Creating Large Building Models

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Foreword

In this document we use the terms ‘model’ and ‘building model’. Their use is interchangeable and they refer to what is technically referred to as an information model, i.e. an integrated, digital 3D representation of a building or design project, which contains not only the geometric description of that building, but also the properties, performances and relationships of the objects within its design. This information can describe the whole lifecycle of the project and encompasses design, construction, maintenance and facility management.

This document initially describes a method for establishing large ArchiCAD models (i.e. generally 100Mb or greater collective pln file size), decomposed into several “elemental” and other divisions, and managed through hotlinking.

The objectives of this technique are:

- Capacity to construct large building databases
- Flexibility of documentation production
- Support for large teams of concurrent model builders
- Reliability of documentation output

Our second goal is to demonstrate how the many features of ArchiCAD can be customized to suit individual requirements. Many examples are given of different methods. We trust you will adapt and modify these to create your own bespoke installation to fully support your business needs more exactly and to be more efficient and productive.

We welcome your feedback.

Please contact your distributor with any issues arising or project feedback.

Acknowledgements

We thank Fender Katsalidis Architects, Australia, for their innovative examples of large building models – for example the Eureka Tower project, Richard Rogers Partnership – Hurley Robertson Associates for the model opposite, the City of Berlin, Senate for Urban Development, for their visualizations of the city, Statsbygg Norway for their construction simulation model example and the Ian Darby Partnership, United Kingdom, for the use of their documentation examples.
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The Facility Development Process

For our purposes, we need to understand the context of the project model. A project consists of the team (both internal and external), and the model. The project evolves through stages that normally represent the increasing levels of detail required to support the services offered and, for the most part, to create 2D documents. The model is sometimes called a Virtual Building™, thereby describing the extent and nature of the facility to be constructed.

Model Management

Before we talk in detail about how we accomplish these tasks, we should briefly highlight “model management”. By model, we mean a virtual building model. Architects are still the key consultants responsible for the design and coordination of a facility. The project model is the integrated information model, and needs management: processes and activities such as the setting up of project templates & standard documentation, project establishment, organizing interaction with consultants digital data, accessing or creating building product data and defining model outputs - drawing lists, animations, visualizations and schedules. Often some of these tasks are overlooked in the rush to “get the drawings out”, usually with cost and quality compromises.

On a large project management of the model is essential. The need to manage the model, the inherent complexity of a large project, and the different nature of a 3D object model are reflected in the significant new roles within a project team.

Poor planning leads to poor quality, and several tools are provided (e.g. PlotMaker, Publisher and Project Mark-up) to free up project leaders and designers from the tedious and manual processes associated with defining and tracking all the documents associated with the model.

Office Project Team

When the project commences a team will be appointed; as the project develops the team is expanded (and later reduced) to carry out the work involved. In the discussion below we define the key roles within the team:

Project Director (PD) - the architect or team member responsible for overall management of the project. The PD should understand the business benefits and opportunities of object model CAD, but is not necessarily familiar with the operation of the software.

Design Leader (DL) - the architect or designer responsible for creating the concept. The design control may be achieved by a small team, but is often under the direction of a specific person in the office or on the project team. This architect should understand the principles of the virtual building, and be able to work with the software, at least in broad terms.

Team Leader (TL) – a senior architect or team member responsible for the management of a designated part of the project. The team leader should have a good working knowledge of the model, and understand the different resource implications of creating object models.

Model Manager (MM) - the person responsible for establishing and maintaining the project model, and any possible associated document output. For a large project as envisaged in this discussion, the model manager is a key member of the team and essential to a successful project through being an expert and very experienced ArchiCAD user. The model manager is also a member of an office technical team (each with model management roles) that liaises with the office CAD Manager on strategic and technical matters.

Documentation Manager (DM) - the person responsible for the definition, issue and management of project documents authored from the building model. The DM is an experienced architect or technician who understands in detail the needs of documentation and ArchiCAD, and works closely with the PD and project leaders.

CAD Manager (CM) - the person responsible for setting model building guidelines and policy, supporting project teams and coordinating with other office experts (documentation, specifications, QA, etc.). The CAD manager is an expert in the technology and works with the senior office management on the office project ICT systems and strategic direction.

Project Architects (PA) - Team members responsible for the design development and building of the model according to their particular roles. They may have a single or combination of zonal (e.g. the podium), functional (e.g. door & window documentation and specification) or discipline (e.g. services coordination) roles. They have an in-depth working knowledge of all aspects of the software.

Project Technician (PT) – a technician skilled in object model usage, and with an in-depth working knowledge of all aspects of the software and CAD documentation drafting.
Project Stages

It would be very efficient if we could design the project model once and use it for the whole duration of the project; unfortunately, as the project develops, there are very different demands on it and the model(s) should respond to these demands.

Facility development stages are well documented by many professional bodies and organizations. Below are the stages used by the International Alliance for Interoperability\(^1\) (IAI) to classify the processes, which are a part of the Process Protocol\(^2\)

<table>
<thead>
<tr>
<th>Ref</th>
<th>Stage name</th>
<th>Stage name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Conception of Need</td>
<td>Coordinated Design</td>
</tr>
<tr>
<td>2</td>
<td>Outline Feasibility</td>
<td>Production Information</td>
</tr>
<tr>
<td>3</td>
<td>Substantive Feasibility</td>
<td>Construction</td>
</tr>
<tr>
<td>4</td>
<td>Outline Conceptual Design</td>
<td>Operation and Maintenance</td>
</tr>
<tr>
<td>5</td>
<td>Full Conceptual Design</td>
<td>Disposal</td>
</tr>
</tbody>
</table>

Table 1: Facility Development Stages

This discussion focuses on Stages 5, 6 and 7 which represent the major project milestones.

