Building Information Management

A Standard Framework and Guide to BS 1192

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This guide includes relevant sections from the acknowledged groups, but also includes new information from current learning by the Construction Project Information Committee (CPIC) and the British Standards Institute (BSI) on a number of recent projects.

This information is published as guidance of a general nature, and the author accepts no liability for any use to which it may be put.

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Production Information: A code of procedure for the construction industry, published by CPIC (www.CPIC.org.uk).

PIX Protocol Guide and Toolkit, published by the Building Centre Trust. Now available from the CPIC website (see above).

Avanti, ICT Collaborative Working: Toolkit documents. Constructing Excellence 2004. Now available from the CPIC website (see above).

Many of the images in this guide are based on those first published in CPIC's *Production Information: A code of procedure for the construction industry* (2003) and BS 1192:2007 documentation or by MR1 Consulting Ltd.

Chartered Institute of Architectural Technologists

CIBSE
Engineering a sustainable built environment

ice
Institution of Civil Engineers

RIBA

RICS
the mark of property professionalism worldwide

UKCG
UK Contractors Group

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Preface

British Standard BS 1192:2007, *Collaborative production of architectural, engineering and construction information — Code of Practice* was published to provide a standard and 'best-practice' method for the development, organization and management of production information for the construction industry.

A 'standard' is required, so that all offices, teams or team members can produce information to the same form and quality – enabling it to be used and reused without change or interpretation. If an individual, office or team changes the standard without agreement, it will hinder collaboration and document sharing. 'My standard' is not acceptable in a team working environment.

Construction Project Information Committee (CPIC) defines production information as 'the information prepared by designers that is passed to a construction team to enable a project to be constructed'. It is independent of who employs the designers and which procurement route or form of contract is used. Production information is the output of the design team and specialist contractors, and is conveyed by drawings, specifications and bills of quantity or schedules of work. In a Building Information Modelling (BIM) working environment the delivery may take the form of three-dimensional models with associated information attached by direct attribution or population from a database.

Unless this information is complete, accurate, well structured and coordinated, it will not be effective and – no matter how good the design – it will not be satisfactorily realized on site.

Poor production information causes delays, extra costs and poor quality, which in turn give rise to disputes over who is responsible for the problems.

Good production information is therefore vitally important to the success of the practice, project and delivery of the major contracts handover document required for the successful management and maintenance of the asset throughout its life.

BS 1192 is not only a means of delivering the two-dimensional drawing information that is required for a project, but it is also the basis on which information management and the delivery of the three-dimensional Integrated Building Information Model (iBIM) and its associated data should be delivered.

We have compiled this guide to give more detailed information on the specific elements of the process supported by the standard.

1 Introduction

This guidance document has been produced using background information on procedures that have been taken from successful application in the construction industry, and has been developed in conjunction with the management processes required to manage information through the project lifecycle. The adoption of such procedures will allow the move from a document-centric environment to an information-centric environment – unlocking the power of information technology.

The toolkit has been developed from the computer-aided design (CAD) standards, methods and procedures of over 70 different companies in the construction industry who work in collaborative framework environments, Construction Project Information Committee (CPIC), its consultants and steering groups, Construction Industry Research and Information Association (CIRIA) research documents (funded by the DTI), and many other individual practitioners.

It also takes account of BS 1192, ISO 13567, CPIC's *Production Information: A code of procedure for the construction industry*, Uniclass classifications and the PIX Protocol Toolkit, developed by the Building Centre Trust. All of these documents are now available on the CPIC website.

This procedure relies heavily on industry documentation, research and practical application within live projects. The projects range from simple housing developments to the value of a few hundred thousand pounds to the most prestigious multi-billion-pound projects.

The knowledge and experiences of those practices have been measured and published over the past 15 years, showing both benefits and blockers to the application of collaborative working. For the most part, such innovative applications have been successful, with the benefits far outweighing the effort employed.

Recommendation: these procedures apply to all organizations, from small consultancies and small projects to major contractors and large-scale projects.

2 Production information for the construction industry

Research has shown that inaccurate, incomplete and ambiguous production information causes many problems on site. The impacts on the project are late delivery and increased cost – estimated to amount to approximately 25–30 per cent of the construction cost, and affecting each member of the supply chain. Effective communication of high-quality production information between designers, manufacturers/fabricators and constructors is therefore essential for the satisfactory realization of construction projects.

The evidence shows that improving the quality of production information reduces the cost of developing that information, as well as the incidence of site-quality problems, leading to significant savings in the cost of construction work. The 2003 CPIC publication *Production Information: a code of procedure for the construction industry* quotes an 18 per cent reduction in drawing costs and an overall cost–benefit of at least 10 per cent of the contract sum.

Further testing on live projects has demonstrated that, when applied properly, standard methods and procedures provide savings and improved profit for each office and all members of the supply chain. To change or 'simplify' any element of the procedure – without an understanding of the impact of that change – puts the improvements at risk, and at best will only maintain the 'status quo'.

In addition, the processes and procedures offer the potential for greater saving in the delivery of the lifecycle information and the asset management data to be used and updated throughout the life of the facility or utility.

There are three specific areas that must be addressed to enhance the production information process. These are:

- roles and responsibilities;
- Common Data Environment (CDE); and
- Standard Method and Procedure (SMP).

2.1 Roles and responsibilities

Ownership of data along with the clear definition of responsibility is a crucial part of any design delivery. This document defines specific roles together with associated responsibilities to aid the process.

2.2 Common Data Environment (CDE)

The CDE is a procedure for managing the iterative development of the design documentation to achieve full integration and spatial coordination of the data/information from all participants and offices, and from all originators within project supply chains.

These procedures are not restricted to the development of the design team information. The procedure must be used throughout the process of delivery and into the management of the asset itself. The subcontractor and fabrication design teams must deliver the final 'virtual construction' model representing the actual construction elements. In turn the contractor, commissioning agents and suppliers must also use the CDE to complete the database of information required for asset management.

The procedure also ensures that data/information is checked and issued fit for a specific purpose at a number of defined 'gates' such that it may be used for the stated purpose. Finally, the procedure allows for the dissemination of the signed-off information 'fit for detail design development' or 'fit for construction', and the collection of all relevant data/information needed to deliver the project handover document for the administration, maintenance and deconstruction of the final product.

These processes were well defined and managed in a paper-based filing system, but with the adoption of new electronic technologies, the need for good management has been overlooked and the systems have not been replaced.

The procedures outlined in this document apply to all approaches to project modelling, including:

- coordination of the project model files in 2D as they develop;
- coordination of the project model files in 3D as they develop;
- production of 2D drawings from 3D models;

- production of 2D drawings using 2D CAD drafting software;
- the collection, management and dissemination of all relevant construction documentation;
- the management of all spreadsheets, text files, etc. as extracts from the model;
- application of the process and procedures for the delivery of the 'integrated Building Information Model' (iBIM) and all relevant handover documentation; and
- application and coordination of the specifications and costing requirements.

2.3 Standard Method and Procedure (SMP)

This document also defines a Standard Method and Procedure (SMP) that should be used for developing and presenting the design information and documentation for construction projects. Organizations should define standards consistent with BS 1192.

When commencing a project that will involve the production of CAD/BIM information, it is critical for each office to adopt the approaches outlined in this document, when using any software solution for producing 3D or 2D models and 2D drawings.

To implement this SMP, the following eight principles should be followed:

- Roles, responsibilities and authorities: agree roles, responsibilities and authorities – in particular, the responsibility for design coordination of the various design disciplines.
- Common Data Environment (CDE): adopt a CDE approach and allow information to be shared between all members of the office team. Some form of document repository – for example, a project extranet or electronic document management system – will need to be used when collaborating on a project.
- Document management/electronic data management (DM/EDM): agree a suitable information hierarchy that will support the concepts of the CDE and the document repository.
- File-naming convention: adopt file-/document-naming conventions, so that relevant information can be identified using file names. Agree the reference codes for 'status' and 'revision' of files and documents, but these are not part of the file name.
- Origin and setting out: agree the origin of the coordinate system and method for spatial coordination.
- Drawing sheet templates: agree the title block, attributes, paper sizes and production scales. Make model file and drawing templates available including: title blocks, layer names, text styles, line types, etc. for consistent delivery of the final construction information.

- Layer standard: agree a 'layer-naming standard' based on BS 1192 that includes a classification system. BS 1192 recommends the use of the Uniclass classification system.
- Annotation: agree a standard for abbreviations, text dimensions and symbols and ensure all models are drawn to scale and dimensioned as such.

Each organization involved must adopt the project SMP, and all relevant parties (client, design consultants, supply chain partners, etc.) must agree and commit to it. Each organization should produce the project SMP at the pre-contract stage and include it in the procurement documents and contracts.

