arises in the office, staff first try to resolve it within their team by asking more experienced users or by consulting the manual. If still unresolved, the problem then goes to the design technology director. If he cannot resolve it, he contacts the Autodesk® reseller (AEC Systems[10]).

This approach, complemented by online forums (e.g. RevitCity[11]), has allowed the company to resolve most, if not all, of its Revit® problems.

Project teams

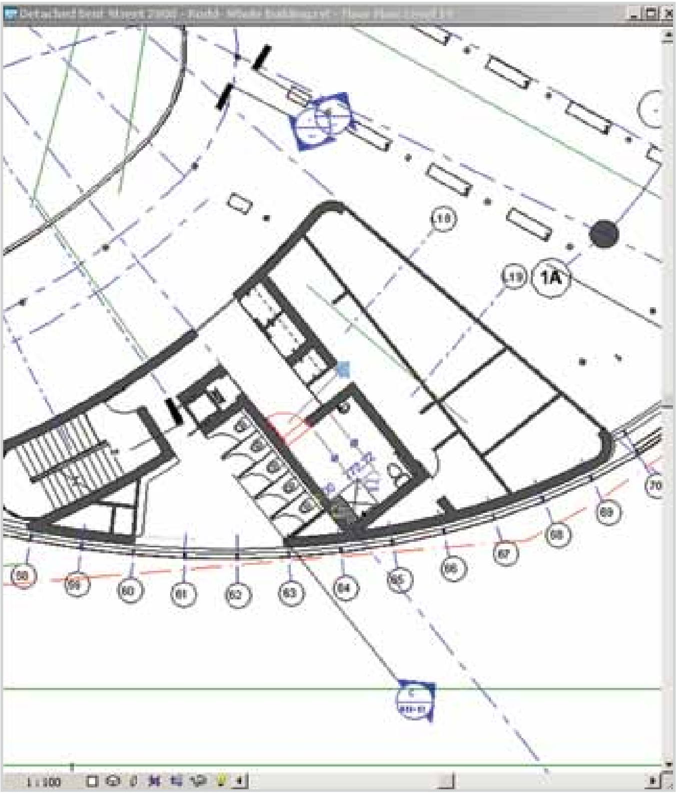
Architectus forms its project teams primarily based on the specific staff experience with the type of project. BIM knowledge, and more specifically Revit® experience, is considered a factor (especially with junior staff), but not a decider in who is in a specific project team. Senior members of the team are selected based on their project capabilities. Junior staff have a mixed level of experience so that they can learn from each other, as previously explained in the training section.

The 1 Bligh Street team is composed of senior staff with sufficient project-specific experience, one Revit® leader (who learnt the software in the office), and a few other members with different Revit® experience so that the team's skill level could improve together. The overall BIM approach is supervised by the design technology director.

10 AEC Systems, refer to http://www.aecsystems.com.au
11 RevitCity, refer to http://www.revitcity.com/index.php

The model

The main model of 1 Bligh Street was developed by Architectus and then shared with the consultants. However, as further described in more detail, the only model-based multidisciplinary collaboration was between the architect and the structural engineer.



2D view of 1 Bligh Street model
Image courtesy Architectus and Ingenhoven Architects

In the opinion of the design technology director, its adopted BIM software has good out-of-the-box content (families): 'There is one of everything. It might not be the one that you want, but is a good starting point; you can then just modify it'. The architects also rely on online communities and other sources, including user groups, for content development. However, the content acquired via these channels does not necessarily align with the architects' system. Still, they found it easier to modify provided content rather than create it from scratch.

Architectus also has a decentralised approach to content creation, and believes that the majority of the people in the office should be able to create content as they need it, and they do. However, all created content goes through a quality check process, and it is reviewed every year, or when an upgrade to a newer version is done. As previously described, this checking process is what is stopping (in part) the upgrade to the new release of Revit®.

Detail level of the model

One of the major problems that the architects had on the 1 Bligh Street model was to define its level of detail, as stated by the project architect: 'You need to choose your level of detail very carefully, and it is not prescribed. It is trial and error'. Still, Architectus has identified three factors that help define the level of detail required in the model:

- the information that is expected to be taken out of the model
- the purpose of the model
- how the model will evolve.

Putting aside the redundant amount of work that unnecessary detailing creates, over detailing can also unnecessarily increase the file size of the model which, among other problems, can (as experienced by the project architect) 'slow down the model to the point that you cannot use it efficiently'. The design technology director is optimistic that the performance of the BIM system will increase when running on a 64-bit platform.

The big file size of 1 Bligh Street (300 MB at the time of the interviews) created problems for the design team: 'It takes 10 minutes for the file to boot up and appear on the screen'. It made navigating and doing changes to the model a slow process, and sometimes even hindered it: 'Right now we want to rotate the building and we can't do that because of the file size and all that is linked to it', said the project architect.

Architectus has implemented three strategies to balance the size of the model without compromising the required level of detail. First, only typical floors are detailed. Second, it relies on 2D line work for detailing anything over 1:20 scale drawings. Finally, it creates different models for different purposes. Although this last approach contradicts the principle of BIM (a single model/database), this 'hybrid' approach allowed it to produce different models with different level of detailing depending on their use. Thus, it had a main model, used for documentation and collaboration with other consultants, and other models for high-end rendering.

> *We did a separate 3D model for the [development application] submission and for the competition to get the best visual quality out.*
>
> ***Project Architect, Architectus***

Multidisciplinary BIM collaboration

As mentioned earlier in this case study, multidisciplinary collaboration using the BIM model only occurred between the architect and the structural engineer. For this, both parties benefited from using the same suite of Revit® solutions (Architecture and Structure). As further explained in the structural engineers section, importing and exporting between the two disciplines was seamless, and did not require the use of Industry Foundation Classes (IFCs – see *Glossary*).

In an attempt to achieve the highest level of interoperability between packages (outside the Autodesk® products), a BIM consultant on behalf of the client suggested the use of IFCs on 1 Bligh Street. Thus, an IFC approach, together with the implementation of a centralised IFC server, was proposed early in the project. However, Architectus considered that an IFC server would require additional resources not included within the scope of the project (e.g. dedicated server and additional software licences).

Furthermore, in-house 'IFC round-trip' experiments done by Architectus using the 1 Bligh Street model highlighted the current limitations of this technology.

One of the first problems identified in these experiments was the large file size that IFCs generate. Given that IFC models are uncompressed and not optimised files (usually four times the original file size), they are difficult and slow to manage. This proved troublesome for a file that was already considered too big, even in its native format.

There was also a considerable amount of extra time required to generate an IFC file. As revealed by the design technology director: 'The time that this process takes [using IFCs] is at least three hours between transfers, three hours compared to nothing [when transferring from Revit® Architecture to Revit® Structure]'.

The architects also experienced data degradation when exporting to IFCs. They attributed this to the fact that Revit® has more categories than IFC classes, creating data loss in the process. For example, in the experiments done on 1 Bligh Street, curtain wall mullions were fused with glass in the model.

Architectus considered that in a project like 1 Bligh Street, where it feels that technology is being pushed to the very limits of its current capabilities, it could not afford to add a developing process to its workflow. It considered it too risky to introduce IFCs in a commercial project.

In addition to these issues, IFC as a term (let alone the technology) is not widely understood in the industry. When the architects offered to export the model in an IFC format, people did not understand what they were talking about: '[When we said to people] "We can export to IFC", [they replied] "Into what?! What is an IFC? How can we use it?" No one understood that', said the project architect.

Internal render of 1 Bligh Street

Image courtesy Architectus and Ingenhoven Architects

Intellectual property

The architects were aware of potential loss of intellectual property by sharing the model with other organisations. Hence, they have developed a 'BIM deed', a legal document prepared by their solicitors. This document established the rules of sharing models and their content between consultants.

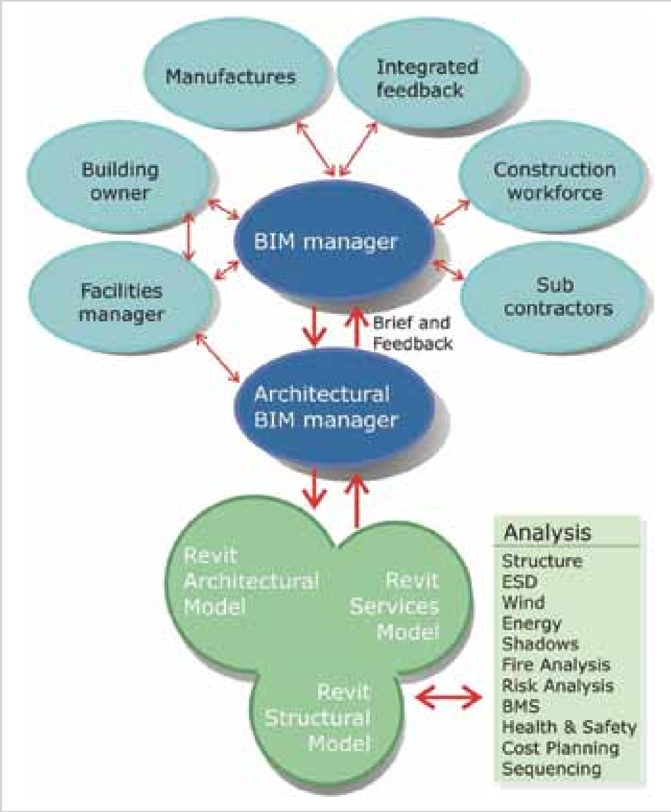
BIM manager role

In this project, the builder contractually needs to supply a BIM model at the end of the project to be used for facility management purposes. However, it is not a requirement that the contractor uses a BIM model during the construction stage, and could do an 'as-built' model at the end of the project. Nevertheless, the contractor is aware of the potential benefits of using the model during construction, and prefers to use the model during this stage. This requires a well thought through communications plan and careful management of the model.

Architectus has developed the following BIM conceptual model for 1 Bligh Street that would allow the contractor to use the BIM model for construction. A key component of this model is the BIM manager.

The role of the BIM manager is to manage the information flow from the architects model (which includes all others consultants) to all the parties involved in the construction and supply chain of the project, as well as other stakeholders (including the owner). Since the flow of information is bi-directional (for example, information could come from the site back to the model), the BIM manager must also be able to update and maintain the model as required.

As defined by the design director: 'The BIM manager is an IT role — somebody who is setting the protocols and driving the knowledge further down through the consultants, minor consultants, contractor and supply chain. A general technical, communication and education role'. It is perceived to be outside the consultancy fee of the architect.



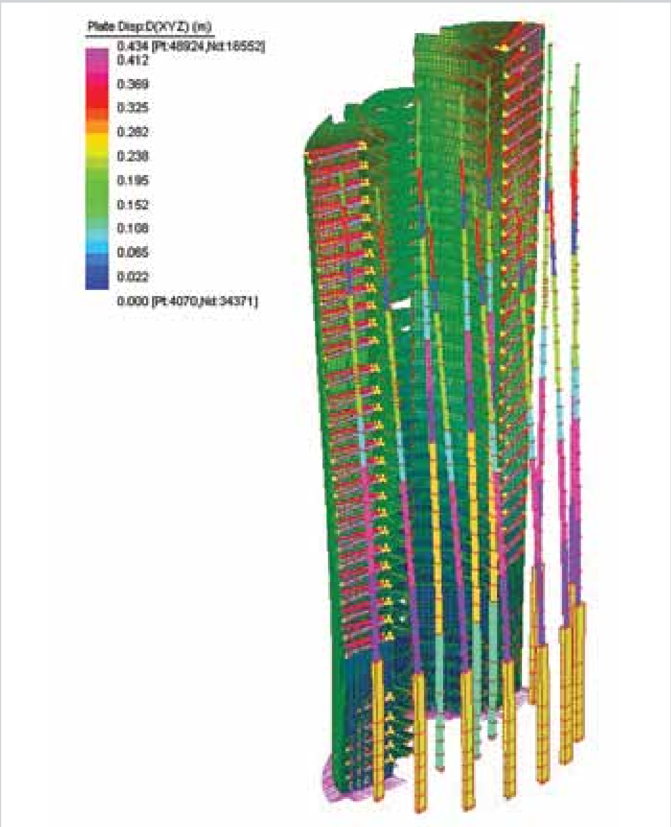
Proposed BIM conceptual model for 1 Bligh Street project

Image courtesy Architectus and Ingenhoven Architects

Given the novelty of this role, it is full of risks (including unknowns) that could be the responsibility of the BIM manager. As explained by the project director: 'Any new, groundbreaking process has risks associated with it'.

Although there are intrinsic benefits in the architect being the BIM manager, the contractor has the option of engaging other companies to fulfil this role, and it has. At the time of the interview, the contractor was evaluating other companies to manage the BIM model, and no one had been appointed as yet.

Structural engineers



Finite element analysis of the structural design using Strand7®
Image courtesy Enstruct

The involvement of Enstruct as structural engineers on 1 Bligh Street started with Stage 1 DA (development application) and continued through design competition, lodging of Stage 2 DA and preparation of the tender documentation. The engineers were then engaged by the contractor to take the design through to construction and completion.

Enstruct is responsible for the entire superstructure building including floor plates, columns, basic structure and foundations. The engineers estimated that their involvement in the project will be between five to seven years in total.

BIM background

Before 1 Bligh Street, the engineers were using and comparing the advantages and disadvantages of structural packages offered by Bentley®[12] and Autodesk®. As a result of their review process, they considered that Autodesk® Revit® Structure[13] would allow them to comply with the BIM requirements set by the client for 1 Bligh Street, as well as their overall BIM strategy.