Not all projects have all of these stages and there are different terms used in local practice. For our discussion we will take three key stages of the project, which are often major milestones in the progress of a project, and usually require a new model to facilitate the next stage.

In a fast-track environment these stages may overlap and this will add an extra overhead onto the model management.

This discussion is intended to be relatively generic and not overly prescriptive; there will be many office and project issues also to be accommodated in the final solution, so these examples should be treated as guides.

Designing a Model

Many offices will have guidelines for establishing project models in their project protocols. At a minimum, the Project Leader, CAD Office Manager and the project Model Manager should participate in the design discussions.

Factors to be considered include:

- Building type(s)
- Service deliverables
- Office skills and resources
- Timetable
- Availability of resources (parts libraries, etc.)
- Client project setup

The decisions of the group should be minuted (as part of QA procedures, for example). At the next stage of the project, these decisions can be reviewed and feedback on the performance of the models evaluated, with the knowledge gained being fed into the next stage and passed on to other project teams.

Example 1 – a Multistory Office Tower

The project, called Tower Plaza, is in an inner city location, with 40 floors of office space, and the maximum car parking allowed under the local regulations. Approval by the Authorities requires an accurate visualization of the proposed development.

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\(^1\) See [http://www.iai-international.org](http://www.iai-international.org) for more details

\(^2\) See the ICCI Project, [http://icci.vtt.fi](http://icci.vtt.fi)
**Concept Stage**

The client expects the maximum return from the development, including an efficient layout maximizing lettable space, and a total cost that represents the best value for money for a 25-year lifecycle.

In this stage the Project Director (PD) and Design Leader (DL) are responsible for generating architectural concepts, and work on a one-to-one basis with two Project Architects (PA), and a Project Technician (PT) assisting. This type of small team typically comprises of 6 members.

![Figure 2: The Concept Stage Team](image)

The DL & PD focus on the design concept. The Model Manager (MM) (or office CAD Manager) helps establish the model and supports the whole team.

The concept is a “rough” model, not necessarily intended for detail design or documentation, and may only provide massing, visualization, gross and net areas by use types, access, parking and site location. Presentation drawings are later generated from the concept model.

**Schematic Design Stage**

In this phase the PD expands the project by creating small groups under a Team Leader (TL) to work on the major building elements. A project Model Manager (MM) is assigned, who works with the CAD Manager (CM) to set up a new ArchiCAD model. The MM works with the PD to create a project model organizational regime that suits the project, and meets the office QA rules and guidelines. A Services Coordinator works with each sub-team and a Documentation Manager to coordinate services planning and consultant data exchange. As 30-50% of the building cost is for building services, this is a vital role. Typically engineering consultants will work with 2D design and documentation files, so coordinating these reliably in the model is required.

The team now consists of 7 to 15 members.

**Note:** See *Design Collaboration using IFCs* manual for an alternative and much improved method of sharing object model based engineering data.

Project planning is resolved to a high level, structural and building service engineering concepts are defined and cost plans developed. The model may also be shared with consultants.

![Figure 3: Schematic Design Team](image)

Sub-teams are assigned to work on the key parts of the project, based on their experience, and the project program.

A full range of presentation and pre-documentation drawings are defined and controlled by the Documentation Manager. This may entail coordination of document issue/receipt with an intranet or extranet.

**Detail Design/Documentation Stage**

This is the most intensive stage of the project; a full project team is appointed and may have from 15 to 25 members.

At this stage, the model has to serve the complete needs of construction and related documentation. While design development will continue, the building is resolved for construction purposes down to the smallest detail and typically in scales from 1:1 to 1:20.

The Model Manager, Project Leader and representatives of the senior project architects jointly design the new project model, which may be able to be copied and reused from the previous stage, but often is re-established now based on well defined site setout and building geometry.
The Design Leader continues to monitor the design; the Project Architects (PA) build the model in detail. The Project Director and Documentation Manager define the requirements for output documents and the Model Manager manages the process of model building.

Tip: The Documentation Team - Project Architects (PA) and Technicians (PT) can be distributed (as suggested by Fig. 4a, opposite), but may also be a separate group (see Fig. 4b, opposite). As they are working on the same files (copies), coordination is still maintained. The choice is determined by the working practices of an office.

Managing the Project Model

What are some of the objectives as the project model is designed?
- The capacity to construct large building model (i.e. 100Mb or greater)
- Flexibility of documentation production
- Support for large teams of concurrent model builders
- Reliability of documentation output
- Responsive editing

While computer processor power is continually increasing, so are the demands we put on the model; in all cases we want a model structure that is responsive to users, reliable and delivers those products and output documents required for the project.

We now examine two strategies aimed at achieving our objectives: Model File Structure and Overlay Documentation

Model File Structure

The first indication of a problem is usually that the current file being worked on has become frustratingly slow; if we cannot get a faster computer, we must reduce the file size, but how do we do this?

Splitting the file (identical in concept to TeamWork’s sharing methods) is an obvious answer, but subdividing the single file has other benefits as well, as we shall see, by providing more flexible documentation methods.