3 Definitions

Table 1 is a short version of the definitions to be used when reading and applying this document.

Table 1: Definition of terms

Term	Definition
2D	Two dimensional.
2D drawing	A 2D drawing contains a view of a model that is referenced into a 'drawing sheet template' (blank drawing and title block). Such drawings must always be considered to be static documents, as they are drawing renditions or snapshots of the design's model files.
2D model	Model with entities having 2D properties. Such models must always be considered to be dynamic, as they will be made up of 'model files' that are 'xref' or 'reference' files.
3D	Three dimensional.
3D model	Model with objects having 3D properties. Such models must always be considered to be dynamic, as they will be made up of 'model files' that are 'xref' or 'reference' files.
3D visualization	3D images from the 3D CAD model or a virtual representation of the building or facility to be constructed; used for visualizing the project.
attribute	Modelling concept used to represent properties of, and relationships between, entities.
author	Originator of model files, drawings or documents.
BIM	Building information modelling.
CAD	Computer-aided design.

Table 1: Definition of terms (contd)

Term	Definition
CAD standard	Standard used to produce CAD models that will include origins, units, layering conventions, line specifications, file-naming conventions, drawing numbering, etc.
CAD viewer	Software used to view CAD models or rendition print files without requiring the user to have the software that produced the model.
CADD	Computer-aided design and drafting. A computer-aided design software application with additional features such as the ability to output drawings from the software.
CAWS	Common Arrangement of Work Sections published by CPIC for use in specifications and bills of quantities.
CC	Construction Confederation.
CDE	Common Data Environment. A single source of information for any given project, used to collect, manage and disseminate all relevant approved project documents. A CDE can be stored on a project server or extranet.
CDM	Construction (Design and Management) [Regulations].
CIAT	Chartered Institute of Architectural Technologists.
CIBSE	Chartered Institution of Building Services Engineers.
CI/SfB	The UK version of the Construction Indexing Classification System for Construction products and elements – a version of the SfB classification system originating from Sweden.
CPI	Construction Project Information.
CPIC	Construction Project Information Committee.
CSG	Constructive Solid Geometry representation. A CSG object is composed from standard primitives using regularized Boolean operations and rigid motions.

Table 1: Definition of terms (contd)

Term	Definition
data	Information not yet interpreted or analysed.
DGN	File extension for Bentley Systems' MicroStation and Intergraph's Interactive Graphics Design System CAD programs.
document management	Technology that provides more control and better management of computer-generated files. It adds enhanced file security, revision control, file descriptions, extended file names and user access privileges to the basic file directory management features of the computer operating system.
DMS	Document management system.
document repository	Entity including an electronic data management (EDM) system, project extranet or folder hierarchy on a Windows file server.
documentation	Section of the CDE for drawing renditions that have been approved as fit for a specific purpose – for example, fit for construction.
drawing title block	Framework – often containing the project team's logos – to show the drawing title, number, purpose of issue, status and revision information.
DWF	Proprietary AutoCAD web format.
DWG	Proprietary AutoCAD file format.
DXF	File format used mainly for importing and exporting CAD data between AutoCAD and other CAD-related programs.
EDMS	Electronic document management system.
entity	Synonym for object.
FM	Facilities management.
graphic file	File format designed specifically for representing graphical images.
IAI	International Alliance for Interoperability. Now known as Building Smart.
iBIM	Integrated Building Information Model

Table 1: Definition of terms (contd)

Term	Definition
ICE	Institution of Civil Engineers.
ICT	Information and communications technology.
IFC2x	Industry Foundation Class version 2x.
information	Representation of data in a formal manner suitable for communication, interpretation or processing by human beings or computer applications.
layer	Attribute given to entities within CAD files enabling their visibility to be controlled. Further values may be assigned to the attribute to enable control of whether it can be edited or deleted.
marked-up drawing	Paper or electronic drawing that has been marked up with comments from other disciplines or the client.
model file	Native CAD file that can be a 2D or 3D model.
object	Item having state, behaviour and unique identity – for example, a wall object.
originator	Author of models, drawings and documents.
OS	Ordnance Survey.
PDF	Portable Document Format. A standard document format from Adobe Systems for transfer between different computer systems.
purpose of issue	States the purpose for issuing the document.
reference file	CAD model file associated or linked with another CAD model file. Also referred to as an xref.
rendition	Documentation in a form enabling the information to be viewed, printed and marked up. For example, PDF and DWF files are documentation consisting of snapshots of 2D drawings. Such renditions are generated each time the drawing is prepared for 'sharing' at regular milestones.
revision	Used to identify revisions of documents, drawing and model files.

Table 1: Definition of terms (contd)

Term	Definition
RIBA	Royal Institute of British Architects.
RICS	Royal Institution of Chartered Surveyors.
SI System	Le Système International d'Unités. [International system of units]
SMP	Standard Method and Procedure.
standard font	Agreed set of font types and sizes to be used for the project.
standard layering convention	Single layering convention used by the project team.
status	Defines the 'fitness' of information in a model, drawing or document.
TBM	Temporary benchmark.
Uniclass	Unified classifications for the construction industry sponsored by CC, RICS, RIBA and CIBSE. The classification system is based on CI/SfB, CAWS and other relevant documents.
VPN	Virtual private network
xref/reference file	CAD model file associated or linked with another CAD model file.
zone	Manageable spatial subdivision of a project, defined by the 'project team' as a subdivision of the overall project that allows more than one person to work on the project, floor plan or staircase, etc. Each zone or subdivision is a reference file. When one or more referenced files is viewed, the full floor plan or site plan may be represented. This subdivision also becomes important when using extranets, as it allows the files to be kept to a manageable file size.

4 Roles and responsibilities

At the start of a project, it is important to identify the roles and responsibilities of the design team, and of specialist subcontractors who have design content in their work packages.

It is also necessary to define the roles and responsibilities of individual team members as well as the schedule of responsibilities for deliverables of the overall team. The titles of the managers may differ, but the important factors are the ownership, responsibility and authority.

Examples of the team member roles required within a large project are set out below.

4.1 Design Coordination Manager (also known as the Design Manager on some contracts)

The Design Coordination Manager provides a communications link between the various design teams and the construction teams. The Design Coordination Manager is usually provided by the contractor, and integrates the design deliverables of the professional designers, specialist designers and subcontractors against the construction programme to ensure timely delivery.

4.2 Lead Designer

The Lead Designer manages the design, including information development and approvals. The Lead Designer confirms the design deliverables of the design team, establishes the zone strategy and ownership, and establishes the structural grid and floor levels. The Lead Designer signs and approves the documentation for detail design coordination and prior to passing to ‘shared’. In small and medium-size projects, a Lead Designer could be the same person as the Design Coordination Manager.

4.3 Task Team Manager

The Task Team Manager is responsible for the production of design output that facilitates the production of such elements of the design that relate to that task. Tasks are often discipline-based, so the Task Team Manager is usually a discipline head, responsible to the Lead Designer.

4.4 Interface Manager

An Interface Manager should be appointed for each task. In a spatial sense, if more space is required – for example, the staircase – the Staircase Interface Manager will have to discuss the need for increasing the staircase area, and negotiate with the Interface Manager(s) for each of the floors served by the staircase to discuss the impact of making further space available. The Interface Manager will be responsible to both the Task Team Manager and the Lead Designer.

4.5 Project Information Manager

The Project Information Manager provides the focal point for all file and document management issues in the project. He/she also ensures that all information is compliant with standards and that each model or file has been signed off 'fit for purpose'. This role should be responsible to the Design Coordination Manager.

4.6 CAD Coordinator

A CAD Coordinator ensures that there is a consistent approach to project modelling (2D or 3D) and CAD issues and practices across the project. He/she also coordinates the project needs for IT solutions, coordinates the agreed project CAD 'standard and method' and updates to the procedures, and also ensures compliance with those standards and methods. This role should be responsible to the Task Team Manager and the Project Information Manager.

4.7 CAD Manager

A CAD Manager ensures that all CAD models and drawings are delivered to the project using agreed IT solutions, and according to the agreed project CAD 'standard and method' and procedures. This role should be responsible to the CAD Coordinator.

Recommendation: the roles, responsibilities and authorities of the team should be established on a project-by-project basis and written into the project procedures. See below for details. On smaller projects one team member may carry out a number of roles.

At the start of a project, roles should be assigned and recorded – for example, as shown in Table 2. List all contact information against each role.