12 Bentley®, refer to http://www.bentley.com
13 Autodesk® Revit® Structure, refer to http://tinyurl.com/RevitStructure2

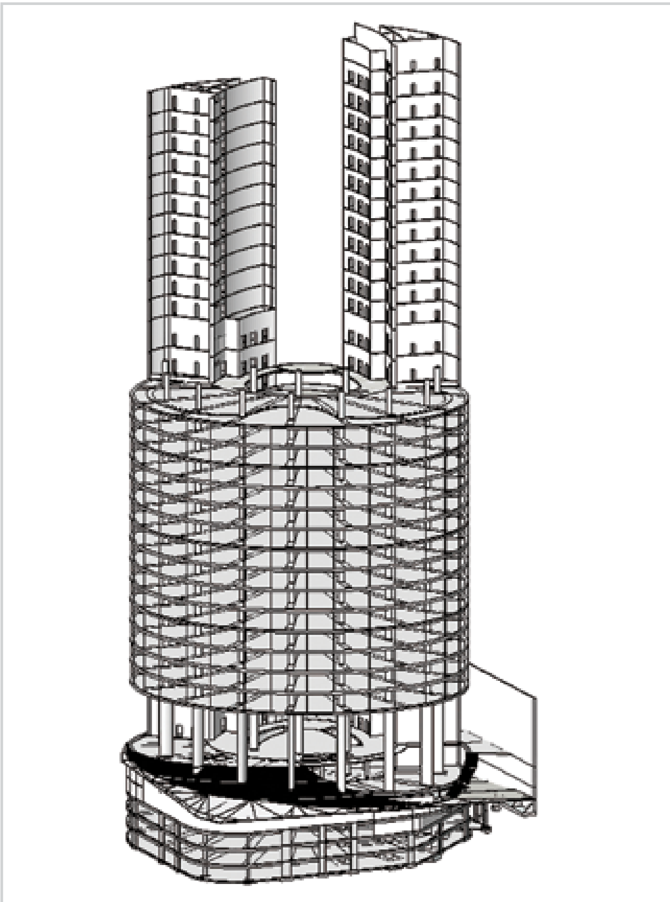
While Enstruct had used Revit® Structures to document projects in the past, the models were only used internally (BIM Stage 1), and the functionality offered by the system was not fully incorporated. 1 Bligh Street was Enstruct's first multidisciplinary BIM collaboration project.

BIM benefits

The first reported BIM benefit experienced by Enstruct was an increase of productivity, stemming from being able to generate multiple views (e.g. floor plans, elevations, sections) from a 3D model. This benefit soon translated into an embedded quality assurance process, because all the views are coordinated by the system rather than manually generated in accordance with, but independent from, each other.

3D visualisation also allowed Enstruct to better understand structures, as noted by the company director: 'Being able to look at something in 3D gives you a far better understanding of what is going on, rather than an old-fashioned 2D plan'.

The structural BIM model



3D view of the structural model in Revit® Structures
Image courtesy Enstruct

Architect and structural engineer model-based collaboration

Enstruct developed its model based on the architects model, and given that structural engineers do not require the same level of detail in their model, the file size is not as large as the architects one. The structural model was reported to be roughly half the size of the architectural.

As previously mentioned, Architectus and Enstruct did not experience problems transferring the model across the two different Revit® platforms (Architecture and Structure).

> *Linking the architects model to our own was seamless; we did not have an issue with it. When we received a new architectural model, I overwrote the last one and there was no drama whatsoever.*
>
> ***BIM Manager, Enstruct***

> *It is seamless to export between Revit Architecture and Revit Structure. That part is very simple.*
>
> ***Design Technology Director, Architectus***

Architectus design technology director attributes this apparent seamless process to both platforms sharing the same file format. He argues that the only difference between different 'flavours' of Revit® (Architecture, Structure and even MEP) is the tools that are in the user interface. The tools are what can be done with the system, but once created, any *'flavour'* of Revit® can read that information and manipulate that information.

While Enstruct has an FTP site dedicated to transferring information between consultants, it is moving towards commercially available electronic document control systems. In 1 Bligh Street, all consultants are using Aconex[14], which was introduced on this project by the contractor. Given the reliability and performance of these types of systems, as perceived by the engineers, they believe that their FTP site will no longer be used for this purpose. However, due to the file size of the model, and the fact that they cannot use Aconex for model collaboration, they shared the model via CDs and limited the use of Aconex to sharing drawings.

Intellectual property

Like the architects, Enstruct perceived a risk of losing intellectual property by sharing the model. The engineers considered that sharing a BIM model could have higher risks than the ones currently exposed by sharing DWG™s (AutoCAD® drawings file format). Enstruct sees its BIM knowledge as a competitive advantage, and believes other companies (competition) can benefit by having access to its models. As pointed out by the director, 'it is probably a bit more risky at the moment because not as many people are using BIM to document things, so we are definitely more sensitive about who we share the model with at the moment'. Still, Enstruct believes that this risk will be less once BIM solutions are more commonly used.

BIM training

Enstruct has a three- to four-year structured apprenticeship program to train young staff on its office and structural detailing procedures. These apprenticeships include training on the various systems used for structural analysis. Revit® training will be included as part of these apprenticeships.

Initial Revit® training in the company was provided by its Autodesk® reseller (CAD Group[15]). During the first training stage, CAD Group sent its training staff to the engineers office, then this was followed by more casual, ongoing training.

While the Enstruct director acknowledged that there is always loss of productivity while training people to use a new package, the downtime 'is far easily outstripped by the benefit that you get from that person when [he/she] knows how to use it'.

1 Bligh Street created a steep learning curve for Enstruct, as it not only required good Revit® skills, but multidisciplinary model-based collaboration.

> *It is the first time that we have collaborated like this. So it is a learning process for everybody involved.*
>
> ***Director, Enstruct***

Although they lack a proper BIM manual, there is consensus by the director and BIM manager that they have achieved a 'good distribution of Revit® knowledge through the drafting

14 Aconex, refer to http://www.aconex.com/

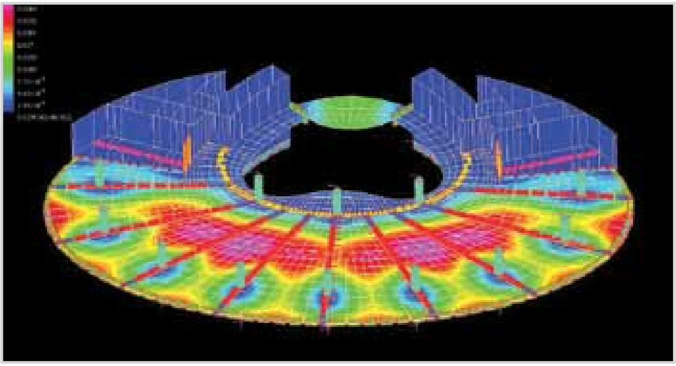
15 CAD Group, refer to http://www.cadgroup.com.au/

side of the office', based on the initial training provided by the Autodesk® reseller, followed by in-house project-based training. Nonetheless, they are looking at documenting the process, in the form of a manual, to standardise procedures.

Structural analysis packages

Enstruct uses an array of software to do various types of analysis. Initially it used ETABS®[16], but abandoned it as it was unsuccessful in making the link with Revit® work. Then it moved to Strand7®[17], which was predominantly used for the lateral analysis of the building. At the time of the interview, Strand7® was not compatible with Revit®, so the structural engineers exported DXFs from Revit® and imported them into the analysis package. However, some information (like loads and materials properties) was lost in this process, and needed to be re-created in the analysis package.

Ram Concept®[18] was another analysis software used for floor plan analysis. As with the other analysis packages, the export/import from Revit® was troublesome, and content needed to be re-created.



Analysis and design of post-tensioned and reinforced concrete floor systems using Ram Concept®
Image courtesy Enstruct

In terms of beam element analysis programs, the engineers used a system called Space Gass. A link between Space Gass and Revit® had just been recently released (two months before the interview).

Despite the previously described seamless link between Revit® Architecture and Revit® Structure, it is between specialised analysis software — like the aforementioned — that interoperability becomes an issue. In the opinion of the engineers' director, a single software system cannot do all the different analysis done by specialised analysis software: 'I cannot see one package doing everything, all things to all men, I cannot see it doing that'. Thus, the need for interoperability.

Like the architects, the engineers also experimented with IFCs and attempted to perform 'round-trips' between the packages. They found the process of having to export the model to an intermediate file (IFC) to be 'not optimal'. As suggested by the director: 'The way to do it would be a direct link. It would be very clunky to export something to an IFC and then into this [a different package]. Then to go back, you have to go back to IFC ... I do not see that as being the future'.

On the other hand, the architect's design technology director preferred not to use a single BIM model across packages, and was comfortable having the structural engineers working on exports with a human interface in between. This was basically because structural packages (mainly UK or US software) might do the analysis based on different assumptions than the ones required in Australia. Thus, the architects prefer the analysis to be made in a separate model, with any changes first reviewed and approved by the structural engineers and then made in the collaboration model. To allow that, monitoring tools were used to track and coordinate changes between the structural and architectural models.

Collaborative trust

Trust between consultants was identified as a key factor (as important as the technological aspect) for good multidisciplinary BIM collaboration.

Based on years of collaboration, Enstruct and Architectus have developed a level of trust that has allowed them to collaborate to the point of jointly developing BIM families. This process allows each party to ensure that the model will have information that is relevant to them — as well as to the other consultants.

> *Architectus have specific requirements for their families. They worry about the surface finish on the wall maybe. Whereas for us, we are only really concerned about the thickness of the concrete structure, we do not care about the surface finish. So in terms of setting up families we are collaborating with them now. So they can set their requirements in the family and then structurally we would add in instance parameters like the concrete strength.*
>
> **Director, Enstruct**

16 ETABS®, refer to http://tinyurl.com/etabs2
17 Strand7®, refer to http://www.strand7.com/
18 Ram Concept®, refer to http://tinyurl.com/RamConcept

New/Unresolved	Structural Columns	Check whether an Element exists	Element deleted	Bent Street Revit 2008 - Architectural 07-08-06.rvt : Structure : Columns : AS_Concrete - Ellipse Column : 1200 x 2400mm Ellipse : id 6102117
New/Unresolved	Structural Columns	Check whether an Element exists	Element deleted	: (Deleted element) : id = -1 Bent Street Revit 2008 - Architectural 07-08-06.rvt : Structure : Columns : AS_Concrete - Ellipse Column : 1200 x 2400mm Ellipse : id 6102116
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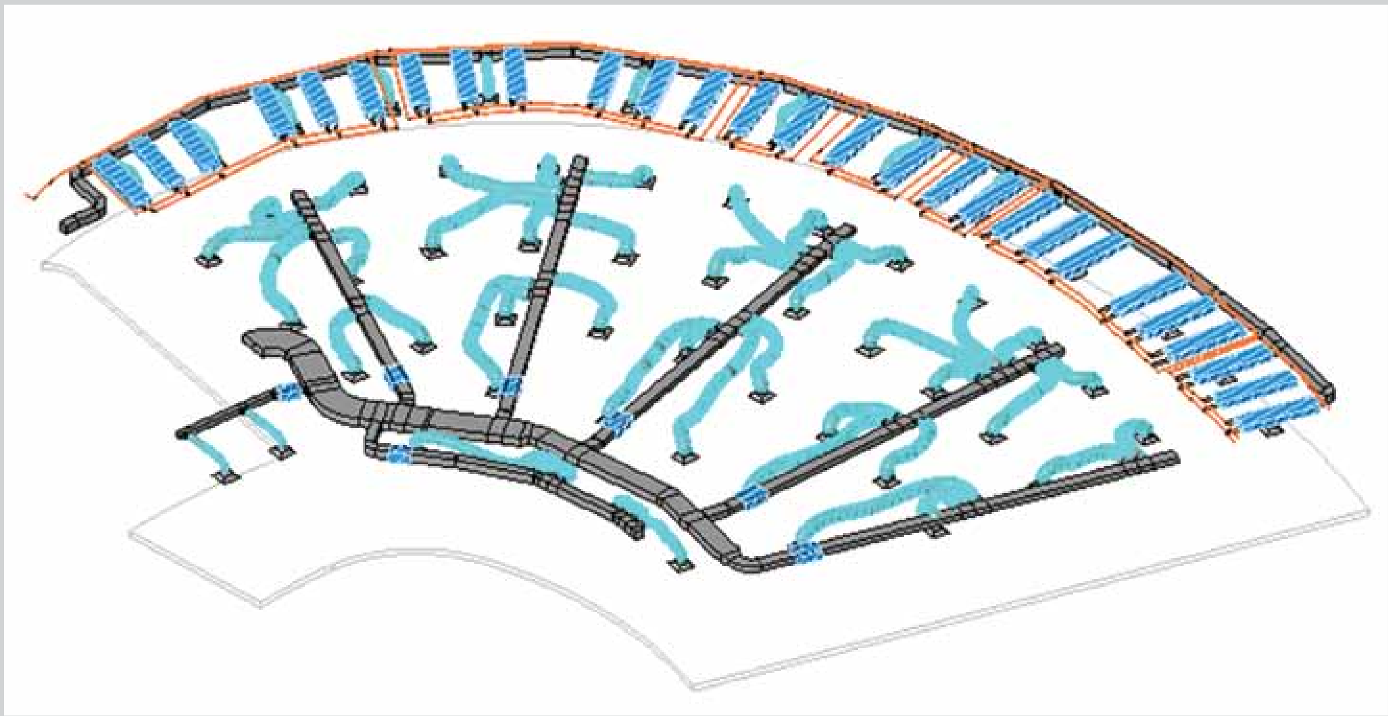
Structural coordination report generated by Revit® Structure

Image courtesy Enstruct

Services engineers



Mechanical services of a typical floor using Revit® Services
Image courtesy Arup

Arup are the services engineers of 1 Bligh Street project — responsible for the mechanical, electrical and fire services, as well as being the façade design consultants.