Subdividing the Model

To reduce the size of files in a composite model, a common technique is to split it based on logical subdivision.
- A university campus project, with a large geographical extent and probably a maximum of 10 stories per building, suggests a building subdivision with
a plan file for each building and perhaps a common site plan.

- A multi-story building, e.g. over 20 floors, suggests on first examination a division based on common floors, often used in layering in 2D CAD. As the ground level floors are usually unique, this suggests a basement, car park levels, ground levels, standard upper floors and finally, roof levels structure. As the number of unique floors increases the advantage of this “plan”-based strategy is reduced.

- An alternative approach is to divide the project into elements or sub-projects. In this method, a large multi-story building is divided into key elements, such as structure, façade, tenancy, site, and podium. Typically, specification and cost measurement guidelines use elemental classifications to organize information (see Appendix B: Useful References).

- A further approach, with very large floor plates (e.g. in hospitals), is to split the project by levels or zones (a zone is a functional or construction stage, for example).

- Another alternative is to base the model on the site construction activities, e.g. siteworks, structure, fitout and finishing.

Alternatively, structure the model by discipline; commonly applied to the structural and building engineering services consultants, such as structure (steel or reinforced concrete), HVAC, Electrical, or sub-discipline; Power & lighting, Data, Communications, Sanitary, Waste and Fire Protection.

It is likely that you will use a combination of several techniques to achieve your project goals, and of course the structure will need to evolve over the 3 key stages we suggested earlier, i.e. Concept, Schematic Design and Documentation.

**Concept Stage**

For this stage we will use hotlinking\(^3\) to create and manage several design options. Hotlinking is easy to set up and is well suited to this initial task. The project team has 3 designers; the office has a city block model, City.pln, which provides a context for the new development. A new site survey has been obtained with accurate boundaries and levels.

The project model now comprises:

![Concept Design Model](image)

**Figure 6a: Concept Stage Model Structure**

A simple structure to allow rapid development of the initial development concept.

Project.pln xRefs the (DXF format) site plan, the only available copy at present. The owner has commissioned a new full survey, but this is not available yet. Instead of merging the old version into the ArchiCAD model, we just xRef it so that we can update it easily, once available. The team develops a number of different schemes and the client shortlists three for more detail analysis.

\(^3\) See Appendix A: ArchiCAD Tools for Model Development

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**Figure 5: Construction Simulation, Statsbygg, Norway**

A large campus development, such as this project, will require a different model strategy than the main example of the Tower Plaza project described here.
Options are saved as Option1.pln, etc. and relinked with City.pln for further development and presentation purposes. Two PAs and one PT are assigned to the three options, and each, by hotlinking the City plan and new survey, are thus able to edit their options simultaneously, while still using the common context files. Option 12 was subsequently selected by the Client and approval given to proceed with this scheme.

**Schematic Design Stage**

The architectural team is now joined by office layout interior designers and expanded to 15 members.

The podium now contains a variety of shopping and commercial spaces. Several levels join adjacent buildings and a pedestrian tunnel connects to a Metro station. The top three levels of the tower will be for apartments.

The team has now been divided into three sub-teams with responsibility for Podium and site development, Tower offices and Apartments. Negotiations are proceeding with the owners of the adjoining buildings about the connection of public spaces.

The structural engineer has developed a structural concept for the tower and is working on the substructure design.

The HVAC engineer has proposed a system and is establishing central plant requirements, risers and distribution systems.

A new model is established, reusing some of the Concept Stage files. In effect Option 12.pln is decomposed into a number of “elemental” models to suit the larger team and emerging work groups in this stage. The whole project is integrated by hotlinking all of the sub-files into Project.pln.

**Developing the Models**

**Using TEAMWORK**

While some files can be worked on in Solo mode, the fact that we have decomposed the project into many defined sub-files, means we have a high degree of flexibility. It is now possible to re-combine them to suit the specific task and priorities.

It should be remembered when selecting a workspace, that there are many different ways in which the project could be shared. User preference, building type, managerial direction and/or any combination of these help to
determine the most appropriate way of sharing any particular project at any
given time.

**Note:** Virtual Building model workspaces can be defined using three basic
methods – the stories method, sectional method or systems method. See
Appendix A for detail references for TeamWork

![Figure 8: A Typical Working Model](image)

Podium.pln and Carpark.pln are shared for TeamWork, while Metro.pln is edited solo.

The Design team can use the files as they like, with as many hotlinked
structures as required.

**Note:** You can hotlink a shared model, (.plp file) to your master model file,
although there should be careful management of the updating process.

Regarding this current phase - Design Development - the Podium team set up
their working environment as follows: (Subsets of the main model files are
hotlinked to suit.)

**Podium.pln,** converted for TeamWorking is shared for three concurrent users:

1. **TL 1** is assigned the main entrance level (L0) and 2 levels of shopping
   below (B1,2) and 2 levels of shopping above (L1,2).
2. **PA 1** is assigned the 3 floors of conference, business suites and the
   Building Development company offices (L3, 4 and part L5)
3. **PT 1** is assigned a central plant and stores level (part L5 and L6)

**Metro.pln,** is worked on by PA 6 in solo mode; there are two metro platform
levels (B4, 5)

**Carpark.pln** is shared for 2 concurrent users;

1. **PA 2** is responsible for the main car park entry/exit ramps on level
   B3 (which abuts the Metro platform).
2. **PT 2** works on car park levels B4 to B10, and a piped services control
   center

The Structure file has the main tower reinforced concrete frame, slabs and
foundation elements and is hotlinked into each working file to ensure
coordination of this crucial carcass element.