Table 2: Assigned roles

Role **Company**	**Name**
Design Coordination Manager Company X	 Name Address Email Tel./mobile
Lead Designer Company X	 Name
CAD Coordinator Company X Company Y	 Name Name
CAD Manager Company X Company Y	 Name Name
Task Team Managers Company X Company Y	 Name Name
Project Information Manager Company X Company Y	 Name Name

Examples of the responsibilities required within a large project are set out below.

4.8 Software versions

Recommendation: before starting the project, the design team must agree the CAD software and versions to be used.

The CAD Coordinator should use the results from the questionnaires in Appendices C and D establish which software is used by the various designers and supply chain teams.

As an alternative, the PIX Protocol Guide and Toolkit should be used to capture the information requirements of the client and the CAD and IT capabilities of the design team members. For more information, see the *new CPIC website. An online version of the PIX Protocol is available from* the *new CPIC website* (www.CPIC.org.uk).

4.9 CAD checking tools

As part of the checking process for CAD/BIM model files, use checking software for compliance with the agreed standards:

- Layer names comply with project standards.
- Dimension text has not been changed 'manually'.
- Title sheet attribute metadata information has been completed and complies with the project CDE/SMP or CAD/BIM standard.

Recommendation: carry out regular audits, and return to their originator any files that fail with a report on non-compliance.

5 The Common Data Environment (CDE)

The fundamental requirement for producing information through a collaborative activity is to share information early, and to trust the information that is being shared as well as the originator of that information. What is needed is a disciplined auditable process that is transparent and controllable.

The method for managing a project through a Common Data Environment (CDE) is applicable to all sizes of practice, and in particular it prepares that office to be able to work collaboratively. As a standard that is adopted by all, it will help to remove the problem of having to constantly retrain on each and every project when client standards are to be applied. If the clients accept the procedures and make them contractual, then these problems disappear.

The CDE is a means of allowing information to be shared efficiently and accurately between all members of the project team – whether that information is in 2D or 3D, or indeed textual or numeric. The CDE enables multidisciplinary design teams to collaborate in a managed environment, where the build-up and development of information follows the design, manufacturing and construction sequence. A high-level functional view of the CDE is shown in Figure 1 on page 18 and a detailed description is shown in Figure 2 on page 22.

The CDE process also ensures that information is only generated once and is then reused as necessary by all members of the supply chain. It also ensures that the information is constantly updated and enriched for final delivery as part of the Facilities Management (FM) document.

There are a number of ways and different environments in which the CDE can be used.

Single design discipline environment, in the originator's office.	The CDE is implemented within the design office to manage the team members producing design information on a number of projects.

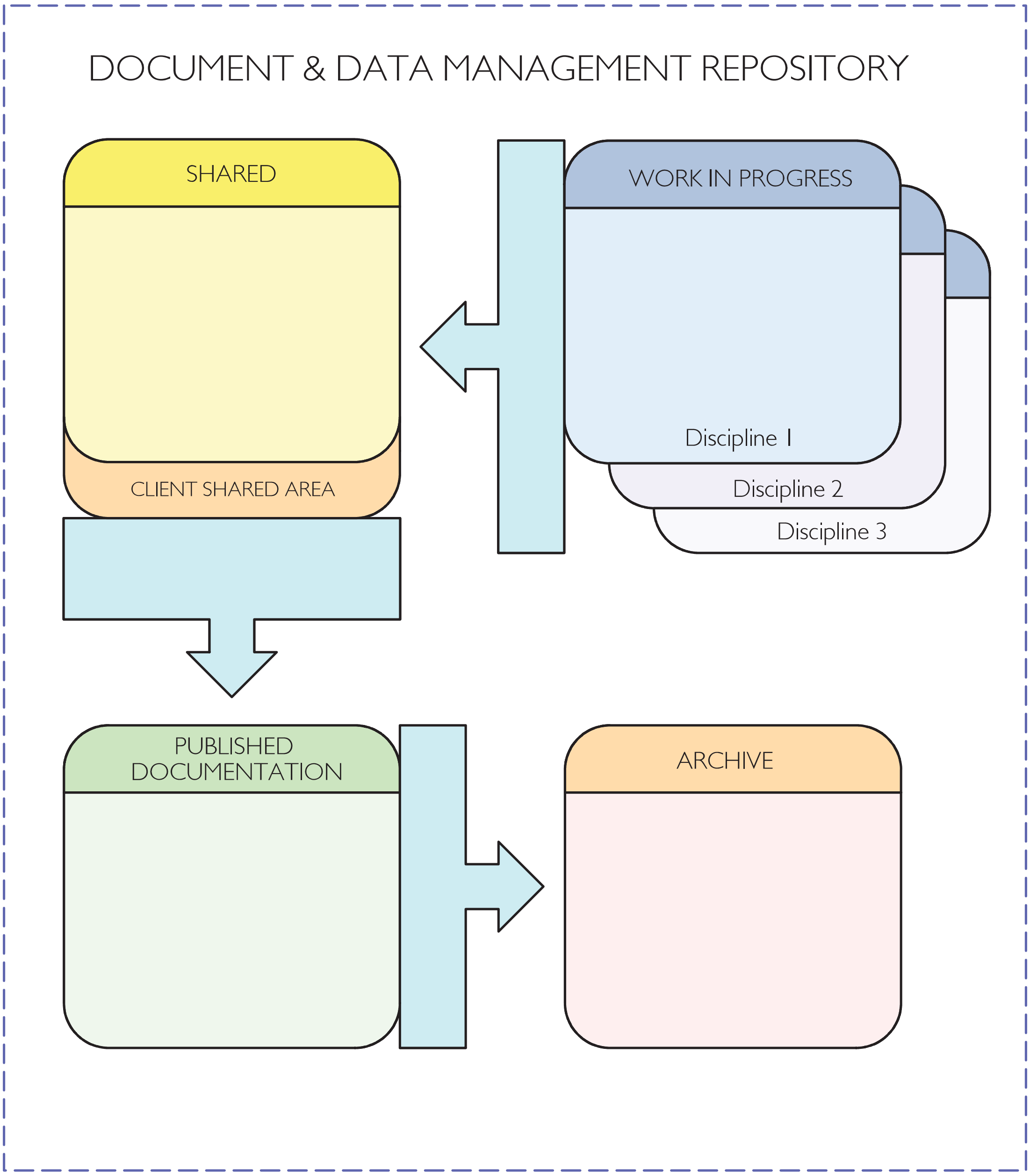


Figure 1: High-level Common Data Environment

Task Team environment, co-located.	To manage the multi-discipline teams on single projects.
Project or programme environment, co-located.	To manage the Task teams in a multi-disciplined and multi-project programme when the teams can be co-located.
Project or programme non co-located.	To manage the workflow and sharing of information across a multi-disciplined, multi-project programme over the web or VPN. A virtual team environment.

Figure 1 shows the high-level functional view of the CDE. This would be used in the discipline or multi-discipline team environments that are co-located.

Advantages of adopting such a CDE include:

- ownership of information remains with the originator, although it is shared and reused;
- shared information reduces the time and cost in producing coordinated information; and
- any number of documents can be generated from different combinations of model files.

If the procedures for sharing information are consistently used by the design teams, spatial coordination is a by-product of using the CDE processes, and will deliver production information that is right first time.

Information can subsequently be used for construction planning, estimating, cost planning, facilities management and other downstream activities.

Coordination should be achieved as a consequence of the detailed design production process.

- Some examples of the different kinds of information that should be available in the CDE through a project's lifecycle are shown in section 5.1.5 of this guide.
- Data within a CDE are finely granulated and structured to ease their reuse. It provides the ability to produce traditional drawings or documents as views of multi-authored data within the CDE. It also gives greater control over the revisions and versions of that data.

- The structured use of a CDE requires strict discipline by all members of a design team in terms of adherence to agreed approaches and procedures, compared with a more traditional approach. The benefits listed above can only be realized with a commitment to operate in a disciplined and consistent manner throughout a project.

One element not defined in BS 1192 or in this guide is a solution to the problem of interoperability between the different CAD and Building Information Modelling (BIM) solutions used within a project. Generally the guidance would state that whenever possible data/information should be made in the native format of the solutions being used. In addition, the project teams should agree on the number of data renditions required, and check these renditions to ensure their interoperability or to understand the limitations of the solutions they relate to. Example formats are .dwg, .dgn, .nwd, .nwf, .rvt, IFC, aecXML, gbXML, CIS2 and SDNF.

The use of the PIX Protocol templates and questionnaires may help to establish the level of maturity and the level of interoperability achievable between the partners on any given project.

5.1 Functional sections of the CDE

Although the CDE can be used to hold any type of information – for example, CAD/BIM models, drawings and any other associated documents or data – the following sections describe the use of the CDE from a CAD/BIM point of view.