While the engineers used Revit® MEP (services) to model a typical floor, it was not used to produce the documentation. Services documentation was done in AutoCAD® and AutoCAD® MEP®.[19] As recognised by the services engineers and the rest of the 1 Bligh Street team, mechanical, electrical and plumbing (MEP) services were not part of the BIM model.

Arup's project director identified the tight program and the complexities of producing services documentation using BIM as the two main reasons that prevented MEP services being included in the BIM model.

> Today, for MEP services BIM requires more time to document than traditional methods.
>
> ***Project Director, Arup***

1 Bligh Street was the services engineers team's first BIM project, and at the time it lacked the content (families) required for the model. As opposed to the view of the architects, the services engineers felt that the out-of-the-box content included was poor, and developing it would take a considerable amount of time with an already tight deadline.

> *We have to draw every component. The data in a chiller is totally different from the sort of data that you get out of a concrete slab. There is much more involved in getting everything right, you need to have all your data correct first.*
>
> ***Project Director, Arup***

Nevertheless, Arup did some isolated simulations, including a thermal simulation, to calculate the sizing of the air conditioning equipment.

In parallel, the project director is also concerned that BIM could be perceived as a potential threat for MEP subcontractors. As described, one of the advantages for MEP subcontractors is that, when they receive a design from a consultant, they can increase their profit by modifying what the consultant has proposed in a way that achieves the same

19 AutoCAD® MEP®, refer to http://tinyurl.com/AutoCADMEP

performance, but in a more economical way. Therefore, the more documentation that is given to the subcontractors, the less room there is for them to modify the design.

> *We thought that if we developed a BIM model and gave it to the subcontractor we would save them a lot of work. While it would save them a lot of work, it would take away their ability to make some money in the grey areas.*
>
> ***Project Director, Arup***

Moreover, as noted by the contractor's (Grocon's) design manager, in a design and construct project like 1 Bligh Street, it is the contractor — through its subcontractors — that produces the services documentation for the design. Thus, it will ultimately be up to the subcontractors to develop the services BIM model.

> *For the mechanical, the hydraulic and electrical services we go straight to our subcontractors and they will document it in Revit®.*
>
> ***Design Manager, Grocon***

It is expected that 1 Bligh Street will have a complete BIM model once the subcontractors model the services.

Team commitment to BIM

According to the BIM modeller, the people in its organisation that were the most highly skilled in BIM were so because they were personally involved and interested in it, 'like a hobby' or 'a video game'. Finding people with this passion was seen as the key to a successful BIM implementation.

All in all, there is consensus from the project director and BIM modeller that BIM will become the norm in the future.

> *We strongly believe BIM is the way to go, we want to be in the future before anybody else ... but it is taking time.*
>
> ***Project Director, Arup***

The contractor

Grocon was the chosen contractor after a successful tender for the construction of 1 Bligh Street, and had already taken possession of the site at the time of the interview (July 2008). However, the contractor has one year's worth of demolition before construction starts.

As previously mentioned, BIM was a client requirement from the inception of this project, and although the consultants have developed the main model (with the exception of MEP services), the contractor is obliged by contract to submit an 'as-built' model at the end of the project. 1 Bligh Street is the company's first BIM project (nationally and internationally), and Grocon perceives itself as a pioneer in implementing BIM during the construction stage in Australia. As a result, the company feels hesitant about what to expect out of BIM. As remarked by the Grocon design manager 'we can see the ultimate advantage, but are finding it not quite as simple as some people want us to believe'.

> *Potentially and theoretically [BIM] is a great idea, but we see some issues. There are not that many projects that have been done with it. A lot of people claim they have done it, but in fact we found that they haven't. They do BIM wash.*
>
> ***Design Manager, Grocon***

BIM benefits

The design manager anticipates that the following benefits could be gained by embracing BIM as a contractor.

One of the most significant benefits expected from BIM was receiving fully coordinated (including clash detection) documentation from consultants. It was expected that building from a coordinated model could translate into smoother construction.

> *The whole sales speech of BIM is that it will not change on site, because theoretically you built this cyber building, so we just have to build it that way. If BIM is truly successful, all the clash conditions that we currently experience on site will be resolved by the consultants at the documentation stage.*
>
> ***Design Manager, Grocon***

3D visualisation closely followed as the next benefit. The design manager believes that having access to a 3D model on site would improve the understanding of the design, its communication and planning between trades. Thus, they were prepared to make some changes to be able to benefit from 3D visualisation on site.

> We want every laptop to have a model viewer so they can access the model and view the elements for the area that they are working on.
>
> ***Design Manager, Grocon***

The design manager also has expectations that BIM will assist them with construction estimating, scheduling and programming.

Even though the design manager could see the benefits of 4D modelling, he identified current skill incompatibilities that are preventing this technology from being successful. While Grocon has experienced programmers in construction and procurement processes, who know very well how to develop a good construction timeline, they cannot produce a 4D model because they do not know how to use specialised 4D software. On the other hand, the people that might know how to develop a 4D model do not have the same level of experience and knowledge to develop an accurate program.

Despite the above benefits, it is the design manager's point of view that the discipline to benefit most from BIM will be facilities management.

Subcontractors

One of the selection criteria for the subcontractors on 1 Bligh Street was their ability to work with a BIM model.

> *It could be said that in the BIM sense, we are as good as our subcontractors. But we are actively bringing them forward so that we can deliver a project and in our next project we would have that [expertise].*
>
> *We are enabling the subcontractors for other builders, but you can't avoid that.*
>
> ***Design Manager, Grocon***

Interoperability

The design manager is aware that subcontractors might have to remodel the Revit® model provided by the consultants, as it might not be compatible with the subcontractors' specific manufacturing softwares.

> *The problem I see for the industry is standardisation. The link between different platforms will be the key for BIM to work.*
>
> ***Design Manager, Grocon***

However, there is disbelief that current efforts are successful.

Training

The design manager commented that, as builders, they do not see themselves developing expertise in BIM beyond the ability to visualise the model. Thus, they will rely on a BIM manager (e.g. architect or Autodesk® reseller) for the coordination of the model. The BIM manager will then become another sub-consultant for them. Refer to BIM Manager section.

However, he also acknowledged that their site engineers would have to be trained, 'because right now they are quite competent technicians with a construction focus, but they are BIM illiterate'.

The design manager commented that due to BIM, their site engineers will tend to have a higher IT skill level. Thus, BIM could be advantageous for less experienced people (e.g. recent graduates) 'as they can be given a higher level of responsibility than they would normally have due to their IT skills'.

In summary

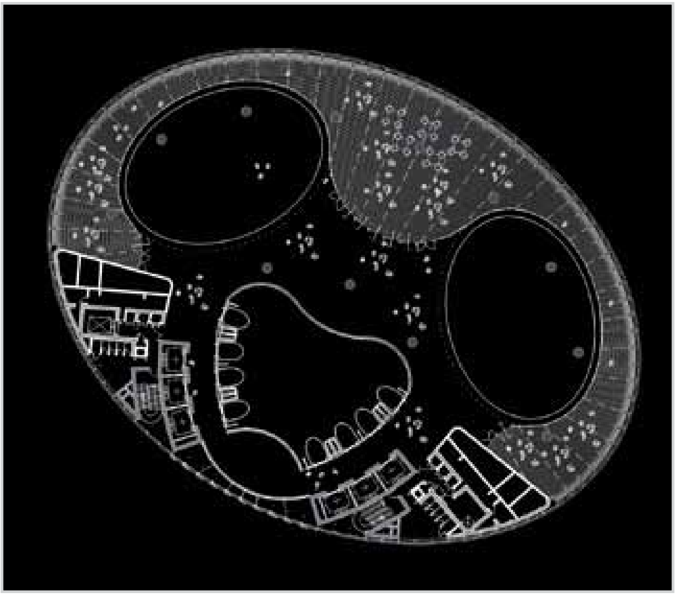


Image courtesy Architectus

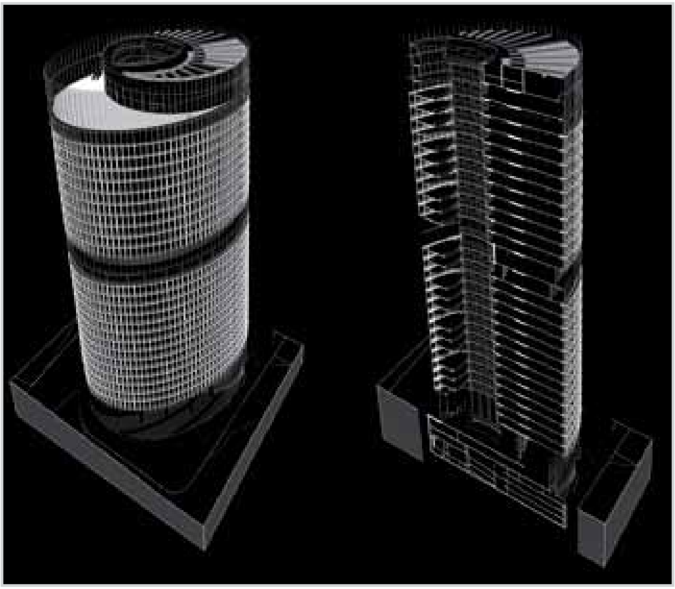


Image courtesy Architectus

1 Bligh Street is one of the first commercial projects in Australia to implement multidisciplinary BIM collaboration.

There were different levels of BIM implementation across the consulting team. The architects had the most experience using BIM and led the implementation.

Collaborative trust was found to be an important factor for multidisciplinary BIM collaboration. The closest BIM collaboration was between the architects and the structural engineers. Interoperability issues between them were minimised by relying on a common BIM platform. However, interoperability was still an issue and a source of rework between specialised analysis software used by the structural engineers. Consequently, there is some scepticism that the current interoperability efforts in their present state are successful.

A 'BIM manager' — a new role identified by the architects — is needed to coordinate the information flow between stakeholders and maintain the model during the construction phase. The BIM manager role was believed to be beyond the original scope of the standard architect consultancy. Given the novelty of this role, it was perceived as quite risky, with many unknowns.

Services (MEP) were not part of the BIM model. However, it is expected that the subcontractors will complete the services components in the as-built BIM model.

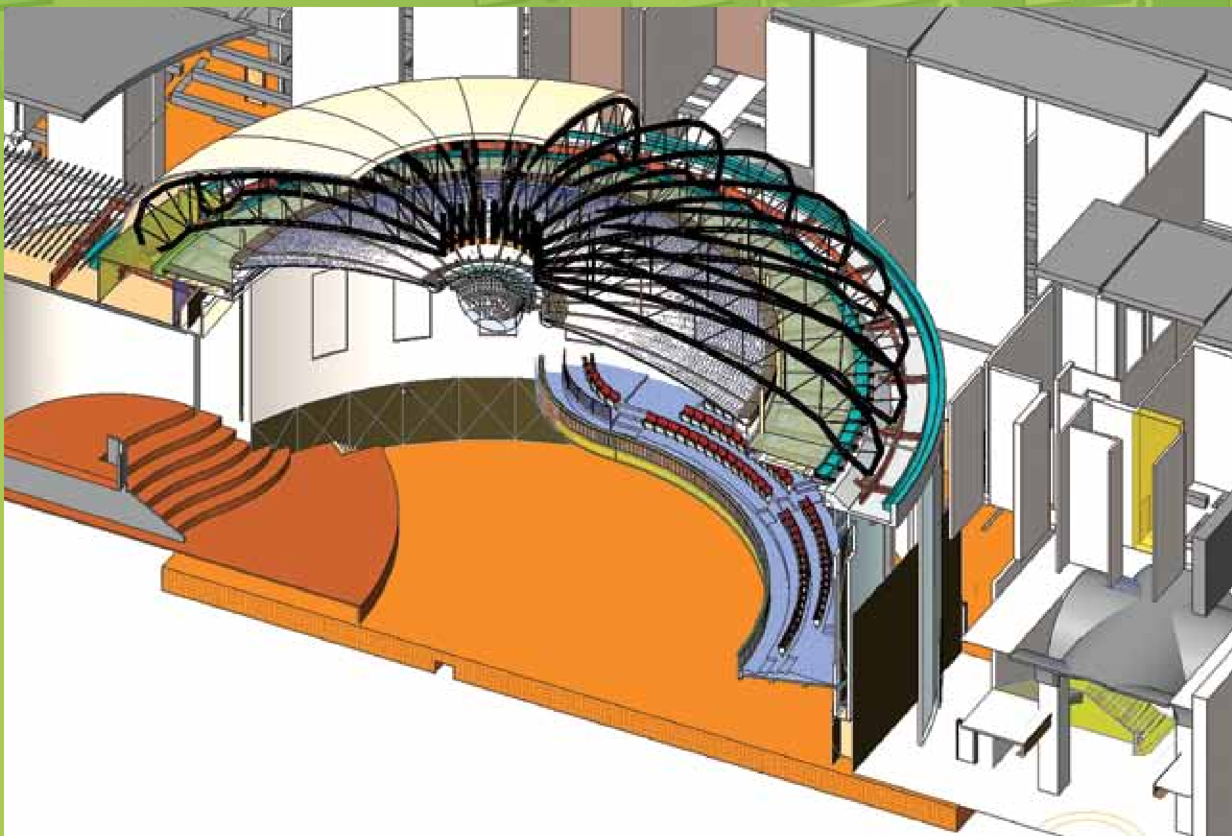
In terms of training, on-the-job learning was the preferred long-term strategy. Documenting BIM procedures in the form of a manual was considered valuable, but not essential for a successful BIM implementation.