The metro architect works with the Transport Authorities and imports and
xRefs several subway drawing files. The main building structure has been
designed to clear the subway tunnels to ensure safety and structural load limits
are achieved. Fire egress, exit stairs and escalators are coordinated and
developed in detail.

The podium level team works as follows: **TL 1** is a senior architect specialized
in large shopping center buildings, who designs and coordinates the main
public spaces within the shopping malls.

**TL1** works with the Development Company retail group, negotiating the layout
of the retail spaces and detailed design.

**PA 1** is another senior architect specializing in office and conference centers
who develops the conference facility and the new Building Management
Center. **PT 1** is an experienced technician familiar with engineering systems
and large plant, and works with the Services Coordination architect and the
external consultants to ensure the systems fit well into the new building.

**Note:** TeamWork logical account, defined in several shares, can be used
simultaneously by a single person. For example, in Fig. 6, PA 6 and PA 1
could be individual or combined roles.

Similar arrangements are made for the rest of the project team. The Model
Manager, upon requests from the members of each sub-team, delivers new
library parts, monitors the performance of the model, and ensures regular
backups.

The Model Manager also chairs regular meetings of all ArchiCAD users to
discuss issues arising, plan work schedules, make new file arrangements and
liaise with the Documentation Manager to ensure model development meets
the project schedule.
**Leveraging 2D Documentation**

In a large project it can be expected that much information will be provided in non-object model format – e.g. AutoCAD’s DWG and DXF, Bentley’s DGN and scanned drawing 2D data drawing formats. Survey, GIS and many engineering services and product suppliers’ data often come in these formats as well. In some cases, design proposals or existing building drawings will also be in this format.

As the 2D format drawing is so pervasive, how can we make use of this information in our project?

The negotiations with our adjoining owners have been successful and integration of the West End and Orchard Shopping Center will be undertaken on several of the main levels immediately above and below street level. Both owners’ architects have DWG databases of their project and provide detailed plans and sections of the levels to be coordinated at 1:100 scale and 1:200 scale plans and elevations of the whole building.

The Model Manager decides to create two more models, WestEnd.pln and Orchard.pln for the respective existing buildings. The new DWG survey plan received at the end of the Concept Stage provides an accurate setout of the three sites, and is used as a control for the project design, and of course for our immediate need to model the adjoining buildings.

Two PAs are assigned to build the existing building models.

**Building a Model from 2D Drawing Files**

The principle is extremely simple, and yet is a very efficient way to create a 3D building model from existing 2D drawings. We will explain the steps in detail to demonstrate the example and to show how, with modification, this can be applied to many model building tasks.

With the two new models for the West End and Orchard Shopping Center, we build a (probably) temporary coordination file, which we call Existing.pln. Then we hotlink them all together with any appropriate files from our current master model set.

The steps in detail are:

**Step A1** Create the sub models (e.g. Orchard.pln)

**Step A2** Create the Site model and import the new Survey.dxf. Adjust layering to allow for property boundaries, building setout points, features, roads, contours, pavements etc.

![Figure 9: Adjoining Buildings Coordination Sub-Model structure](image)

*DWG files of the existing adjoining buildings are xRef’d to the new sub-models, and hotlinked to a temporary coordination model, Existing.pln.*

**Step A3** Hotlink Podium.pln, the new building models, and the master structure file into Existing.pln to create the master design setout context.

**Step A4** Beginning at an appropriate level, xRef the existing Orchard Shopping Center floor plans (e.g. OSC_P200PB03_T.dwg; a 1:200 plan for level B3, version T). You may want to filter the layers so that only those elements to be modeled are displayed.

Hint – keep level marks and text visible to check your new model elements.

**Step A5** Commence, for example, with the floor slabs. Select the Slab tool, configure for thickness and elevation, and then using the profile on OSC_P200PB03_T.dwg, trace the outline and save. Repeat this for each level, and add columns, walls, doors and windows, etc. If the layouts are identical or share some basic layout, copy the common plan (above or below) as needed and correct for the exact arrangement.
ArchiCAD supports DWG, DXF, DGN and DWF formats. Plan2Model (see Appendix A), a separate application converts 2D drawings into models where a large number of conversions are required and also supports scan formats.

**Step A6** at an appropriate point; for example when all slabs, columns and party walls are complete for the chosen levels, create sections to match the section drawing locations provided by the Orchard Shopping Center Architects.

**Step A7** xRef the section drawing (e.g. OSC_S100V14_K.dwg) to the plan, adjust layering if required, copy the view from the plan and paste it into your new model section, adjusting the alignment against a known common reference. Compare the two images and correct as necessary.

**Hint**: Do not be surprised if you find there are errors between the DWG-based plans and sections. This is where most errors occur in 2D documentation, and is one of the benefits of the Virtual Building with its integrated building geometry.

The level of detail required will be determined by the project’s design and documentation needs. In our case at present, we need to make physical connections and penetrations with the existing building, so slab details and finished levels must be drawn accurately. In another case, e.g. a new fitout of an existing building, an almost complete carcass model of those areas to be refurbished will be required, but little else.

**Documentation Stage**

The project has now received approval from the local authorities, and has investment funding locked in. Car parking and street access have to be adapted to the new Council requirements. A Leasing Agent has been appointed at this stage and is actively marketing the office and apartment space.
A Head Contractor has been appointed and the design team may be novated. While waiting for this decision, the client has directed that an early contract will be let for site works and the substructure. The architectural team now has over 20 members, with a dedicated group for documentation.