There are four sections of the CDE and 'gates', or sign-off procedures, that allow data/information to pass between the sections. See Figure 2 on page 22. The naming of the gates is significant:

Work in progress to shared – check, reviewed and *approved*
Shared to published – *authorized*
Published to archive – remeasured (checked) and *verified*

5.1.1 Work-in-progress

The work-in-progress (WIP) section of the CDE is where members of the project team carry out their own work using their company's software systems. Such work-in-progress information is likely to be stored on their in-house servers, with access to view or change information limited to the owner and other project team members of that company (see Figure 3 on page 24).

It is important to understand that within the offices of individual disciplines it is essential to maintain the same processes to manage the internal team as those used in the project environment. This is the WIP process.

The design teams are responsible for the quality of the WIP information, and should ensure that appropriate checking and review processes are in place. Therefore each model file will only contain the information for which each design team is responsible. Note that the design teams also include Work Package subcontractors who develop designs based on consultants' designs.

CAD information can be structured into a number of models. A 2D model file comprises a series of layers that represent, for example, a grid, columns or walls, as shown in Figure 27 on page 58.

In the case of 3D models, the information is described at the level of objects or elements that represent, for example, a column, wall, door or window.

Within the WIP, management systems must allow for version control of each update of the data file, and these must be filed using a 'Minor Version' index, e.g. 1.1, 1.2, 1.3, etc. This is usually indicated as a version number. For data that is still in its preliminary design iterations, this is usually indicated as P1.1, P1.2, P1.3, etc.

When the data are shared with the remainder of the external project team, they are transferred to the shared area, and the revision is updated to a 'major revision', e.g. P2 and P3, etc.

When this occurs, the data continue to be updated in the WIP (in the internal system) area, but the minor versions will be indexed to P2.1, P2.2 and P2.3, etc. until the next shared milestone.

The version numbering of the files is important, as extracts will be taken from the models during their development to verify material schedules and checks against the cost plan. This may pass through a number of iterations until the data and information can be shared with the other members of the team. The data files or extracted files (perhaps text files or spreadsheets) will use the naming conventions, and the revision/versioning procedure is applicable to all.

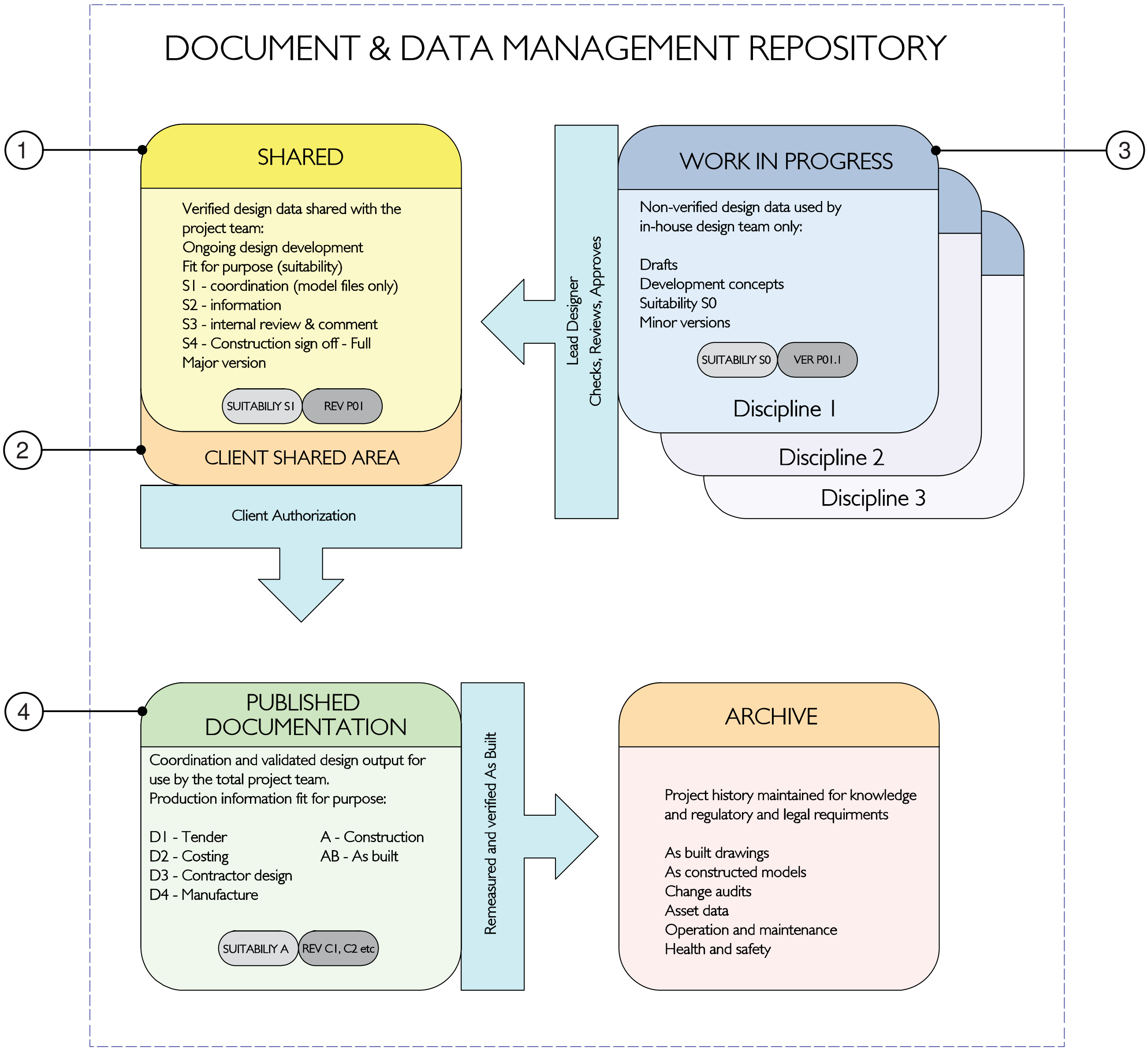


Figure 2: CDE expanded description

1 SHARED

Minor full revisions
This system starting at P01 is the interger of the WIP revision.
Therefore P01.1 becomes P01.
Uprevving in the shared area will be for design progression, be that through coordination with other discipline models or a natural evolution of the design.
The owner of the model is the only discipline that may uprev, update or remove a model.

Status
The status in the SHARED area may be one of the following:
S1 – Fit for Coordination (with other discipline models) model files only – non litigious
S2 – Fit for Information – This status is non-litigious and therefore indicates sharing with technical consultants to exchange information.
Not to be issued to the client for information. (See D status.)

S3 – Fit for Internal Review and Comment – must be undertaken before issue to the client – non-litigious.
S4 – Fit for Construction Approval (RIBA D)
Fit for Construction (RIBA E, F & G)
Non-litigious information, to be issued to the client for final sign-off status.

2 SHARED SIGN-OFF AREA

Area where data is issued to the client.
A client sign-off area for checking, verifying and approving data.
Data will normally be issued to this area in agreed packages in line with the design programme as dictated by the client.

3 WORK IN PROGRESS

The WIP will contain:
Minor versions. This is the minor revisioning system starting at P01.1 and increasing in increments, P01.2, P01.3 etc.

The status of the model in the WIP area will be set at S0 (initial status).

4 PUBLISHED DOCUMENTATION

Major revisions
The approved revisioning system will be alphabetic, A, B, C etc. The use of the full major revision indicates that the model is now a legal document and will form part of the client's audit trail. This does not mean that the documents are ready for construction unless the status code is set to A. See below.

On each successive submission to the client the alpha revision will increase incrementally.
No alpha revisions shall be skipped in the client's audit trail. (This excludes I, O & P, which Technical Consultants have been instructed to omit.)

Status
Data issued to the client as a temporary request will be issued with a D status. This indicates that although published data, it may not be used for construction approval or construction. This data will not have had client sign off.
D1 – Fit for Costing – legal doc.
D2 – Fit for Tendor – legal doc.
D3 – Fit for Contract Design – legal doc.
D4 – Fit for Manufacture/Procurement – legal doc
D status will usually be a request from the client to the Lead Designer. This data will not be issued to the shared area, but direct to the client. This data will not be used for construction approval or construction unless issued through the shared area, coordinated and issued in the correct manner for client sign off.

Published data with full client sign off will be issued:
A – No Comment – fit for construction.

Published data with partial sign off:
B – Comment/Partial sign off – fit for construction with minor comments from the client. All minor comments need to be indicated with a cloud and a statement of 'in abeyance'.

AB – As Built.