3D visualisation is one of the main benefits of BIM as perceived by the consultants and the contractor. The architect also stressed that fast access to accurate building information is a major benefit of this technology.

While the contractor seems convinced of the benefits of using a BIM model for construction, they are yet to experience the actual benefits of BIM firsthand. The ability to use BIM was included by the contractor as one of the selection criteria for subcontractors.

Case study 4:

Brisbane City Hall



Brisbane City Hall Auditorium roof model

Images Case Study 4 courtesy Brisbane City Council

This case study discusses the experiences of an architectural team as it undertakes its first pilot Building Information Modelling (BIM) project. The project selected is a complex multi-layered heritage structure posing a number of challenges and opportunities. The choice of the pilot project and its project team is atypical and provides more than one lesson to be learned.

The client

The client is City Assets (a purchasing services group) and City Hall Management (the main stakeholder), which manages City Hall on behalf of the Brisbane City Council (BCC).

The organisation

The interviewees are part of the Built Environment Group consisting of three building services engineers, around 19 architects and design managers and around 15 landscape architects. The project managers and structural engineers are part of City Design's Project Management & Structures Group within the BCC. The above disciplines and staff are part of the Brisbane Infrastructure Division. BCC handles many types of architectural and engineering jobs including parks, libraries, pools, amenity/park structures and bus depots.

City Hall – aerial view

Case study participants

The design manager and architect are members of City Design and four interviews were conducted covering their roles in the Brisbane City Hall Project.

Design manager

The design manager responsible for the City Hall Project joined City Design in early 2008. With a background in heritage architecture and services engineering, he has no background knowledge of BIM concepts and did not receive any BIM tool training before assuming responsibility for this project.

Architect

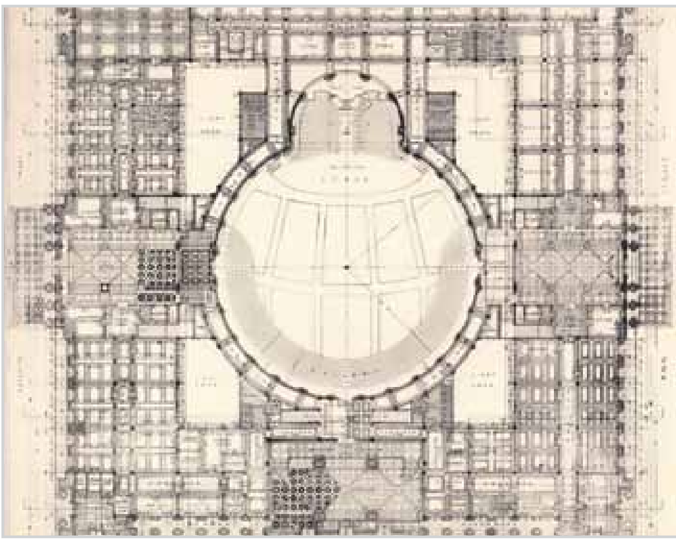
The architect was one of the first staff at City Design to embrace BIM and had three days off-site training in Revit®. She is currently working on multiple library projects, and her role typically ranges from schematic design to contract administration.

BIM modeller 1

The first BIM modeller joined City Design in the past two years and has a CAD drafting background. After being selected to work on the City Hall project, he received three days offsite-training in Revit® Architecture.

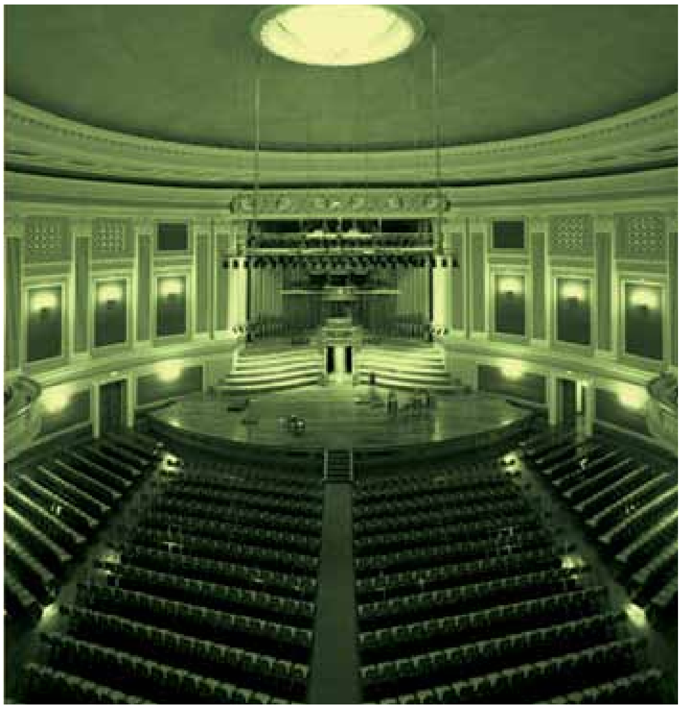
BIM modeller 2

The second BIM modeller joined City Design to specifically work on the Revit® platform and had not received any formal BIM tool training before joining the project team.



City Hall – legacy hand-drawn plan

The City Hall, a challenging building



City Hall – auditorium view 1

City Hall – auditorium view 2

The City Hall[1] was built in the 1920s and is now due for a services upgrade and other works to improve fire safety throughout the building. The services and fire upgrades included the need for compartmentalisation, adding fire alarms, sprinkler systems and fire treatment of the steel structures. The fire-risk reduction strategy is intended to not only to reduce threats to occupants, but also protect the heritage-listed building itself.

City Hall is landlocked within Brisbane, has an original structure, original finishes and original spaces, which are all heritage listed. There are limited vertical services shafts that can be used for the services upgrade, and there are pre-existing uses of the roofs preventing location of new service plants where actually needed. In addition to the complexities of the building itself, there are external rigging consultants as part of the project team. All this invariably increased the complexity of this project and increased its challenges.

The City Hall is under review by the Lord Mayor through a special committee (October 2008), which is expected to lead to a much more extensive program of restoration and maintenance. The architect aims to provide the fully modelled project to assist in that review. Room allocation to councillors and commercial use will also be decided. Accordingly, no construction program has been generated yet, noting that the project manager is also part of the BCC.

Modelling the City Hall

The architect received a succinct 17-point brief from the client, and City Design considered using 3D modelling to simplify the complexities of the project and meet the provided brief. In light of the three-dimensional nature of the problem, the design manager took the opportunity to model the building and integrate the architecture, structure, services and heritage layers that needed to be analysed and understood in context. The fire protection effort has been the major driver for modelling the whole building, but the architects calculated that the model may eventually play a role in facility management.

The project started in earnest in March 2008, and was mostly resolved by December 2008 using two full-time modellers with design detailing experience. The design manager coordinated the team, including the fire engineers who were part of the BCC team, and the services engineers who were external consultants.

1 Brisbane City Hall, refer to http://tinyurl.com/CityHall

City Hall – model of auditorium and adjacent spaces

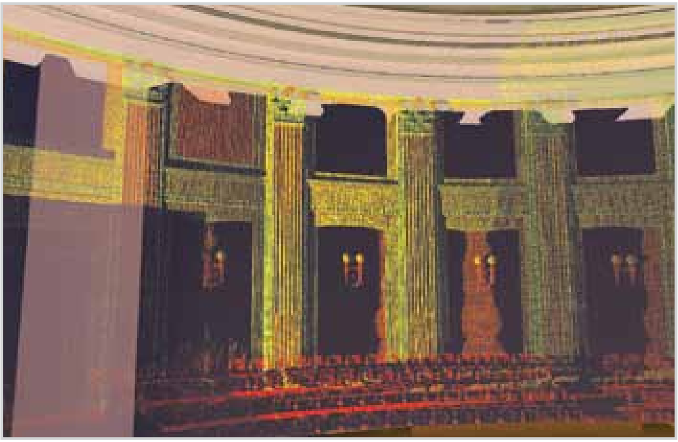
The BIM process

The modelling of City Hall was based on dimensions taken from site, legacy CAD and hand-drawn archive documents. Using this data, the City Hall was first modelled in ArchiCAD®[2] during the sketch design phase. At this stage, the model was used to generate a couple of studies — thermal analysis through Ansys® TAS[3] and daylight studies through Autodesk® Ecotect™[4]. After that, the City Hall was modelled using Revit® Architecture after the software was introduced in late 2007.

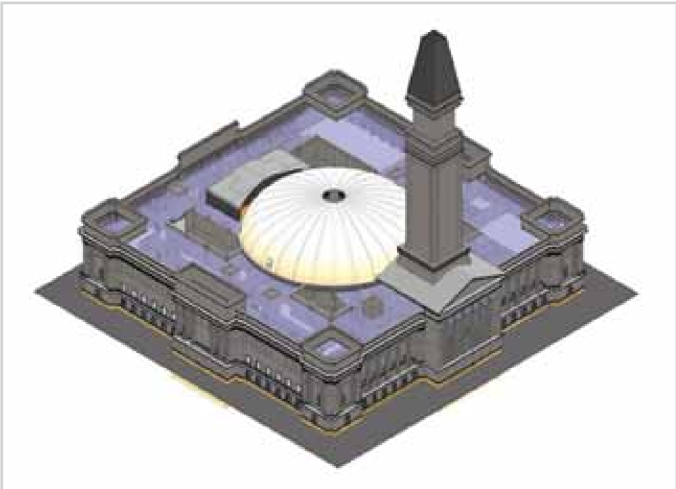
Laser scan study

During the progression of the Revit® model, it was overlaid with a laser dot-cloud survey to test its accuracy. The laser scan was generated by a third party, and the study covered the round auditorium and surrounding foyers. The laser survey was delivered in 3D Studio Max format (around 2 MB in size) and then imported (as DWG™ format) into the Revit®[5] model. On comparison with the overlay, the laser survey proved to fit 'like a hand in a glove' as it meshed 'beautifully' with the Revit® model. This was a critical consideration in establishing an accurate 3D profile of the existing curved ceiling, located 20 metres above the floor and out of reach. Only with this accurate information could the new ceiling then be designed.

The project was first modelled generically (e.g. using generic walls) based on the available legacy CAD and hand-drawn data. When more accuracy was deemed necessary for a specific area or room, a visit to the site would ensue and more up-to-date measurements would be taken. According to one of the modellers, countless site visits have been conducted to crosscheck the legacy information against actual site conditions. As the project progressed, each of the modelled elements was given a code (0 through 4) designating its heritage sensitivity, where the highest code (4) designates a heritage status preventing any modification to the on-site element.



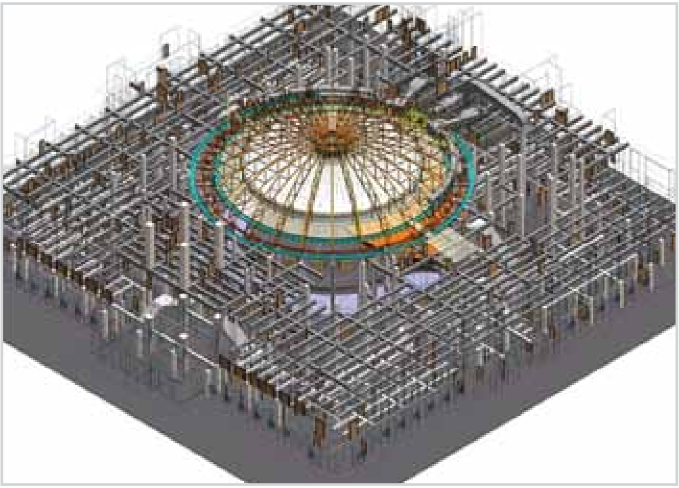
City Hall auditorium – laser scan superimposed over object-based model



City Hall – BIM – axonometric view

2 Graphisoft® ArchiCAD®, refer to http://www.graphisoft.com/products/archicad/
3 Ansys® Thermal Analysis System (TAS), refer to http://www.ansys.com/Products/tas.asp
4 Autodesk® Ecotect™, refer to http://ecotect.com/home
5 Autodesk® Revit® Architecture, refer to http://tinyurl.com/RevitArch

The design manager would sit next to the modellers as they generated the 3D model and would sometimes include the in-house structural engineer in on-screen discussions. However, the architectural modellers took responsibility for modelling the existing structural trusses after taking extensive on-site measurements. The architect has also encouraged the services engineers (BECA[6]) to use BIM and provided them with regular updates of the architectural model. After some 'hesitation', the engineers resolved themselves to generate an independent model — using Revit® MEP[7] — which included new ducting routes for the auditorium area. Project managers (part of the City Design group) had access to the continuously updated model from their site offices, and used the access for monitoring progress, responding to client enquiries and providing up-to-date modelling to the services engineers.