The project scope has altered little, but in this phase the connection to adjoining properties becomes very important. New files are created with partial models of the two adjacent buildings, West End and the Orchard Shopping Center. This will allow the large city model file to be replaced with more accurate and detailed files for the documentation. City.pln will be updated at the end of the construction phase and building handover to further extend the practice’s building model.

Podium.pln is subdivided into Carpark.pln and a new version of Podium.pln. The model is now extended for the car park (to be managed in a special sub-contract), and the Tower file is subdivided into a Tenancy file, to allow for the large fitout work needed for the users.

Based on a 40-story building the following file sizes are possible:

<table>
<thead>
<tr>
<th>Ref</th>
<th>Model files (.pln)</th>
<th>Size (Mb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Metro</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>City</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>Site</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>Facade</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>Podium</td>
<td>40</td>
</tr>
<tr>
<td>6</td>
<td>Car park</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>Structure</td>
<td>30</td>
</tr>
<tr>
<td>8</td>
<td>Tenancy</td>
<td>40</td>
</tr>
<tr>
<td>9</td>
<td>Apartment</td>
<td>15</td>
</tr>
</tbody>
</table>

Table 2: Schematic Design Stage Model Files
Indicative sizes of each plan file; together they are a large model and need specialized management.

The benefits of splitting the model become obvious. Each file is relatively easy to work with, but a single user will have considerable difficulty working on Project.pln. In our example, the Metro file is very detailed, with information on the subway tunnels, platforms and associated facilities. However, it need not always be linked and is only used where needed.

**Note:** A master model used in hotlinking may not need any data of its own. In the example above, Project.pln is simply the aggregation of all the subfiles, and is used for master coordination, visualization, general arrangement, etc. However, in the case of Podium.pln, the file contains all of the underground car parking, entry level and shopping and conference center levels, as well as being linked to the Metro and Site plans to ensure proper context for the design development. The choice of either option depends on your specific working arrangements.

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4 In this procurement arrangement, the Head Contractor takes responsibility for the building cost and agrees with the client typically a maximum price. The design team now work for the Head Contractor who directs the final design, documentation and construction sequences.
Digital Workflow

We have given examples of different team organizations and the corresponding model structures at key stages of large projects. In essence, we are modeling a continuous evolution of a project, which at different stages can alter the team organization, result in different objectives and utilize different skill sets and resources.

We are establishing in fact, a process of digital workflow, in two environments – the creation and development of the building model, prioritized on user (client) requirements, the design and performance of the building concept and the production of documents are, as far as possible, generated automatically from the model. 2D drawings are typically the most common output, although we can generate images, animations, and other file format exports, e.g. DWG and IFC, including scheduling, costing and statistical data. Monitoring this process of model development – the digital workflow – results in several benefits; it allows a practice to understand how teams work efficiently, it identifies best practice, it can lead to the identification and re-use of knowledge and new techniques, thus further automating processes and improving knowledge.

Documentation Options

Having created the model file structure, and with the team developing the model, we now need to establish the documentation. We will use PlotMaker to manage the production of drawings, etc, but note that a couple of approaches are possible:

- Working directly on the hotlinked master model.
- Separating the model into a design model (used solely for design and general model development), and a documentation model used to store the sheet definitions and the 2D and related annotation, etc. for each sheet.

Both approaches have their relative merits, but for large models the separated approach offers several advantages.

The Documentation Model Concept

Separating Model Editing from Documentation

Tasks that can usually be carried out by just one team member now need to be done by several members in larger projects. It becomes important to ensure that every team member working on the building model(s) can work efficiently and productively, without requiring the direct intervention or cooperation of others. For some tasks, this may be desirable, but for normal activities, independent, but coordinated progress is required.

Model development and documentation are really very independent tasks; indeed, as indicated above, a dedicated team member, the Documentation Manager, has sole responsibility for the definition of drawings and their output and issue, while the Model Manager supervises the creation and editing of the project model.

Consequently, separating these now two clearly distinct groups can offer considerable advantages to the model building (design resolution) team and the documentation team. We explain this in more detail in Figure 8, below.

Aspects of the Documentation Model

We mentioned earlier the concept of (digital) workflow. Managing the development of such large models and large documentation sets (several thousands drawings is typical) puts a lot of pressure on the project team leaders, and the Documentation Manager in particular. Tracking changes, milestone issues and regular design & documentation editing all have to be taken into account.

Separating the models allows the following workflow management processes:

- **Incremental update** - achieved by making a new copy of the design model and updating the hotlink to Documentation.pln (as in our example).
- **Milestone issue** - make a final incremental update and archive the respective model to reflect the state of the models at the milestone.
- **Site feedback** - edit the current copy version of the design file (e.g. Project_v4.pln), export a correction drawing and merge this back in the master design file or appropriate subfile (according to the current hotlink structure).

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5 It is always assumed that users can view other parts of the project model whilst working in their area, based on TeamWorking or Hotlinking.
Building Large Databases Guide

Figure 12: Creating the Documentation Model
Project.pln is copied to the documentation directory and renamed Project_v2.pln. This copy is then hotlinked into the Documentation.pln in which the project documents are defined.

The documentation model is created as follows:

- **Step A** - Creating the documentation model files
- **Step B** - Share the Documentation file (.plp) to the documentation team
- **Step C** - Create the sheet (drawing) definitions
- **Step D** - Issue, update and edit drawings

Refer to Fig 10 (below) for an overview of the process.