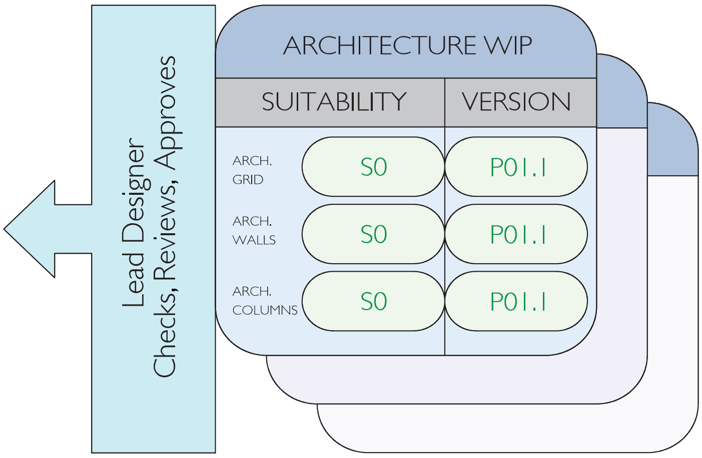


Figure 3: Example work-in-progress architects' models

5.1.2 Shared

When the models relating to, for example, the architectural design have reached a status that is 'fit for coordination', the model information should be uploaded into the 'shared' section of the CDE, as shown in Figure 4 on page 26.

To be able to move information to this area, all model files will have to have been thoroughly peer-reviewed, checked and approved, and fit for a specific purpose. It is also important for the model files to be checked to ensure they conform to the project CAD standard.

The model files can now be shared by the whole design team and trade contractor's disciplines.

The shared section of the CDE is where information can be made available to others in a 'safe' environment. The early release of information assists in the rapid development of the design solution. To allow this to be achieved, the concept of information 'status' has been adopted.

The information status gives ownership of the data to the design teams, and restricts access by the construction teams until information is sufficiently coordinated and authorized.

The definition of each status required to assist in the design development process is given in Table 9 in section 6.1.3 of this guide. These 'information statuses' should not be confused with the client/construction authorization (sign-off) status of 'A', 'B' or 'C'.

The data shared with status 'S1 = Fit for Coordination' should be in the native CAD format, DWG or DGN, as model files in either 2D or 3D.

All data/information with status 'S2 to Sn' should be produced as documents (electronic drawings) in DWF, PLT or PDF non-changeable formats. Although specific reference is made here to CAD formats, the same process can be used for all other types of documents, such as text reports and spreadsheets.

For a more detailed example of creating model files, see Appendix B.1.

Any member of the project team can use the shared model files for reference or coordination. Other design team members can reference the latest versions of models from the shared section of the CDE into their WIP areas, as shown in Figure 5 overleaf.

These referenced models can be used as background information onto which the recipient can overlay their design information. See Figure 6 overleaf.

For a more detailed example of sharing model files, see Appendix B.2.