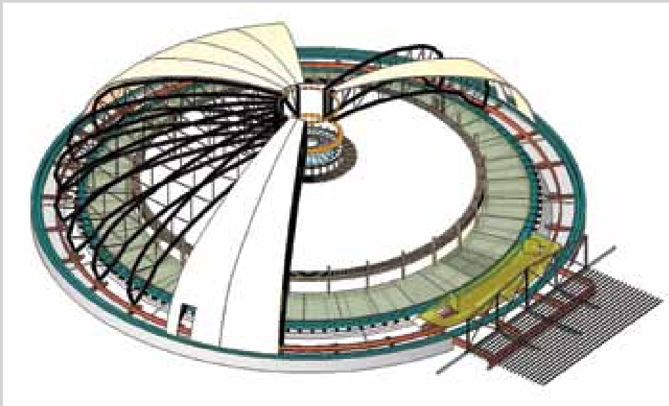


City Hall – BIM showing the structural layer

The 3D model was used to manage the complexity of the project. Some of the design studies (like the new entry door system) were modelled in SketchUp®[8], while most of the building was modelled in Revit®. According to the architect, the Revit® model included a lot of information and produced 'complex pictures' — a counter intuitive product of this process. This complexity has discouraged the architect from showing the model to the client until more suitable visuals are generated.

Implementation, training and support

City Design started deploying Revit® in March 2008 and — at the time of these interviews — had up to seven Revit® Architecture, two Revit® Structure and one Revit® MEP licences.



City Hall – 3D model of the central dome showing layers of existing and proposed building fabric

The architects at City Design were the first to receive basic formal training, followed by the engineers. Also, City Design engineers met their counterparts at Project Services (Queensland Department of Public Works), shared ideas about BIM and adopted some of their BIM-specific standards

While one modeller expressed an opinion that learning Revit® is 'easy', another expressed a feeling that, with only three days of basic training, he 'was thrown into the deep end, to sink or swim' when placed on such a complex and layered project. The lack of sufficient training has manifested itself in modellers using the wrong tools to manage their workflow (e.g. using the 'worksets' work-subdivision tool in Revit® as a layering system). It also appears that Revit® implementation was not based on a carefully prepared implementation plan (e.g. basic components were not prepared beforehand, but were being generated 'on the go').

The BCC receives support from its Autodesk® reseller, and has access to short training videos developed by a third party (CADclips) and an online service (based in Canada). There is also an internal CAD newsletter.

There is an apparent high regard for what the BIM team is attempting to achieve at City Design, as CAD drafters who used Revit® on this project were labelled as 'champions' by many of their colleagues.

6 Beca Pty Ltd, refer to http://tinyurl.com/BecaEngineers
7 Autodesk® Revit® MEP, refer to http://tinyurl.com/RevitMEP
8 Google® SketchUp®, refer to http://sketchup.google.com/

A final note

Because of the sensitivity of this project for the BCC and the strict confidentiality agreements governing the remodelling/upgrade project, some information cannot be shared at this investigation stage.

While that may limit the amount of information accessible to the research team and conveyed through this case study, there are many successes and lessons learned that can be shared. One such success is the courageous selection by City Design to undertake a complex multi-layered project as its pilot BIM undertaking, driven by the necessity to integrate the many constraints within the building. City Hall and the spirited BIM team working on it have generated many evident results.

Case study 5:

Joint Contact Centre Zillmere Queensland

JCC Zillmere – external perspective

JCC Zillmere – internal perspective

Images Case Study 5 courtesy Project Services (QDPW)

This case study explores the collaborative processes used between the various disciplines to test the adoption of an approach to Building Information Modelling (BIM) moving towards the construction of a 'virtual building'.

At the same time, the project is seeking to achieve a 6-star Green Star outcome, while delivering a quality project on time and on budget.

With an emphasis on green design, the team faced many challenges, not only with the integrated modelling, but also with the stringent requirements imposed by the Green Building Council of Australia. The design team worked to ensure these targets where met, and gained valuable experience for future integration of building modelling and Green Star projects.

This case study is an overview of the knowledge gained and the issues experienced by many stakeholders involved in the planning, design and construction of the new Joint Contact Centre (JCC) in Zillmere Queensland.

A primary objective for the project was to enhance design methodology across the discipline team to include an integrated, multidisciplinary 3D model for the project. This enabled the model to be shared with the tenderers and their supply chain to better inform the delivery of the project, and to ensure the project meets the stringent Green Star requirements.

Project overview

Introduction

The Zillmere JCC is targeting a 6-star Green Star rating (Office Design, Office As-Built and Office Interiors) and to be a purpose-built, accredited facility housing the Queensland Police Service (QPS) and Smart Service Queensland (SSQ) call centres. The development has been designed as medium density commercial office space, containing 4686 m^2 of net lettable area. These departments will jointly operate 24 hours a day for non- emergency police calls and general government services, with the ability to operate as a 000 call centre in an emergency situation.

The project and its stakeholders

Major stakeholders in the JCC Zillmere project are:

- **The Accommodation Office —** client — a group within the Queensland Department of Public Works. The Accommodation Office's role is to provide government departments with the accommodation needed to support the delivery of services across the state of Queensland.
- **Project Services** — project management, design, documentation and sustainability services — a commercialised business unit within the Queensland Department of Public Works providing professional services across all disciplines.
- **Glenzeil Pty Ltd** — contractor — a privately owned commercial construction company based on the Gold Coast.

A note on planning

Planning and design for the JCC focused heavily on the end user tenants, both being operators of a call centre. The building is a Class 5 office building to accommodate up to 460 employees, and incorporating large open spaces, call rooms, meeting rooms, training and support spaces and a small café.

It proved to be possible to change the client's habits with regard to their current computer infrastructure. They have approved the installation of HP Thin Client virtual hardware instead of conventional workstation computers. These machines are half the size of conventional machines and have dramatic power savings associated with their use.

JCC Zillmere – external perspective

JCC Zillmere – internal perspective

Model-based collaboration

The JCC Zillmere project was used to further continue the benefits of collaborating with all disciplines of the design team by creating an integrated 3D model. This process requires extensive communication between all parties and has significant benefits to the overall project.

The collaboration process

The model allowed various disciplines within Project Services (PS) to collaborate and work more efficiently in a team environment. This included using the model to check for clashes between architectural elements (e.g. rooms, separation walls, doors and windows) and service requirements (e.g. duct and pipe routing).

Heating, ventilation and air conditioning

From pre-design, an energy model was used to best achieve a green building with the stringent requirements of the client and the Green Building Council. The software program, Integrated Environmental Solutions (IES), was used to analyse energy, lighting and daylight, and mechanical services. The energy model was initialised using mass modelling, with multiple options analysed to achieve the best building orientation and HVAC system, and the most suitable façade design.

Electrical engineering

The electrical engineers at PS used Revit® MEP and IES for electrical modelling and analysis, and linked their modelling into the current architectural integrated model.

The original architectural modelling was enhanced by the use of Revit® MEP functionality and was not limited to power, voltage and photometric data. All electrical data was modelled in 3D, including materials data and rendering, which provided valuable ongoing knowledge during all stages of the design and construction.

Training, support and documentation

The PS design team emphasised the need for training and support to be adequate for the effective use of the software throughout the project. Architects and engineers took part in internal training sessions for Revit®, Revit® MEP and IES to better familiarise themselves with the enhanced functionalities of each software package.

Design process

The initiative

A directive from senior management was to progress the initial 3D integration used on the North Lakes Police Station Project and deliver the JCC with full 3D integration between PS disciplines. The design team used the same BIM integration tools and principles for sharing information. The project was chosen for its complexity, not only in design and construction, but also due to the green design requirements. The project had to be delivered on time and on budget, yet allow for further investigation and implementation on model data management, and achieve a Green Star design outcome.

Project workflow summary

In general terms, the project's workflow was as follows.

Project initiation and schematic design

The client supplied a design brief to PS detailing its requirements and objectives for the JCC project.

The initial design work was created using ArchiCAD®, as it was the software preference of the internal design architect. Affinity was also used to link the ArchiCAD® model to the design brief, as this enabled confirmation of any design changes which affected the design brief.

At the same time, the services engineers were preparing preliminary designs in IES.

At Schematic Design Stage, the initial model by the architectural team was discontinued because of limitations on resources experienced in working in ArchiCAD®. A decision was made to continue the design development in Revit® 2009, the alternative architectural modelling software used by PS, as it was the program more able to accommodate the specific needs of the secondary disciplines within the PS Brisbane office.

In addition, the majority of services engineering disciplines had adopted the Revit® MEP (mechanical, electrical and plumbing) program because of the advantages that it was seen to provide over other alternative software used to that time.

3D use within the project:

Architecture
Revit® Architecture 2009

Structural
Revit® Structure 2009

Mechanical
Revit® MEP 2009

Electrical
Revit® MEP 2009

Communications
Revit® MEP 2009

Fire services
Revit® MEP 2009

Hydraulics
Revit® MEP 2009

Office interiors
ArchiCAD® 11

Civil
12d Model®

Quantity surveying

The base cost plan was compiled using traditional quantity surveying techniques from a 2D dwfx drawing file. In parallel with this, as a check and a concept evaluation, analysis was conducted from the 3D dwfx database file into both the CostX® 3D (beta version) and CostX® 2.82. Both resulted in bulk quantities being reviewed against the base cost plan, with varying degrees of quality of the data output. Feedback was provided back to both consultants and the CostX® developers as to the quality of the information obtained, from which further significant progress has been made.

Design development

The architectural Revit® model was built collaboratively between an architect working from the Toowoomba office and technical staff in Brisbane, using the wide area network (WAN) available to the business. The architectural model was linked to each discipline to avoid rebuilding individual components in each software package. This approach may not always be possible for consultants working in different offices and different locations because of network and computing facilities complications. However, because of the multidisciplinary nature of the team at PS, it is achievable, with architects and engineers working in the same building, with the same IT infrastructure, and having a good working relationship.

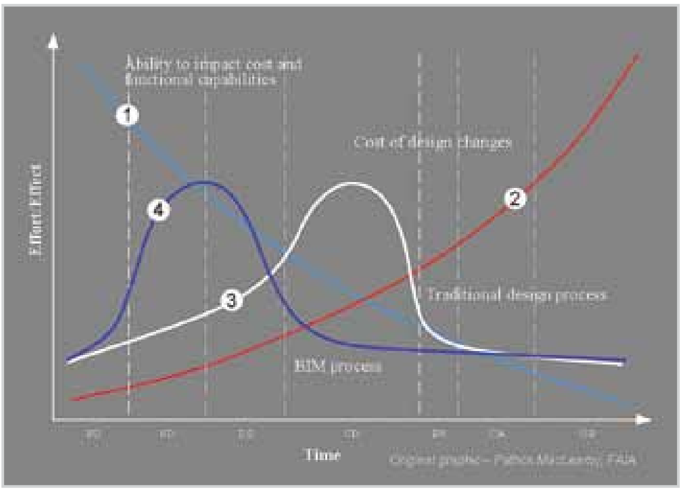
An important benefit is coordination and collaboration, with a large number of elements common across the disciplines. Columns, walls and floors are elements featured in both architectural and structural documentation, although this is less common with other disciplines. For example, ductwork included in mechanical documentation is not necessarily duplicated in the architectural documentation.

Creation of the topography for the site was based on a 12d Model® point file, which provided preliminary site levels. Drafting staff then created proximity of the finished site for use in the elevation and section views, as well as the 3D views for overall presentation purposes. Even though the topography created is believed to be a very accurate interpretation of the civil engineer's design, no references were made to any levels to avoid any possible inconsistency with information that might be indicated on the 2D civil contract documentation (CD).

It was intended that all documentation teams would have their 3D models 75 to 80 per cent CD completion by the end of the developed design (DD) stage. An intense amount of forward decision making was required from the principal consultants to allow this to happen.

However, due to the very complex nature of the Green Star outcome planned for this project, and because of late design changes made to ensure mechanical design integrity, this objective was not entirely achieved.

The shift of effort and benefit from the CD to the design stages as design/documentation shifts to modelling is real and was experienced on this project.



Time commitment: Traditional and BIM

Ownership and transfer

Models have reduced duplication, but the issue is that ownership and responsibility for objects remain. A toilet modelled by the architectural discipline in the Sketch Design Stage will then be copied into the hydraulic model during the Design Development Stage, and both copies of the same toilet can continue throughout the construction stage.

More appropriately, the ownership of the toilet is transferred to the hydraulic discipline and removed form the architectural model, with the toilet then linked into the architectural model.

All disciplines, except structural engineering, started their 3D models using the architectural model as a base. The architectural model was linked into the consultant's models using 'shared coordinates'. This allowed all disciplines to be able to link their models, ensuring they where located exactly in the right position according to the site/survey plans.

Contract documentation and modelling

The 3D model, which started at SD stage, had grown from a basic model showing medium levels of detailing to a complex document of both 3D and 2D components mixed together to provide a comprehensive set of output sheet data.

The majority of components have been created as parametric objects (which allows the same object to be copied a number of times with variable sizes and configurations). These components were all created within PS by internal technical staff.

Architecture and structure disciplines decided to share the one document, as this approach was expected to hasten the development of the model. This proved to be a good decision, as both teams worked well together to achieve the project outcomes.

With up to 14 people accessing the model at any one time, documentation started to slow down, but this was largely due to issues with the use of the 3 GB switch in the Boot.ini file on a Microsoft Windows XP Professional-based workstation. This was a significant issue to all parties involved until it was resolved.

Systems were created to manage the detailing of doors and windows, with over 300 doors, 230 widows and 180 details. This system is particular to PS and allowed it to ensure that all doors and windows were accounted for and appropriately detailed.