**Step A - Creating the Documentation Model**

The process of creating the documentation model is summarized as follows:

- **Step A1** Establish the working model (e.g. Project.pln). See Subdividing the Model, p5
- **Step A2** Copy the working model, rename and/or add the version ID (e.g. Project_v1.pln) to ensure it is both uniquely identified and has a known source from which it was copied.

- **Step A3** Hotlink the copy (Project_v1) with the documentation model (e.g. Documentation.pln) as the master, and any other supporting files such as detail libraries.

**Step B - Sharing the Documentation Model**

Another advantage of separating the design files from the documentation file is that we can now share the task of defining and editing drawings.

- **Step B1** Share the model (convert to Documentation.plp)
- **Step B2** Define view sets based on the current workgroup.

**Figure 13: Sharing the Documentation Model**
Documentation.plp is shared to the documentation team.

**Step C - Creating Drawings**

Each user of the shared model can be responsible for their own or their team’s drawing production. View sets created by each user are updated in the master file, and at each send/receive action, these sets will become available to other users.
Figure 14: Creating Drawings
Step C1  Check views in Documentation.plp (including sections and elevations)

Step C2  Establish documentation sets, either created from scratch or copied from a Documentation Sets folder (i.e. a company template)

Step C3  Import View Sets from ArchiCAD as needed

Step C4  Define Master layouts (title blocks, standard sheets, etc.).

Step C5  Assemble the layouts in PlotMaker.

Step C6  Plot and/or publish as required

A detailed understanding of TeamWork and PlotMaker is essential for a well-performing model. This role and management of the documentation model is thus under the control of the Documentation Manager, who has knowledge of both building construction and also building modeling.

Tip: Master layouts, office drawing sheets, etc. should be created by the CAD manager and made available as part of the office CAD protocols, complete with standard presentation, documentation and other output sets.

Advantages of the Documentation Model Concept

The principal advantage here is that the documentation team, those responsible for the issue of documents, can work independently of the design team. The source design model data must, of course, be updated periodically (e.g. on milestone dates), which will require direct synchronization with both teams. Some additional considerations are:

Pros

- The documentation or presentation set(s) can be defined very early on.
- Section and elevation definitions often add a large amount of data and a processing overhead to a model, which limits editing and development. In this method this overhead is acceptable to the documenters, whose tasks are ‘documentation-based’, not model development-based.
- Drawing overlay data (2D annotation, titles, dimensioning etc) is independent of the design model.
- Document issue does not require the design team to stop working, only for them to export a new version of the design model.
- Different presentation and documentation styles (linestyles, fonts, colors and fills, etc.) can be applied without interfering with the design model.

Cons

- Management is more complex and needs dedicated resources

Extending the Concepts

Supporting Many Documentation Needs

There are many demands for documentation during the late design development, documentation and construction phases. For example, trade package documents, which are provided to suit the Contractors construction sequences, present a challenge to traditional project team procurement. To reduce time for the overall project delivery, the contractor is issued with early works documentation and trade packages, allowing them to mobilize earlier, rather than having to wait for the completion of all documentation.

However, as the design is not yet complete, and may often only be partially resolved, coordination between the site and the design team is essential so that continuing design development and new documentation reflects the actual conditions on the site. In essence, this means that there must be measurement of what has been constructed on site and the project model updated with these measurements.

The benefits of an integrated model become more apparent.

The organization of the models described allows multiple documents views to be defined to suit specific purposes during these stages, and even the commissioning and management stages.

As all these document views are always linked back to the design model, a high level of coordination is possible.

Note: For a discussion on the collaboration with external building structural and service engineering consultants see the Design Collaboration using IFCs manual.

In practice, using the whole model in one hot-linked file is not necessary very often. Each group in the project team normally has a specific role and only need to edit their own data, with a few other parts of the model for context and coordination. Thus, a much smaller set of files is used, improving editing speed and model development.

Note: With the emerging possibility of exchanging object models of

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6 A package is a detailed part of the construction, such as steel piling, concrete block walling, doors and hardware, let out to a sub-contractor for rendering and construction.
engineering systems - structure (e.g. concrete & steel), HVAC, electrical and piped services (H&C water, waste, fire protection and roof drainage) - will further extend the structure and the need to have smaller working sets.

Figure 15: Creating Sub-sets of a Master Model structure
A subset of the whole project is chosen to create Early Works documentation. This subset may only be required by the Documentation team, while many (coordinated) activities are concurrently proceeding on the whole project development.

The process of creating documents is similar to before.
The documentation team may now have several sets of ‘documentation’ under concurrent production, all developed independently of the design model working team:

- A design set (based on Project_v2.pln, for example)
- An early works set (based on EarlyWorks.pln)
- An engineering coordination set (based on a Services grouping)  
- An as-built set (based on AsBuilt.pln), etc.

Figure 16: Special Documentation
The EarlyWorks subset of the master model is copied and hotlinked to the Trade package
 Documentation Model

Working with External Project Partners
While the structural engineer and HVAC engineer will be involved in the conceptual design, it is during the detail design phase that the full team of engineering consultants will be requiring project data and providing engineering system information back to the architectural team.