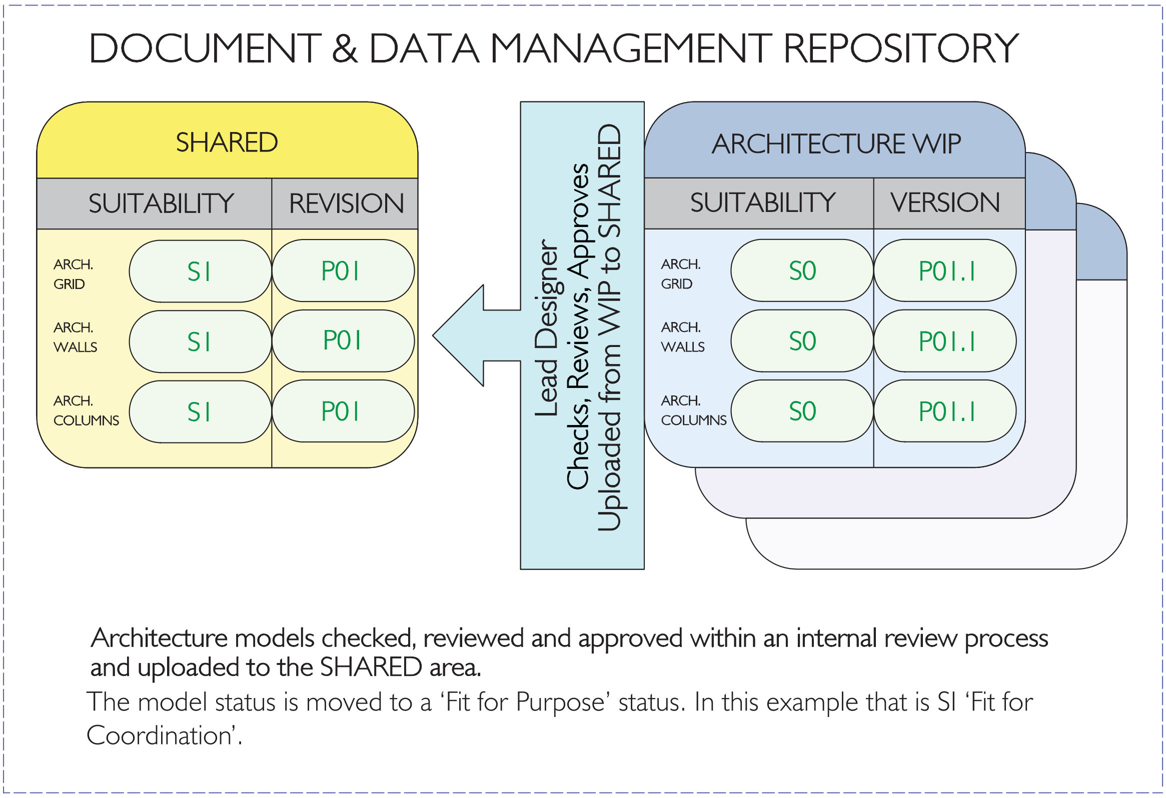


Figure 4: Architects' models uploaded for sharing

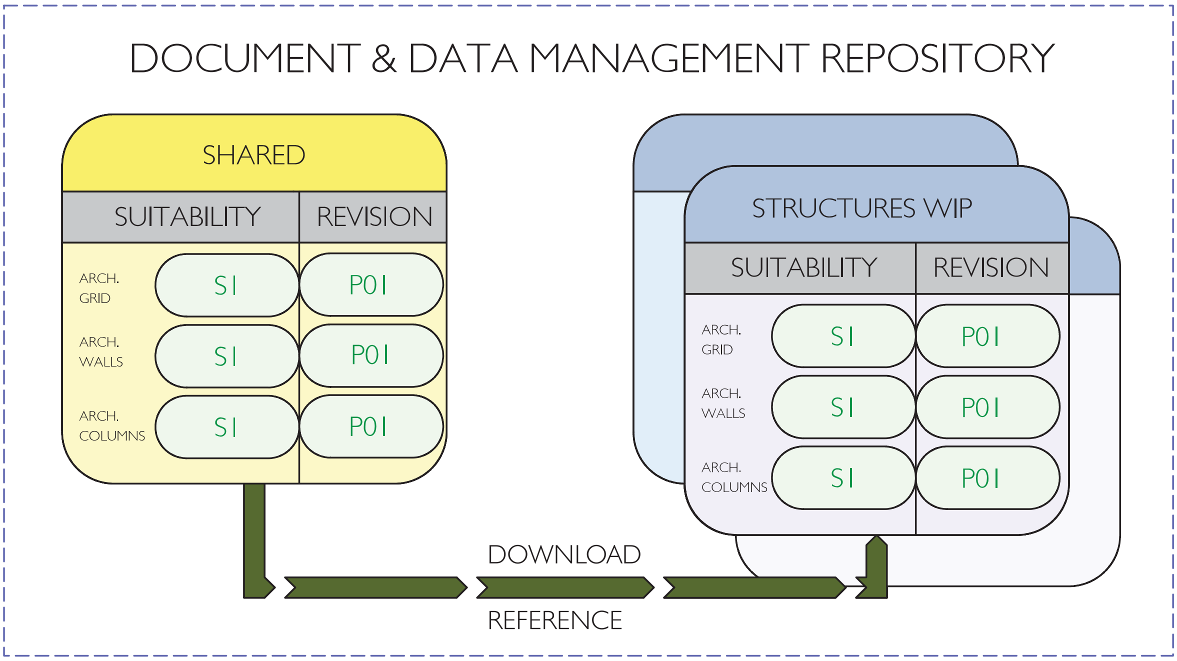


Figure 5: Sharing model files

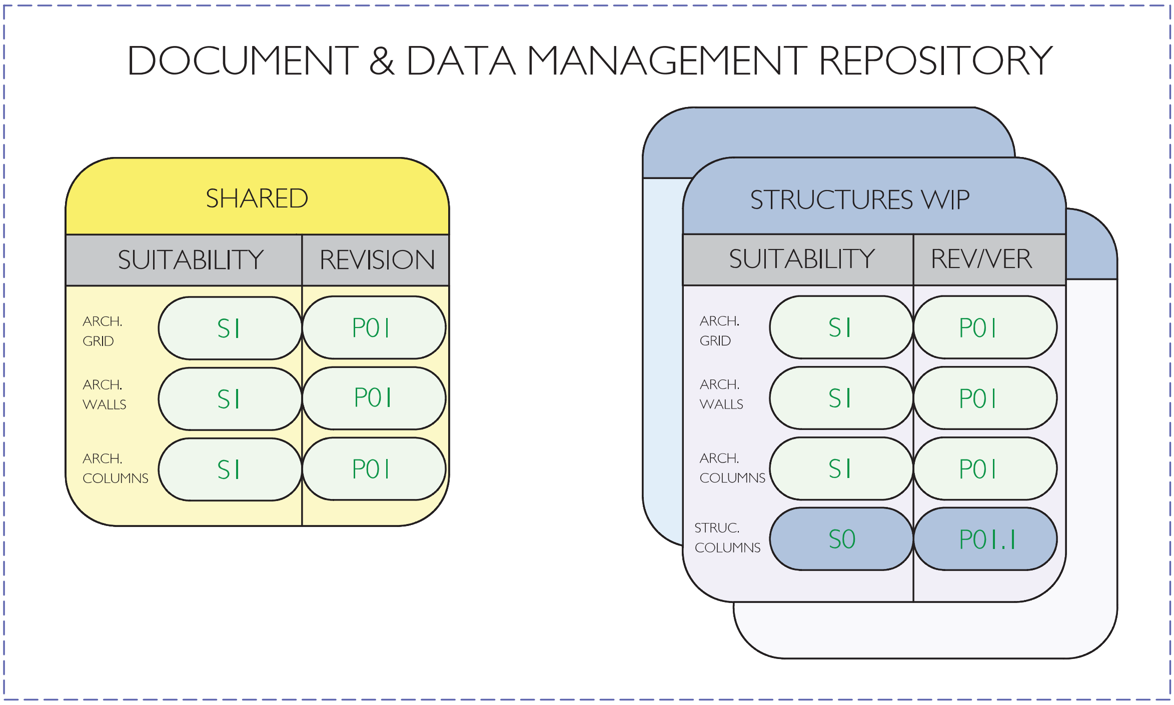


Figure 6: Coordinating model files

Where the supporting systems allow this to be achieved, model files should be referenced. However, where these systems do not exist, the files are downloaded from the shared area by other design teams. These files must never be re-uploaded or changed and uploaded. When a model file is used as background information by another design team member (see Figure 7 on page 30), it is important to ensure that this does not result in information being duplicated in model files – for example, layers in 2D models or objects in 3D models. Therefore, the team must agree a procedure that ensures information occurs only once in the shared area.

For a more detailed example of model file coordination, see Appendix B.3.

In the example shown in Figure 7, the structural engineer has designed the structural member sizes and takes ownership of the structural column layer. When the structural engineer uploads this information into the shared area, the architect's file must be revised and re-shared to remove the architectural ownership of the columns (see Figure 8 on page 31).

For a detailed example of the transfer of ownership, see Appendix B.4.

In Figure 9 on page 32, the process of continual uploads and referencing is set, and the project continues sharing, defining and refining the iterative process to completion. The task or discipline design managers should control the rate of sharing, specifying through the review, check and approve stages when data has reached a point where it should be shared. The managers should set the whole process against an agreed and integrated plan of delivery or through a 'master document index' (see Appendix A).

5.1.3 Published documentation

The published documentation section of the CDE contains drawings – and, if agreed by the project teams, the model files – which are snapshots of the shared information taken at a specific time. They are compiled by referencing the relevant approved model files into a coordinated model file and cutting the views and sections from the models. These in turn are referenced into a drawing sheet template that contains a title box and associated text attributes. A drawing rendition is then created in a non-changeable format – for example, a PDF or DWF file. This drawing rendition will contain a snapshot of the coordinated multi-authored model files in the 'shared' section of the CDE, as shown in Figure 10 on page 34.

For a detailed example of creating drawings from models, see Appendix B.5.

Before information is released into the documentation section of the CDE and made available to the wider project team – for example, for procurement or construction – information must be checked and approved.

Suitable review and authorization processes must be defined and rigorously adhered to, and these should apply equally to Work Package subcontractors' drawings as well as to design consultants' documents.

Approved documents will be given a status of 'A' or 'B' (or 'C' if rejected), as shown in section 6.1.3 of this guide.

Where the construction team requires documents for purposes other than construction (e.g. tendering or procurement) at a time prior to their approval for construction, the status 'D' is used (also as shown in section 5.1.4 of this guide). These 'D' status documents retain a preliminary revision reference 'P1–P*n*'.

Once the documents have received sign-off status 'A' (fit for construction), the document moves to the contractor's ownership and the revision notation changes to 'C1–C*n*', to show that this is a construction document and no longer preliminary information.

For a more detailed example of approval routes, see Appendices B.7 and B.8.

5.1.4 The purpose of the 'D' code

The S0–Sn status codes are used when the information is being developed and 'shared' by the design teams and the specialist subcontractors. The information is approved for a specified use, but is *not* 'authorized' by the client.