The model was issued to all tenderers along with a model viewer to allow them to fully visualise the extent and complexity of the work. The model was not issued as a measurable part of the tender set, as the possibility of issuing it as such was not raised until late in the modelling process.

A note on integrated modelling

Future large projects of this nature should consider the increase in computer speed to a 64 bit operating system, as this is recognised to be the best format for 3D/BIM documentation, and something that stakeholders struggled with over the course of the project.

JCC Zillmere – internal perspective

JCC Zillmere – external perspective

Quality of documentation

The quality of the documentation taken from the model and issued as 2D documents has to date proven to be high.

Providing tenderers with access to the model was done on the basis that the model had no standing as a formal tender document. It was available to test the possible acceptance of models by tenderers, and to enable tenderers to access additional information that may be useful in preparing their tenders.

The next step of using the model as a tender and construction document raised the standing of the model to a legal document, with implications for the client and the consultant team. However, experience to date suggests that the quality of documentation available from well-built integrated models improves the quality of the documentation, with many more problems identified and resolved before the documents are issued.

A bigger issue in the use of models for tendering and construction is likely to be the exposure of contractors to the use of models, at least in the short term.

Clash detection

Clash detection software provides the opportunity to improve and validate the quality of the model significantly.

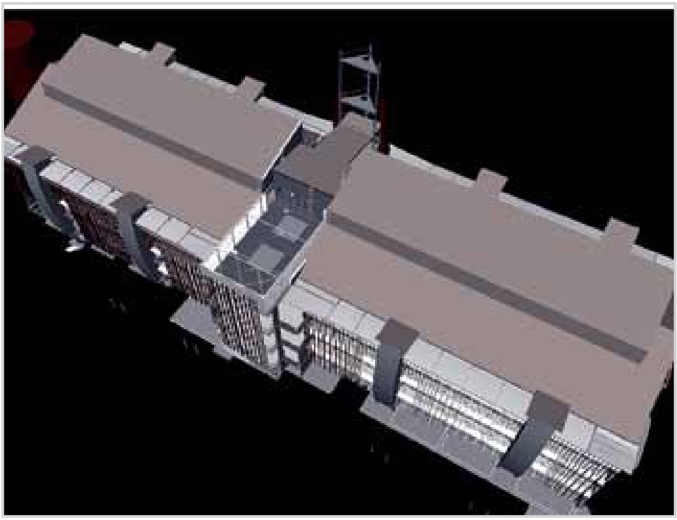
A common use is in the identification of clashes in elements under the control of different disciplines, with clashes between ductwork and structure being one of the more common instances.

This model checking can be undertaken at progressive stages of the design process, and is essential at the contract documentation stage.

Legitimate and accepted clashes

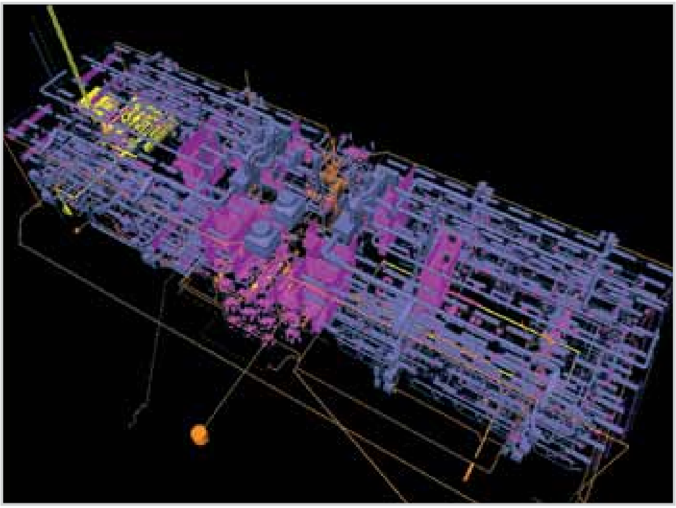
A current issue with clash detection is defining the difference between acceptable and inappropriate clashes. Some elements can show as a clash, yet be not only acceptable, but necessary. For example, a power point needs to be located within a wall, but will show as a clash unless the settings in the clash detection software recognise it to be an acceptable clash and ignore it. The same power point sitting in a window needs to be identified and highlighted. Another example of this is a pipe running through a footing. Is the pipe correctly located, or is it an error with the potential to adversely affect the performance of the footing? Only specialised disciplines can resolve some of these questions. Without proper and detailed rule sets, very large numbers of clashes can be identified, which makes for time consuming checking processes.

These issues were experienced in JCC and successfully overcome.

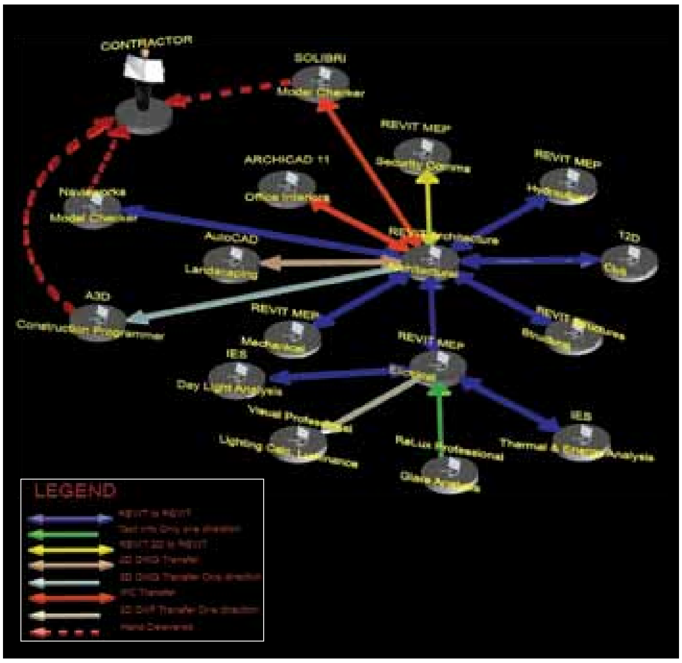


JCC Zillmere – clash detection models

Model-based construction



JCC Zillmere – clash detection models (continued)



JCC Zillmere – software interaction flow

JCC site at start of construction

After the tender process, Glenzeil Pty Ltd was awarded the contract for the project. Glenzeil Pty Ltd is a well-established building company based on the Gold Coast with experience in commercial, institutional, medical, tourism and industrial project construction.

The tender required the successful contractor to prepare and use a 4D model as the primary means for coordinating the construction of the project and reporting to the superintendent on progress.

Glenziel had no previous experience in working with a 4D model. This was anticipated by PS, which arranged for each of the tenderers to be collectively provided with a presentation by three consulting firms capable of preparing a 4D model. Tenderers could make arrangements with any of the firms to prepare a 4D model and program for them, or go to a firm of their own choice, or prepare the 4D model and program themselves.

Glenzeil elected to use A3D, one of the three firms introduced to it during the tendering stage, and engaged A3D to prepare the 4D model.

The primary responsibility for planning and progressing the construction remains with the contractor. The consultant programmer can only give expression to the decisions made in a form that can make the decisions and the consequences and opportunities more meaningful. The 4D process potentially allows the contractor to manage resources and materials better, and can identify and mitigate clashes during

Model-based green outcome

construction if that has not already been done through a 3D model. It can use time more efficiently and help avoid re-working, providing the most effective use of the time available.

Progress claims and disputes

4D compares the base plan and the actual plan, allowing the identification of components that are behind or ahead of program more successfully than traditional programming methods.

Cause of delay

The use of 4D methods requires a commitment to a single program, with all parties having access to the same information. This can be more challenging, but issues on site can be determined on the basis of real, more accurate information, rather than perceptions.

JCC is still in a relatively early stage of construction, but the expectation is that 4D will prove to be a success for the project.

The brief for the JCC Zillmere was to achieve a green outcome and the first 6-star Green Star rating for the Queensland Government.

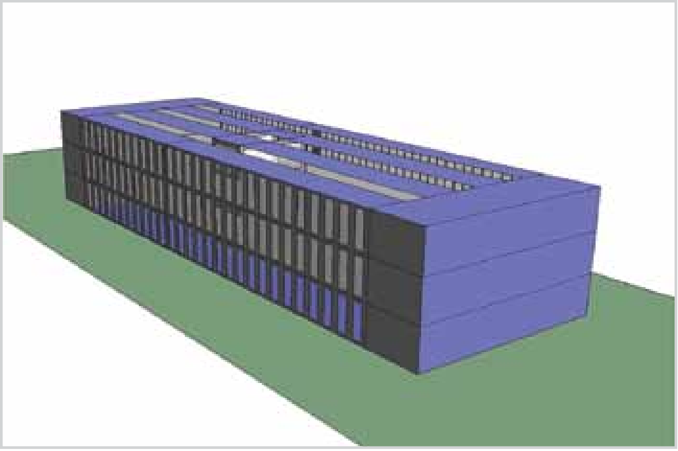
The Green Star rating covers a range of categories that assess the environmental impact of a project from design through to the construction and maintenance over the building's life span.

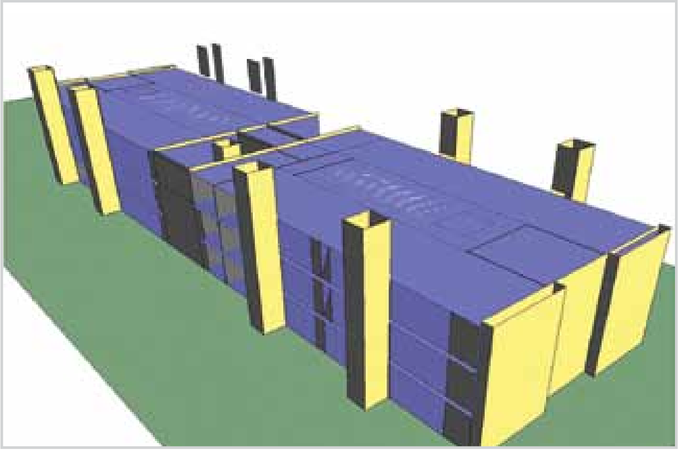
An important contribution to the green outcome for the JCC has been the collaboration between disciplines, the sharing of models to enable analysis of daylight and energy, and the iterative testing and review of solution options.

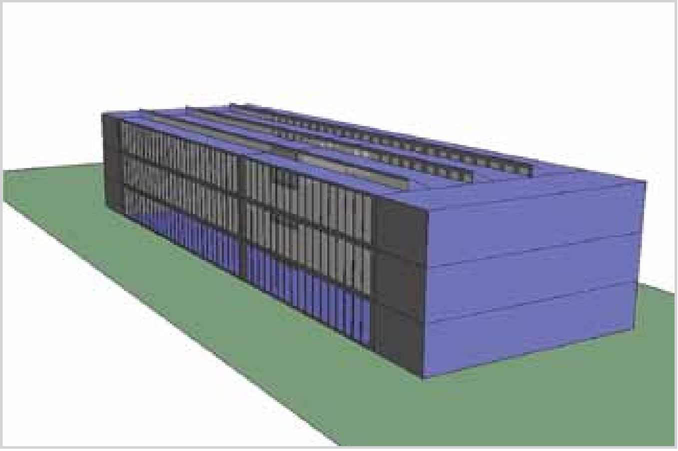
The early architectural model was imported into IES and tested for its potential environmental performance. Successive iterations varying the proportion of windows in the external wall and providing different options for ceiling heights contributed to the final architectural solution.

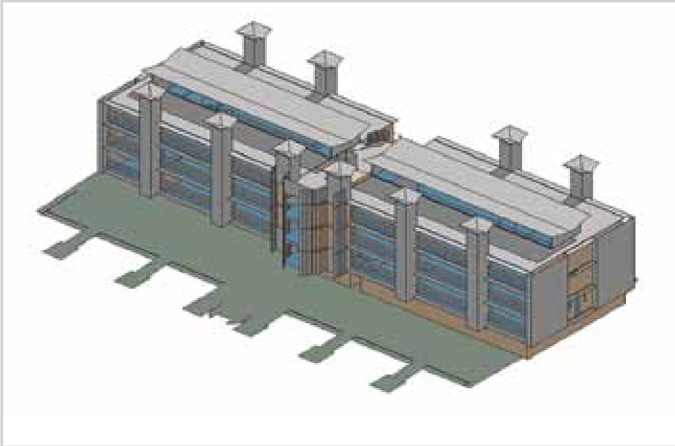
JCC incorporates passive design principles combined with high ceilings and double glazed windows, minimising the building's exposure to the harsh western sun. The design also enables JCC to achieve 77 per cent or more natural light throughout the net lettable area, with a night purge system performed automatically by the HVAC building management system when permissible to reduce energy consumption.

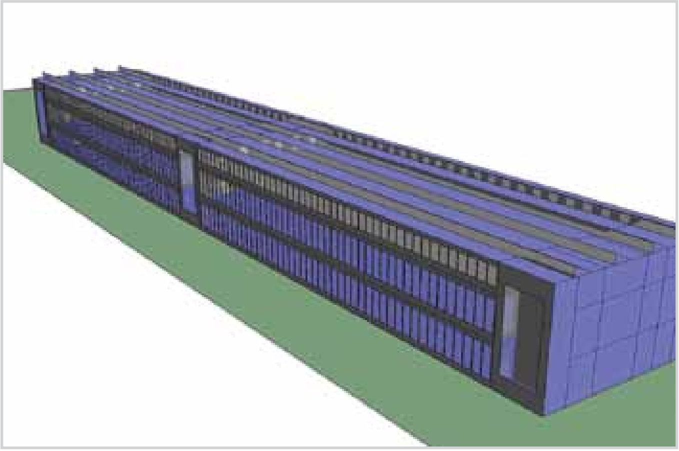
During the design and development stages, a considerable amount of R&D was undertaken to select products and materials that comply not only with Green Star criteria, but also with other sustainable environmental considerations.