2D DWG drawings will be most common and can be either xRef’d or imported into the .pln files.
See the ArchiCAD Reference Manual for details of DWG import/export
If IFC object model data are used, these data should be an independent discipline plan file (e.g. HVAC.pln or Sanitary.pln), which is updated periodically by incremental IFC imports, with the new data merged into the discipline file.
Objects and Libraries

In larger projects, the performance of the model (in parts or assembled as a whole) will be influenced by the processing of GDL objects. In a 40-story model, a particularly detailed window cladding object may place a great load on display times for instance. Hence it is important that a balance of detail and performance is achieved. Another aspect is that in the design phase parametric objects are useful, even essential, as the model is gradually developed. However, in the documentation phase, the parametric functions are both an overhead and often, non-essential data.

One solution to this problem is to have different libraries for the appropriate stages of the model. In the design phase a normal library is used. In the documentation stage a different library is created, based on the design library, with the relevant parameters either hidden (the best option) or locked. Thus, project GDL creation standards should be developed and mandated across the Team. The Model Manager should be responsible for ensuring there is a consistent object development. This becomes even more important if scheduling from the model is to be carried out.

Note: Some schedules do not work in hot-linked models (e.g. zones). Check this requirement early in the model design phase.

Customizing GDL Objects

Another important aspect is the level of detail of building elements. For key building parts, such as wall cladding, structural components and furniture and fittings, feedback from advanced users suggests that object creation should be thoroughly examined. Often, the extra time required to add flexibility to support design development or documentation is well worth the wait, as major benefits come from a more productive object.

Figure 17a: Windows and Cladding panels Systems – Detailed view
This window has a level of detail to support 1:1 documentation (see plan view blowup) and the highest fidelity of product visualization. Consideration needs to be given about the appropriateness of detail for each project stage.

Figure 17b: Windows and Cladding panels Systems – Simple view.
The same object has been visualized in a simple view, removing unnecessary detail, for example in 1:100-1:200 general arrangement plans, elevations and sections.
In the example above, three levels of detail have been provided: the detailed view (Fig 17a), the simple view (Fig 17b) and the basic view. The detail selection can be determined by the scale of the plan or elevation view, configured as shown in Fig 18a. Applying these ideas and techniques, objects can be designed both to make the processing of the model efficient, and to also lead to automation and related time saving results. Some examples are:

- Joinery fittings with settings to modify the detail in plan for 1:50 detail plans, versus general arrangement layouts
- A presentation layout (colors and fills)
- A coordination setting to only show junctions or locations of service connections (such as floor wastes, H&C water services, power connections, etc)

Setting to show the “design space” of an object, for example a refrigerator, with its required door swing and access (used in the design phase, but not required during the documentation phase)

Alignment lines or hotspots used to locate (e.g. panels) according to the building setout.
Detailing and Detail Libraries

Many practices have developed libraries of detail, usually in 2D DWG format. For organizations changing to the object model approach, ensuring that the investment in this drawing data is not lost or re-invented from scratch is vitally important.

Detailing is a precise and critical activity in the preparation of production drawing and, done properly, ensures the design intent is achieved. It also ensures that material and product specifications are appropriate for the project, correctly applied for the use-case and meet the office QA procedures.

**Note:** 2D DWG drawings will be most common and can be either xRef'd or merged into the .pln files. See the ArchiCAD User Guide for details of DWG import/export.

Option 1 – Creating a Detailed Building Section

One of the traditional methods for creating details is to “blow up” a large-scale section drawing, editing the profiles graphics for greater accuracy in their detail, adding extra components (e.g. flashings and reinforcement), showing more explicit material representations (e.g. fills and special linetypes) and text and dimensioning annotation. These detailed master sections prove the construction and detailed design development are feasible.

In this method, a section is defined in the building where the details are required (typical or special). The scale is typically about 1:20 or 1:25 (so if we are applying this to our Tower Plaza project, the section is carefully chosen to best represent the detailed construction).

**Step 1.1** Define and save the section, e.g. “Master Section 20”.

**Step 1.2** Define the detail extents from this view using the Detail tool and locate the set of detail quick views in a details view set called, e.g. “Master Section 20”

**Step 1.3** Unlink the master view and now edit the section drawing (in 2D mode) to create an accurate description of the profiles, products and material representations as required. The drawing is targeted for a 1:5 scale final detail.

**Tip:** you can restore the link later to ensure that any building element relationships have changed.

**Step 1.4** Open PlotMaker and use the detail sets view to layout the 1:5 detail sub-views, suitably aligned to represent the master section.

**Tip:** You can control the alignment of the details using hotspots.

Option 2 – Using the Detail Tool & xRefs

The user has a DWG library of office standard details, which are a single DWG file for each detail. The project team are using ArchiCAD, but want to make immediate use of the existing office DWG library.

**Step 2.1** Choose the appropriate plan or section view and apply the Detail tool. Open the detail and check the extent.

**Step 2.2** Import a DWG detail, by xRefing or merging, and adjust accordingly.

**Step 2.3** The selected detail is now referenced properly with the project model and View Sets.

**Step 2.4** Open PlotMaker and assemble the details in layouts for integration into the production drawings.

**Step 2.5** Issue and manage the drawings using Publisher.
Option 3 – xRefing a DWG Detail sheet

The detail library has been based on A1 sheets divided into a number of standard boxes, which leaves space for a small title block and a detail “zone” (e.g., c.150x180mm) for 1:1 to 1:5 scale details (see Figures 20 & 21 above).

Tip: Use a GDL object to make standard drawing title objects.