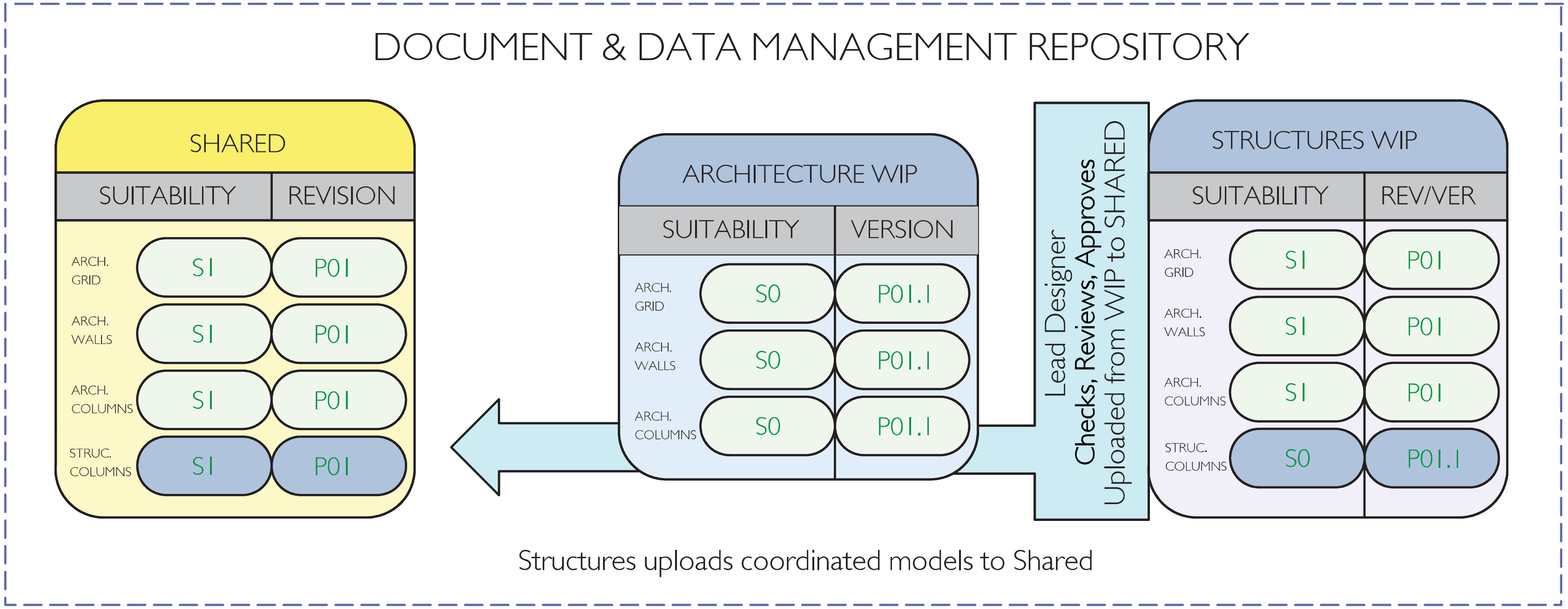


Figure 7: Uploading structural models

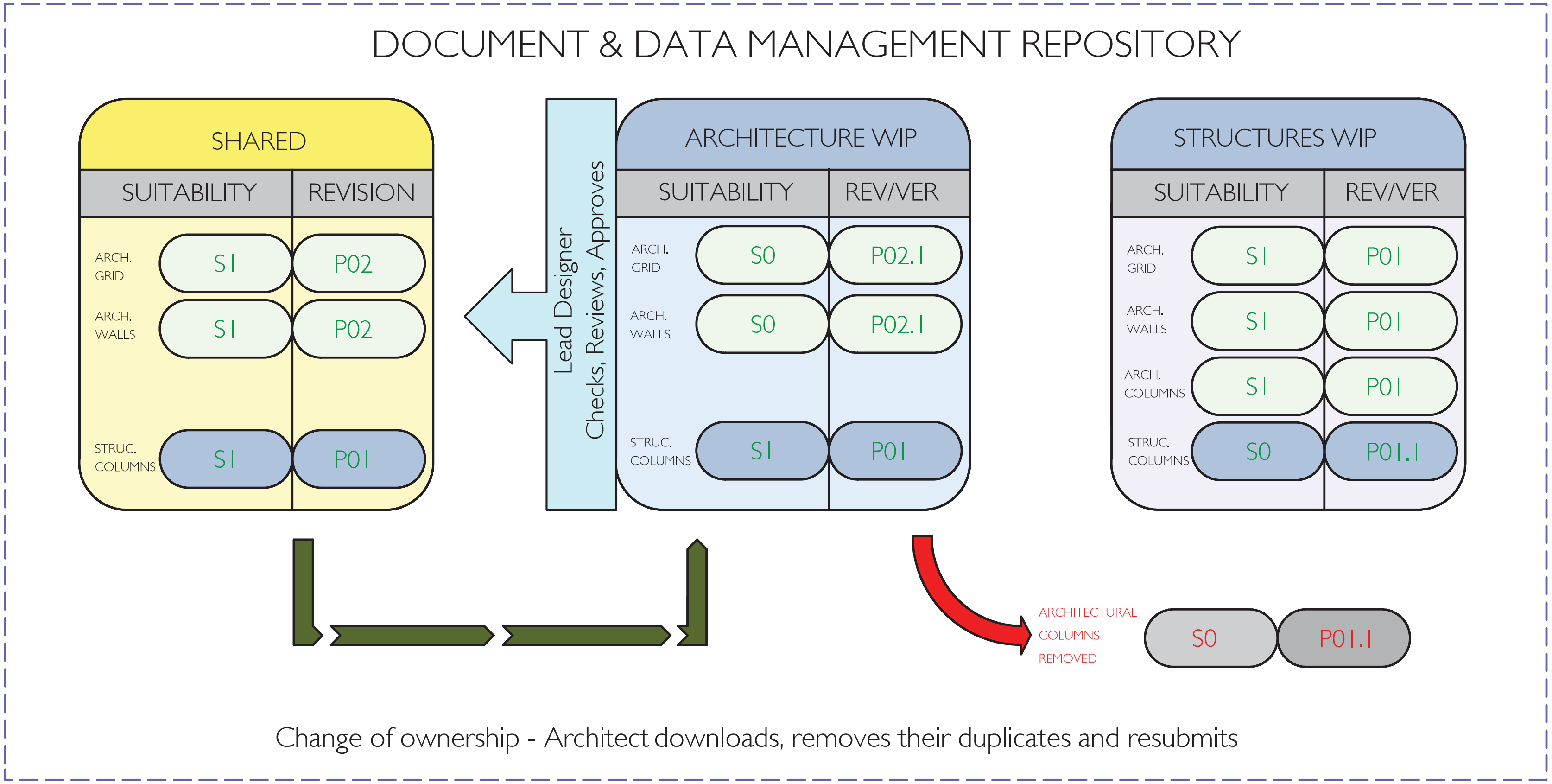


Figure 8: Architect's removal of duplicate layers

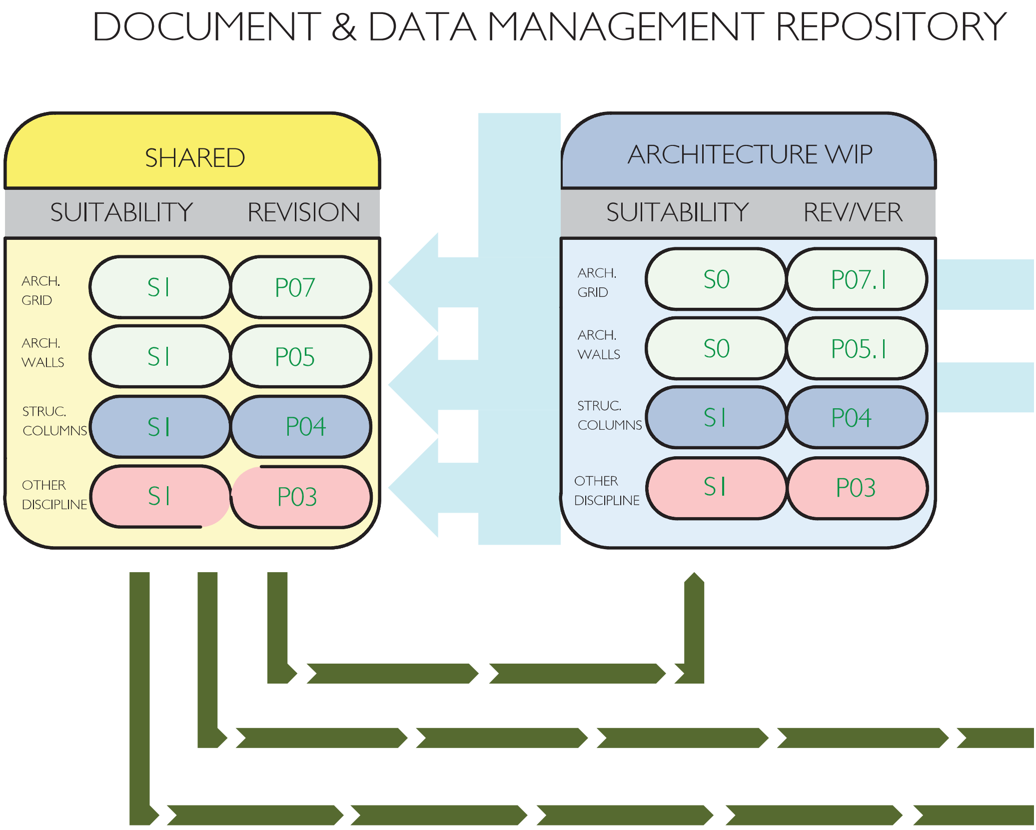
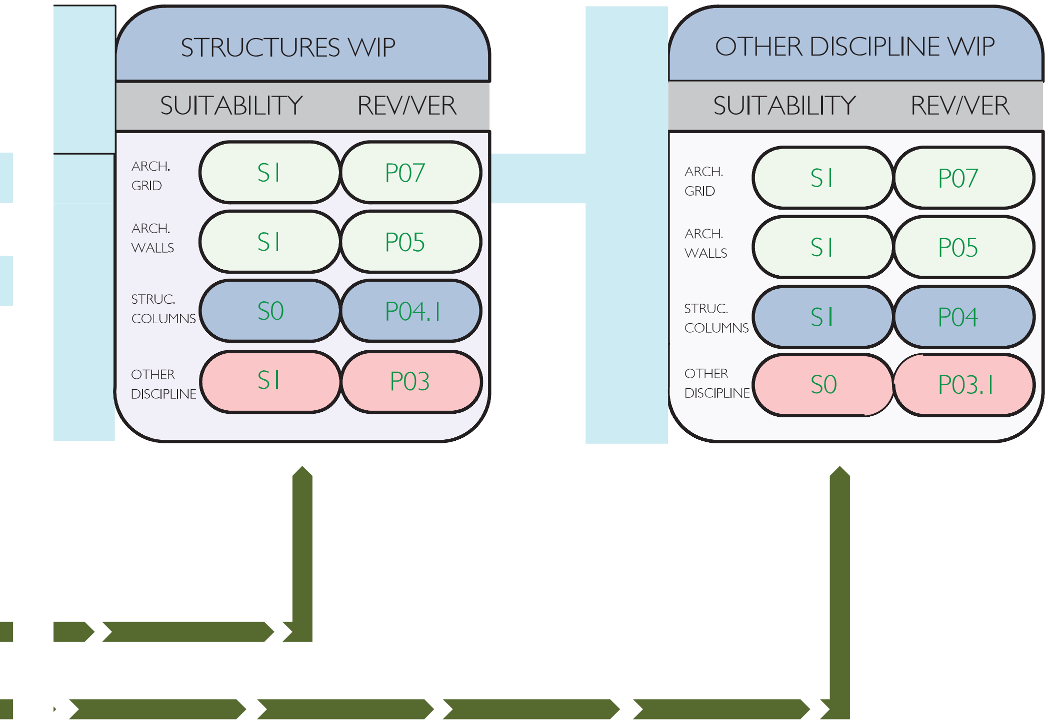