Massing models used to analyse the JCC project using IES energy simulations

Case study 6:

8 Chifley Square

8 Chifley Square

Image courtesy Mirvac

This case study documents and analyses preliminary Building Information Modelling (BIM) investigation within a client–developer structure. The incentives for the client–developer to embrace BIM are clear and the business benefits for property owners and operators are many, and appealing.

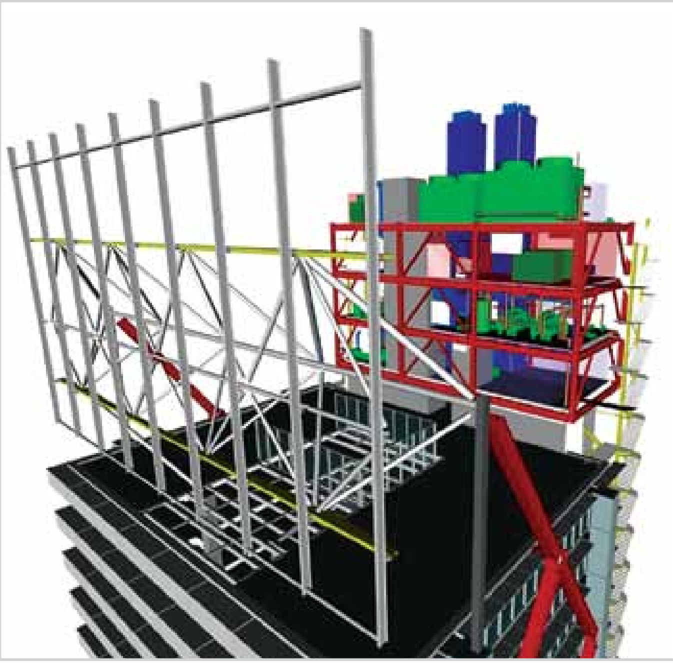
This case study of a new project development in a prime location of the Sydney central business district documents and provides insight into adopting BIM in a high-rise development.

The process within the design team proved challenging, and although the client organisation has resolved to adopt BIM in the long run, it was clear throughout this case study that the adoption of BIM is a more complex task than installing software into the design team environment.

There were a number of important lessons learned through this case study. Perhaps the most important is that BIM requires a completely different way of thinking about the design and documenting of a building. This paradigm shift will have a profound and immediate impact on the practice of architecture, engineering, quantity surveying and construction planning.

The following case study provides insight into the expectations and realities of BIM in high-rise commercial developments.

Project overview



Revit® SMEP
Image courtesy Arup

A new landmark designed by Rogers Stirk Harbour + Partners is to replace the 38-year-old Goodsell tower on Hunter Street. The new project features an expressive structural diagrid system, roof gardens and an open public atrium at ground level as distinctive architectural features. 8 Chifley Square is expected to become an immediate landmark in such a prominent location.

As a result of the downturn in the Australian economy, the 8 Chifley Square Project has been postponed and further documentation has been deferred for the present.

The project will comprise 30 levels, with an approximate net lettable area of 19,000 m^2, including 21 office levels ranging in size from 1800 to 2600 m^2, two levels of basement parking, 128 bicycle bays, and showers and lockers on every office floor and in the basement.

One of the key features of this building is its environmental credentials which are planned to achieve 6-star Green Star and 5-star Australian Building Greenhouse Ratings. If this is achieved, it is expected that it will consume less than half the energy used by a typical Sydney CBD office building.

According to the developers, the building's environmental features include design optimisation with the correct orientation and sun shading for passive energy savings; advanced water recycling systems, including black water treatment; on-site electricity generation systems; and subfloor chilled beam air conditioning.

Project stakeholders

Major stakeholders in the project are:

- **Mirvac Development** — client and in-house design team
- **Rogers Stirk Harbour + Partners** — lead architect
- **Lippman Associates** — external architects
- **Arup** — consulting engineers.

The following table lists the interviews undertaken with project participants.

Consultant	Interviewees
Architects	Rogers Stirk Harbour + Partners Lead architect
	Mirvac Design Senior project architect
	Lippman Associates External architect
	Mirvac Design Project architect
	Mirvac Design Senior draftsperson
	Mirvac Design Architectural technician
	Lippman Associates Architectural technician
Structural engineers	Arup Virtual Construction Coordinator
	Arup Project Structural Engineer
Client-developer	Mirvac Development National Manager Commercial Design

Five main stakeholder organisations were interviewed and respondents represented three organisational levels including:

- senior/strategic
- project principals
- project architects/engineers.

BIM adoption

Project location

The 8 Chifley Square site is in the heart of the CBD financial district, adjacent to a number of Sydney's best premium-grade buildings including the recently completed Deutsche Bank Place (126 Phillip Street), Chifley Tower and Aurora Place.

The building at 8 Chifley Square is bounded by Hunter, Elizabeth and Phillip Streets, and is not far from Sydney botanical gardens. Planning approval included approval for demolition of the existing 20-level Goodsell tower built in 1970.

Square – site with existing Goodsell Tower

© Google and MapData Sciences

Site background

Mirvac Group acquired the Goodsell Building in Sydney for AUD$60.2 million in a 50–50 joint venture with the Australian Retirement Fund (ARF). The vendor was the NSW State Government, which was also its last tenant.

The former Goodsell Building was a 20-level commercial property comprising 13,000 m^2 of net lettable area and basement car parking. The value of office space in the area is around AUD$365 per m^2.

Mirvac Development provided the architectural brief and initial building parameters, including shape, height, lettable space and environmental performance among other specifications. The project was launched for competition in 2004, and there were a number of finalists including Rogers Stirk Harbour + Partners, the winning entry.

As a vertically integrated company, Mirvac designs, develops and constructs its own product. There are many considerations in the implementation of BIM processes and software.

At the time of 8 Chifley Square, Mirvac Design had been investigating 3D modelling software with the view to understanding just how far BIM technology has progressed in the industry. Architectural Desktop had previously been introduced into the company from version 3.3; but in 2006, Autodesk® had begun to redirect its focus to Revit®, promoting it as its nominated BIM solution.

Revit® has been adopted in the office to develop an understanding of the software and its capability relative to Mirvac's requirements.

With one pilot Revit® project underway in the Brisbane office, and the use of Revit® for concept design occurring around the country, Mirvac Design chose to go one step further.

The initial intention for the 8 Chifley Square Project was to design and document the building using Revit®, and investigate some of the issues associated with collaboration between Mirvac Design and Arup engineers.

Migrating to a data-driven digital model will affect all Mirvac departments and is a major task. Software today provides a view of the near future, but in Australia, interoperability and the use of add-on programs is still falling short of aspirations.

Architectural concept and the schematic design of 8 Chifley Square were awarded to Rogers Stirk Harbour + Partners (RSH+P) in a two-stage design competition. The winning practice — based in London — has attracted critical acclaim and won a number of international awards including the Stirling Prize 2006 for Madrid Barajas Airport Terminal 4. Richard Rogers received international acclaim for his work with Renzo Piano for the Pompidou Centre in Paris.

Recent projects include the sites of the World Trade Centre, New York; the European Court of Human Rights, Strasbourg; law courts in Bordeaux and Antwerp; and the National Assembly for Wales, Cardiff.

For 8 Chifley Square, RSH+P is the lead design team working along with the Mirvac Design studio and Lippman Associates, based in Sydney. Mirvac Design provides all design documentation and project development. Mirvac Design and Lippman Associates are co-located at the Sydney office.

Design and modelling stages

BIM, or virtual 3D modelling, began with the Mirvac Design team. Lippman Associates took the winning design of RSH+P and began a coordinated design development process. This would eventually deliver up the refined building for submission for approval to the local authority.

The architectural Revit® model would become the centrepiece for coordination. Mirvac Design worked up the building from structural schematics produced by Arup engineers. Although the preliminary structural design was done in 2D using a mix of software (GSA + Strand7®), the detail was well thought out. Mirvac was then able to produce a quite detailed virtual building.

Sharing the model with external consultants typically stayed as a one-way process. The following list shows the use of the architectural model:

- transferred to RSH+P (in the UK) via ftp website and EDC
  - used internally by RSH+P for 3D Studio Max design development and rendering
- transferred to Cermak Perterka Petersen (CPP) Wind Engineering Consultants
  - converted Revit® for wind analysis of the building
- transferred to Arup engineers
  - used for coordination to produce Revit® Structural model
  - used for coordination to produce Environmentally Sustainable Development report
  - used for coordination to produce mechanical design.

BIM in architecture

The implementation of any new technology can be disruptive, but in the case of BIM, there was the feeling that the disruption would be very significant, especially when all element and object libraries needed to be redone.

Chifley Square – aerial view looking from south to north
Image courtesy Mirvac

BIM was planned to be limited to designing the building in 3D for coordination with Arup engineers, and to allow for the production of working drawings from the model.

The process of design development would be coordinated by Lippman Associates, working with both RSH+P (in the UK) and Mirvac Design (in Australia). Images produced from the Revit® model, along with design option sketches, would be sent to RSH+P for comment, then returned with mark-ups etc. to the Sydney office

The building has a dramatic form of exposed steel and glass, and the use of Revit® for architectural design resolution proved to be invaluable. One of the early challenges was how far to take the detail of each component. The team was creating a virtual building, but also looking for ways to keep the change process easy to manage.

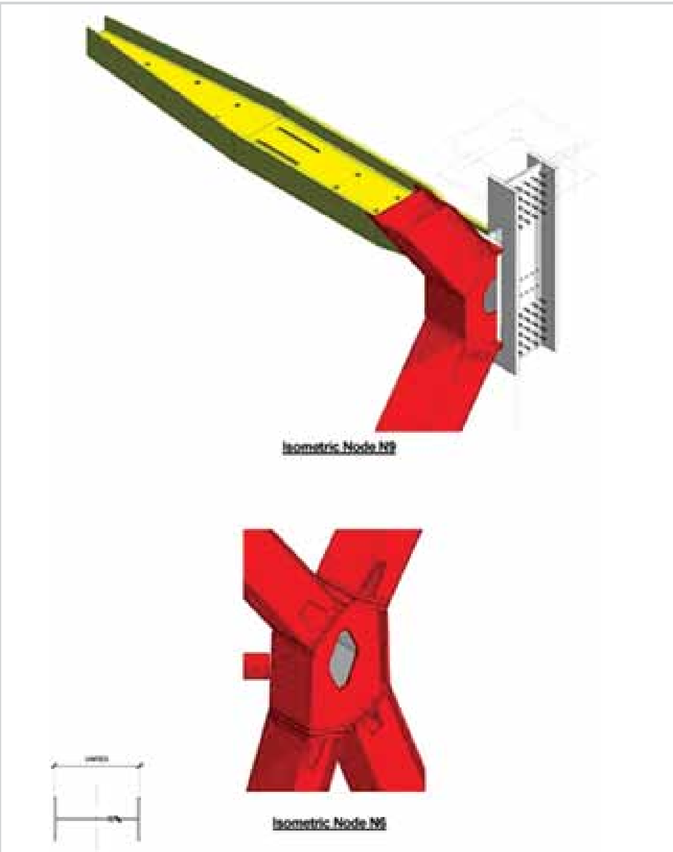
This would lead to some objects in Revit® being modelled initially for architectural intent, rather than being 'virtual' components for engineering or fabrication.

The building would end up being transformed over time from design components to construction components with regular input from Arup engineers.

From a BIM perspective, the team was not going very far down the path of data management. No additional data would be put into the virtual components for quantity take off, or cost, nor would there be any intention to use additional third party software for direct energy analysis, programming or post-construction facilities management.

On this particular project, the architectural model would only be ‘passed on’ to external consultants to show design intent, and although becoming quite detailed during the process, it would not be used directly for engineering analysis or shop detail fabrication. Separate models would be created as required per discipline.

In the future, particularly with the Revit® platform covering multiple disciplines, Mirvac anticipates a higher and more coordinated sharing of the model, and a much more integrated working process with engineering companies.



Structural meganode
Image courtesy Arup

BIM for structural design

Through the design development process, Arup engineers were initially designing the building using a mix of 2D software, GSA and Strand7®. These preliminary drawings were used by Mirvac Design to further develop the design model prior to handing the Revit® file over to Arup for coordination. Arup then used the Mirvac Design model for review with its own Revit® Structure model, as well as Revit® MEP.

BIM practices for structural design backed the standard within the organisation, and for the last three years every project has been in the 3D environment, at least for the structural side of things.

The engineers from Arup take pride in that they also operate the software and understand its capabilities and what it can really do.

BIM collaborative practices between consulting firms is not yet complete for this project — unfortunately, as this is one of the fundamental conditions for BIM to achieve its full potential. In the case of Arup’s contribution to the 8 Chifley Square Project, the use of BIM was internal to the organisation only.

Interoperability is of top priority if BIM is to be the medium for full project collaboration. In this respect, a lead structural designer for 8 Chifley Square commented:

We also need to think on how the data will be transferred across software applications, especially when changing disciplines. We need to make sure packages talk to each other before we start using them in particular projects. For example, in some cases we were documenting the building in Revit® including architectural projects, and then wanted to run the analysis tools, but required extensive translation and in some cases, data was lost.