The sheets are typically ordered by scale and no sheets have different scale details. The detail sheets are included as a whole sheet with standard detail references.

Step 3.1 Choose the appropriate plan or section view and apply the Detail tool. Open the detail and check the extent.

Step 3.2 Now import the DWG detail by xRefing or merging, and adjust accordingly.

Step 3.3 The selected detail is now referenced properly with the project model and View Sets.

Step 3.4 Open PlotMaker and assemble the details in layouts for integration in the production drawings.

Step 3.5 Issue and manage the drawings using Publisher.

Option 4 – Converting a DWG Detail Library

The Project Leader, in discussion with the office CAD manager, has decided it’s time to convert the DWG libraries to be used on this project into ArchiCAD format. The library needs updating with feedback from some recent projects and several building products are no longer available. A small team is assembled to carry out the work.

Step 4.1 Review the details with the appropriate Design and Documentation Leaders and agree the changes to be made.

Step 4.2 Apply the office documentation formats for details, and determine any necessary font, linestyle or fill mappings to be applied to the conversion.

Step 4.3 Create a DWG configuration for the conversion based on step 4.2.
and test it out on a sample detail. Review and repeat the process until the correct result is achieved.

**Step 4.4** Create a new Detail library pln file and merge the DWG detail drawings and then check the conversions.

**Step 4.5** Edit the results as required in Step 1.

The new office details library can be made available in several different formats. Consider these options and choose the one most appropriate to your needs:

- **Step 4.6i** Name the .pln file “DetailsLib.pln” and place it in an appropriate place in the ArchiCAD resources directory.

- or

- **Step 4.6ii** In PlotMaker, arrange the details in convenient sets and publish on the company intranet.

- or

- **Step 4.6iii** In PlotMaker, arrange the details in convenient sets and publish as reduced A2 PDF digital booklets.

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**Implications for Large Projects**

**Securing Your Data - Backing Up**

There are several types of project data:

- The approved design
- The working model
- The construction issue documents and model
- As built data

Daily incremental, weekly and monthly backups are required to protect the work created by the project team.

The size of the backups can be considerable; if we consider the single model (say 300 to 500Mb including libraries), for all versions this implies a 1.2 to 2.0Gb incremental backup. (This excludes the GDL libraries).

An automated, high capacity hardware system is essential. A crash or other failure of the computer network can result in a very expensive delay, during which no work is possible.

Backup procedures need to be carried out by trained IT staff, with a project team member appointed to coordinate with the IT Department.

**Document Management Systems**

It is not the purpose of this document to discuss the topic in detail; many organizations have their own Document Management Systems, while some will have separate drawing management, etc.

Extranets provide a centralized facility, some with workflow options. From the whole Project Team viewpoint, this single source of document information is efficient. From an individual perspective, the extranet may duplicate the internal system and will entail additional resources to support it.

Whatever the case, the project model design must be compatible and integrated with both internal and external systems.
Appendix A: ArchiCAD Tools for Model Development

There are three primary methods for creating and editing models: Solo project, Hotlinking or TeamWork, and also a fourth method to create models from 2D data: Plan2Model.

Solo Project
This is the most common way of using ArchiCAD. It is used by individuals or very small teams and will not be considered further here.

Teamwork
TeamWork allows several users to simultaneously work on a model. Sharing a model requires the definition both of user roles (i.e. what rights they have), and their access to the model (i.e. what parts of the model they can edit).

For detailed instructions on using the hotlinking commands, see the ArchiCAD User Guide, TeamWork & the TeamWork Function Guide

Hotlinking
The principle of hotlinking is to associate an independent model (.pln file) with a host (or master) file. The linked file cannot be edited from the master file and must be edited directly. The master file may have multiple linked files, each containing their own linked files, providing for a high level of flexibility in structuring a project model. Modules are linked by story.

For detailed instructions on using the hotlinking commands, see the ArchiCAD User Guide, Hotlinked Modules.

Using IFC collaboration is an alternative approach and is documented in the IFC 2x Guide and the Design Collaboration Using IFCs manuals.

xRef and Merge
The xRef function permits the linking of a DWG file with an ArchiCAD model. Merge, in contrast, imports the DWG file data into the .pln file where it can be edited.

For detailed instructions on using the hotlinking commands, see the ArchiCAD User Guide, Working with DXF and DWG Files.

Plan2Model
Plan2Model is an Add-On application that assists the manual or automated conversion of 2D vector format files into 3D ArchiCAD models.

Where a number of legacy drawings need to be converted, Plan2Model creates conversion templates - a mapping library - by associating 2D graphics with an ArchiCAD building element. The program then scans the drawing and rapidly interprets the drawing according to the template.

For detailed instructions on using Plan2Model, see the Plan2Model User's Manual.
Appendix B: Useful References

Several international and national standards or guidelines exist for the classification of information in building projects. These systems can often be used to great benefit in structuring models, documentation drawings and specification information.

**ICIS, the International Construction Information Society**, represents the interests of its nearly 20 national specification and information broker members. See [http://www.icis.org/](http://www.icis.org/)


The **IAI, International Alliance for Interoperability**, is a worldwide alliance dedicated to the development of a global, neutral object-based building information exchange protocol, called IFC. The IFC model was adopted as an international standard (ISO PAS 39537) in October 2002 by the ISO. See [http://www.iai-international.org](http://www.iai-international.org)

For national specification bodies and organizations see [http://www.icis.org/Icismem.htm](http://www.icis.org/Icismem.htm)