BIM in construction

Mirvac uses an in-house document control software program (EDC) for typical project collaboration, both internally and externally. Mirvac Construction typically receives pdf drawings derived from AutoCAD® or AutoCAD® Architecture.

During the early stages, Arup engineers arranged a presentation to Mirvac Construction on Navisworks®. The potential is there, but some refinement is required by Autodesk® to synchronise objects in Revit® with project management tasks. Also, the way a building is created virtually may need to be coordinated to a higher level to allow for isolation inside Navisworks®.

The ability to combine multiple discipline model files inside Navisworks®, followed by a clash detection process, was a strong positive for embracing this in the future. At present there is a fair amount of manual coordination required inside Navisworks® to get the desired function.

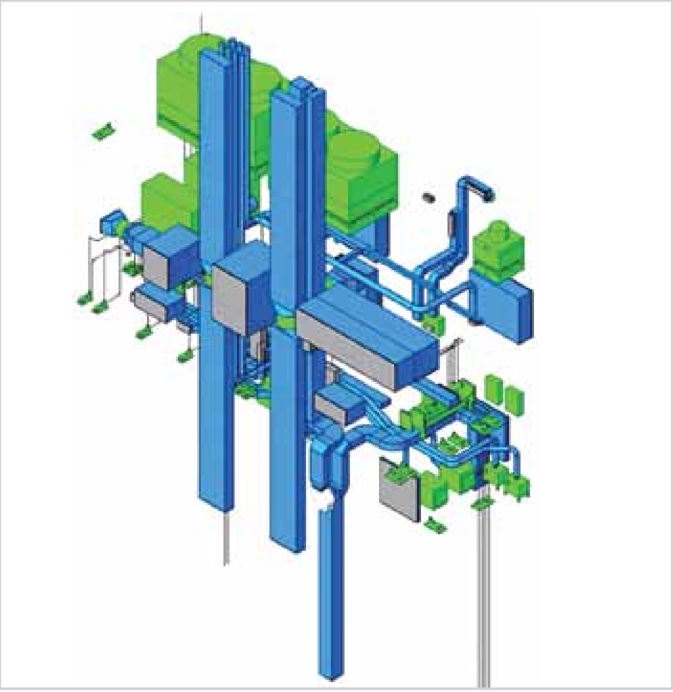
BIM facility management

Mirvac Group has made a strategic decision to embrace BIM, especially as it is both a property owner and operator. In the long run, an investment in BIM is expected to pay off as it will be a platform to study life cycle cost, undertake maintenance analysis (as a way to move towards proactive maintenance instead of reactive), look more into space planning, and as an interface for tenants and users manuals.

BIM potential

As a vertically integrated company, Mirvac sees the potential of using BIM to bring a higher level of coordination and efficiency between divisions. There is opportunity for improved estimating, feasibility, design review, building resolution and services coordination, as well as post-construction building management.

Again there is a sense that the software available isn't quite tailored to the task. Mirvac is already trialling CostX® for its estimating process, but data inside Revit® is limited in the way it is extracted into CostX®.



Mechanical plant

Image courtesy Arup

3D BIM visualisation

Image courtesy Arup

BIM was an initiative raised within the 8 Chifley Square Project. Prior to that, Mirvac Design architects mainly used AutoCAD®, Architectural Desktop, SketchUp and 3D Studio Max as the design and documentation tools.

Although the initial design process was successful using Revit®, time and budget pressures would contribute to the decision of the team to freeze the model and revert to AutoCAD® for documentation.

Aspects of BIM adoption for 8 Chifley Square certainly provide interesting lessons that are important for client, architectural and design practices — the fact that the 8 Chifley Square Project returned to AutoCAD® does not mean that the whole BIM agenda was abandoned.

In the view of Mirvac, the promises of the benefits that come with BIM in operation are so significant that they are hard to ignore, whereas for Arup, BIM exploitation is a different case, as the firm is already much more familiar with BIM and sees itself among the current industry leaders.

Mirvac is a client-developer organisation with a number of different design and property professions under one roof, including design, interiors, architectural services and quantity surveying. It also performs as the client–eveloper and property manager, and is adopting technologies that would allow it to run and maintain its facilities over their life cycles.

The strategic view for Mirvac Development and Design is that it will set new standards for adopting BIM for the design, development and operation of facilities.

In the 8 Chifley Square Project, Revit® was chosen as the BIM authoring tool. However, balancing Revit®'s functionality with Mirvac's package-driven documentation needs would prove to be no small challenge. Even with technical assistance at hand, the change of process and the team dynamics involved in managing the BIM model would over run the delivery dates for trade package documentation. This would be a key influence in refining a better process.

BIM innovation

BIM is the new order in building and architecture, this is to stay in our practice starting with closer collaboration with construction, including changes to cost planning. We see BIM as a way to link office with site people. Builders linked to our models on site. We are not there yet but certainly, important lessons emerged for the company as part of this pilot.

On the life cycle and operation of buildings, BIM is also a promising field, and as a client organisation, Mirvac is looking at the benefits of BIM for facility management and building operations.

We also have a property management section. We saw the potential in linking our facilities management systems to initial project information and contract documentation. The BIM models will be a tool to run our facilities, as an interface for facilities managers.

The third major driver for BIM adoption by Mirvac has to do with automation and improved efficiencies. For instance, in the quantity take off and cost modelling fields, both areas are highly attractive to Mirvac, since architects and quantity surveyors are co-located under the same roof. It is worth noting that Mirvac Design only works for Mirvac Development, thus the drive for improving the quality of design documentation and design checks is paramount.

Design and modelling stages

At the Schematic Design Stage, the project was conceived and modelled with traditional design techniques such as hand sketches and massing studies using wood and acrylic models. Most of this work was carried out primarily by RSH+P as part of the preparations for the design competition.

Through the development of the building, the Revit® model became instrumental in communicating changes and allowed for a much greater degree of resolution.

The fact that the model was able to be passed on to consultants as changes were made meant that some degree of cross-checking between models was available.

8 Chifley Square – massing studies using traditional techniques – the client and planning authorities would still request physical models

Image courtesy Mirvac

Often, at the design stage of the process, there is quite a lot of change to deal with, and typically several options or variations.

With BIM we are seeing a greater need to resolve the design of the building earlier in the more traditional time line.

This is bringing the need for architects and engineers to collaborate sooner and more efficiently, and is changing the peak workload to an earlier time frame.

BIM process

BIM process and collaboration is radically different to that of AutoCAD®. Ideally, it is expected that BIM should be a concurrent process, where various teams are solving aspects of the project in real time. The concurrent design process can happen at both levels, within an organisation or externally with other consultants, project team members or organisations.

In our view a BIM is not just another architectural model, it is a model where different tools are used including those for structural engineers, quantity surveyors, architects and so forth.

Within the organisation, the challenge is breaking the gap between design staff and technical staff, including CAD operators. In the case of BIM, the lead architect, more often than not, would need to understand BIM processes and possibilities.

For Mirvac, the change of process will not only affect its architectural division, but also construction and development. Ultimately, more information is going into the model. More data is required to be connected to the components in order to get true collaborative BIM.

In the case of the 8 Chifley Square building, Revit® Architecture and Revit® Structure were used independently. With the initial input from structure coming from 2D information, the exposed steel framing was modelled for architectural intent.

In a BIM design environment, it is important to model some aspects of the building first, especially the main structures, and then architectural, and finally mechanical. Ironically, structural design tends to wait for architects to provide detailed modelling and instructions.

On the 8 Chifley Square building, the exposed steelwork was a strong architectural feature, which meant that Mirvac Design would initially take ownership of the virtual steel components in the model. Mirvac would then pass on the intent back to Arup for its reworking of its own structural model.

On future projects, Mirvac and Arup would use the built-in collaborative features of Revit®, and combine their models to allow for structural steel components to come directly from the engineer.

Data transfer and exchange

Although file size is becoming less of a problem as hardware continues to evolve, moving large files over the wan or lan can come up with a few problems.

Uploading and downloading Revit® files across the web meant that the minimum requirement would be a broadband connection and the use of 'ftp' sites. This would prove essential for exchanges with RSH+P based in the UK.

The Revit® file for 8 Chifley Square would be stored on Mirvac's internal server, and each team member would work on a local copy of the file on their own workstation. This meant that saving changes back to the server became more difficult as the team increased in size and the model became more complex. Good team communication and fixed times to save work became essential.

HR, training and knowledge

At the start of the 8 Chifley Square Project, the intention was to go one step further on the road to BIM. Revit® was already in use for design, and this project was a good candidate to extend the use of modelling in 3D, as well as an opportunity to investigate some degree of collaboration with Arup engineers.

A team of experienced architects and documenters was put together with various skills in AutoCAD®, Architectural Desktop and Microstation. This group would receive Revit® training as well as technical assistance at the start of the project, with the goal to work through the design, development and documentation of the building.

Learning the fundamentals and setting up the project went reasonably well. The development of the model, architecturally, was giving the right feedback and allowing for development of the building. What didn't work well was getting the right relationships between team members and tasks.

The software vendor that supplied the training also provided on-site technical support to assist the team in using the product. This approach did help the team with additional teaching and solved any technical issues at time. What was missing was experienced judgment on managing the team. Unfortunately for this project, all the team members were treading new ground.

As a BIM tool, Revit® works in a very interconnected manner and relies on keeping all the functions of the product switched on. Mirvac, as a practice, breaks down its documentation into trade packages for its construction division. Tasks that could previously be done with a degree of isolation were now impacting on other areas of the model. Managing the task of modelling and keeping the model in good order was taking longer than anticipated.

Time pressure and commitment to deadlines would influence the teams decision to go back to 2D AutoCAD®. This would allow additional resources to be on hand at short notice during peak workloads.

We were at the front-end in setting a new model with all the initial BIM architectural and structural elements for the overall BIM model. It was very tough for everyone but especially for the BIM manager, as we needed to deliver the project on time — we were managing a lot of data exchange and frustration.

These are early days for Mirvac in bringing BIM into its typical approach to business. There are many repercussions in adopting BIM across the divisions, and Mirvac continues to proceed with caution.

Knowledge and experience increases by trial and effort, and in hindsight some valuable wisdom has been hard won.

For Mirvac, the commitment to succeed is undeterred, and the knowledge gained from 8 Chifley Square is already being applied to the next project.

Lessons learned and metaphors

This case study has certainly given insight to the team and the company.

A full implementation across multiple divisions to establish a functional and practical method of BIM is going to take time.

For any company, a move to BIM equals change, and for Mirvac, careful consideration is required, along with negotiation on how much change to embrace at one time.

In hindsight there is one ingredient that stands out as a 'must have' before embarking on any introduction to BIM. You need knowledge born from experience. This is still difficult to find while BIM processes and understanding are relatively young in the industry.

Real success doesn't begin until the right level of skill and understanding is within the team. Senior management must also be willing to adapt their traditional approach when it comes to process. Team sizes, time lines, technical knowledge are all affected, and collaboration on all levels takes on new responsibilities.

There is a tipping point in momentum and productivity that comes once you have experience on-board, which is much more effective if it comes from within the company. However, to get this skill, it will most certainly involve some degree of external training.

Getting the small steps right are lessons in themselves. Some good examples are team size. The nature of Revit® lends itself to smaller teams. Two or three good calibre people can produce a commendable amount of work, which also helps keep communication and teamwork easier to manage.

To a degree, building a model imitates real life, and it became important to find people with good construction knowledge to also be the main modellers. Design architects were encouraged to review the model, but were kept away from making direct changes to the all important central file.

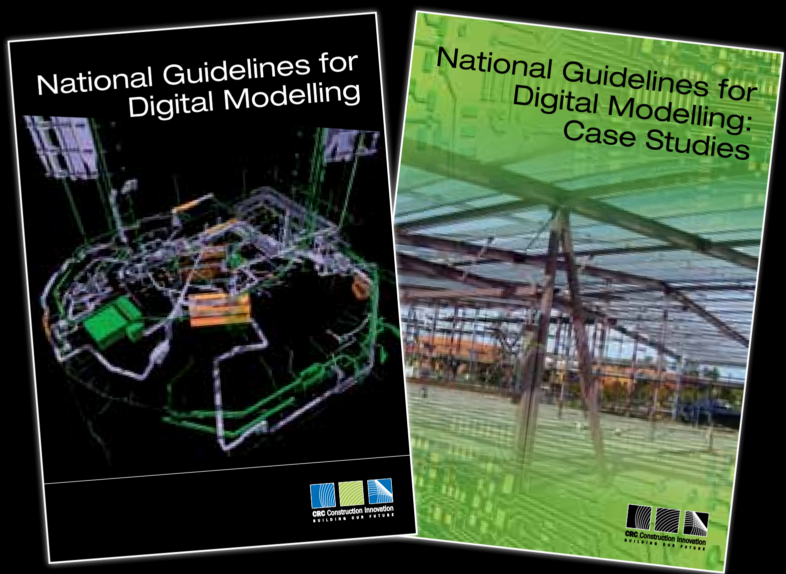
There was also a definite shift in the time frame for building resolution. Many issues which typically would be raised during actual construction were being addressed in the virtual world before working drawings were even issued. This had the effect of bringing much shorter time frames for consultants to start focusing on solving issues.

It is a really exciting concept - if we use it as a design tool, it will change the way architects design.

For most, if not all of the architectural staff, the biggest thing they learned with the 8 Chifley Square Project is that BIM is a fundamentally different process to designing and documenting a building in AutoCAD®.

Mirvac has taken its first steps, and Building Information Modelling has found a solid foothold.

Notes



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