Figure 9: Concurrent and iterative uploads and downloads


STRUCTURES WIP
SUITABILITY
REV/VER
ARCH. GRID
S1
P07
ARCH. WALLS
S1
P05
STRUC. COLUMNS
S0
P04.1
OTHER DISCIPLINE
S1
P03
OTHER DISCIPLINE WIP
SUITABILITY
REV/VER
ARCH. GRID
S1
P07
ARCH. WALLS
S1
P05
STRUC. COLUMNS
S1
P04
OTHER DISCIPLINE
S0
P03.1

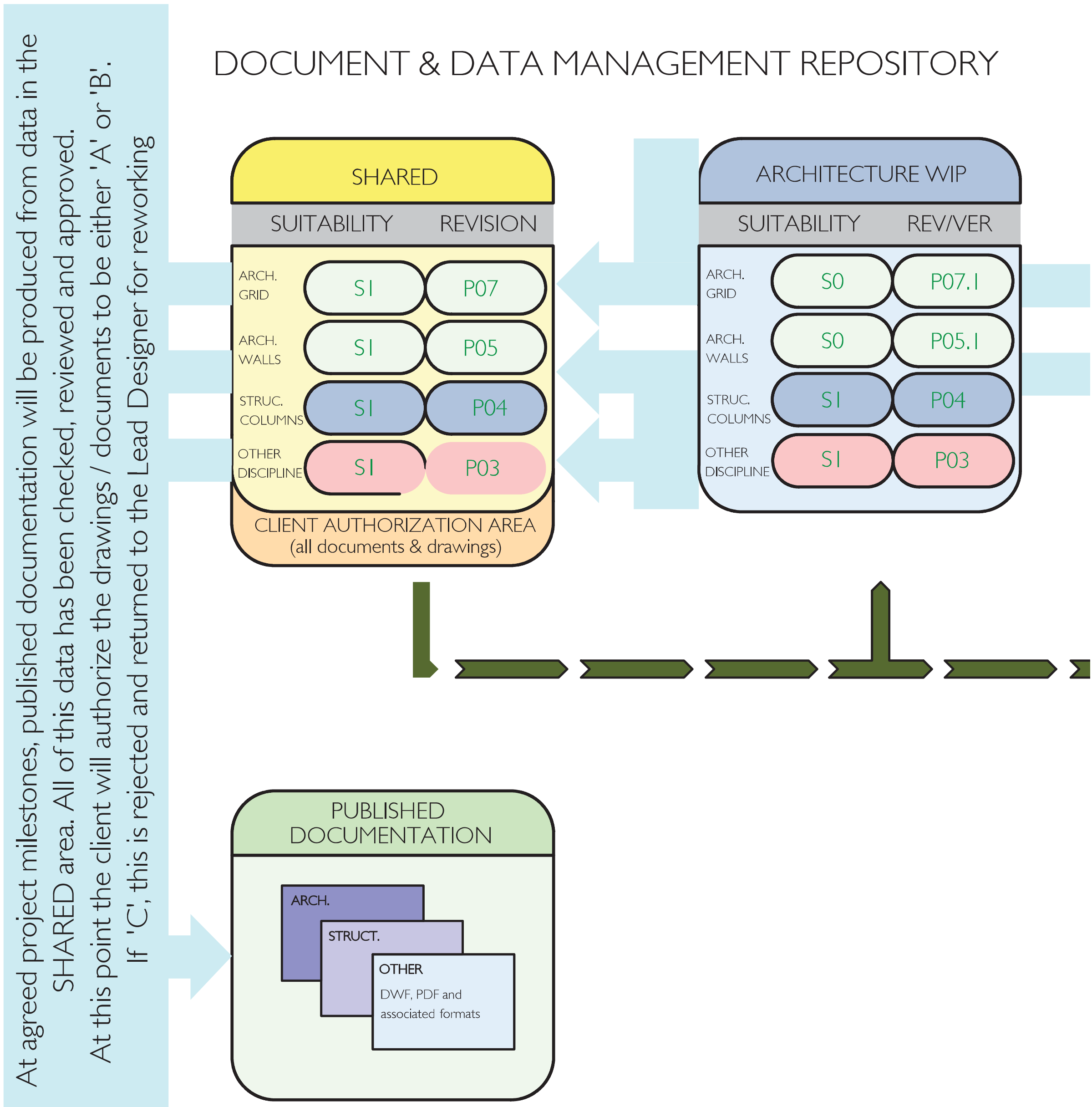
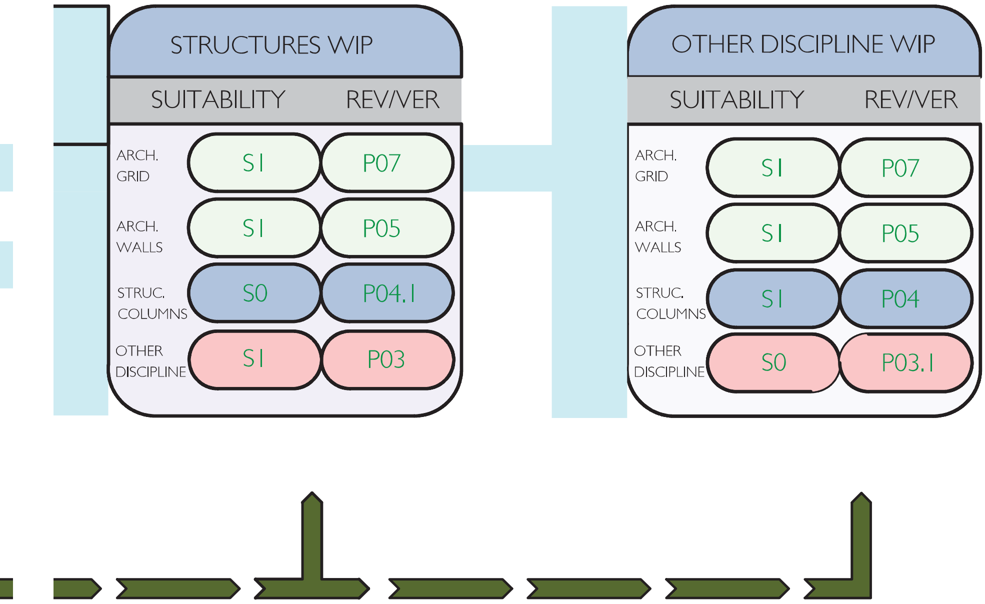


Figure 10: Creating drawings from shared models


STRUCTURES WIP
SUITABILITY
REV/VER
ARCH. GRID
S1
P07
ARCH. WALLS
S1
P05
STRUC. COLUMNS
S0
P04.1
OTHER DISCIPLINE
S1
P03
OTHER DISCIPLINE WIP
SUITABILITY
REV/VER
ARCH. GRID
S1
P07
ARCH. WALLS
S1
P05
STRUC. COLUMNS
S1
P04
OTHER DISCIPLINE
S0
P03.1

The D1–Dn status codes are used when information is needed by the contractor or client for a specified purpose, but is *not* 'authorized' by the client as fit for construction. These data and documents must never be used for construction purposes, or to give others an instruction to construct. Figure 11 shows the use of D status coding.

As shown in Figure 11, the information is transmitted from the WIP area directly to the Published Documentation area; it does not pass through the client authorization process but goes through the review, check and approve stages.

5.1.5 Archive

The archive section of the CDE is for inactive or superseded material. Such information will provide a history of the project information transfers, change orders and knowledge retention, and can be used for other contractual purposes or 'discovery' (see Figure 12).

Such an archive may be a physical location in a file system, but in many document repositories the system automatically manages the archiving process. However, it is important to keep the history of superseded information so that after completion of the project, teams can analyse the project's development for 'lessons learned'.

Although the task of managing 'archive' information can be within a document repository, the team should also consider scheduling data backup at agreed intervals.

In addition to the auditable tracking of the project history, the archive should also contain all relevant information as a handover document for the project lifecycle, including:

- remeasured as built/as constructed and verified information;
- as drawings and model files;
- change audits;
- asset data;
- health and safety file, including Construction (Design and Management) regulations (CDM);
- all relevant operations and maintenance information; and
- documentation as specified in the client's brief as deliverable. See the PIX Protocol for collecting the client brief for deliverables.

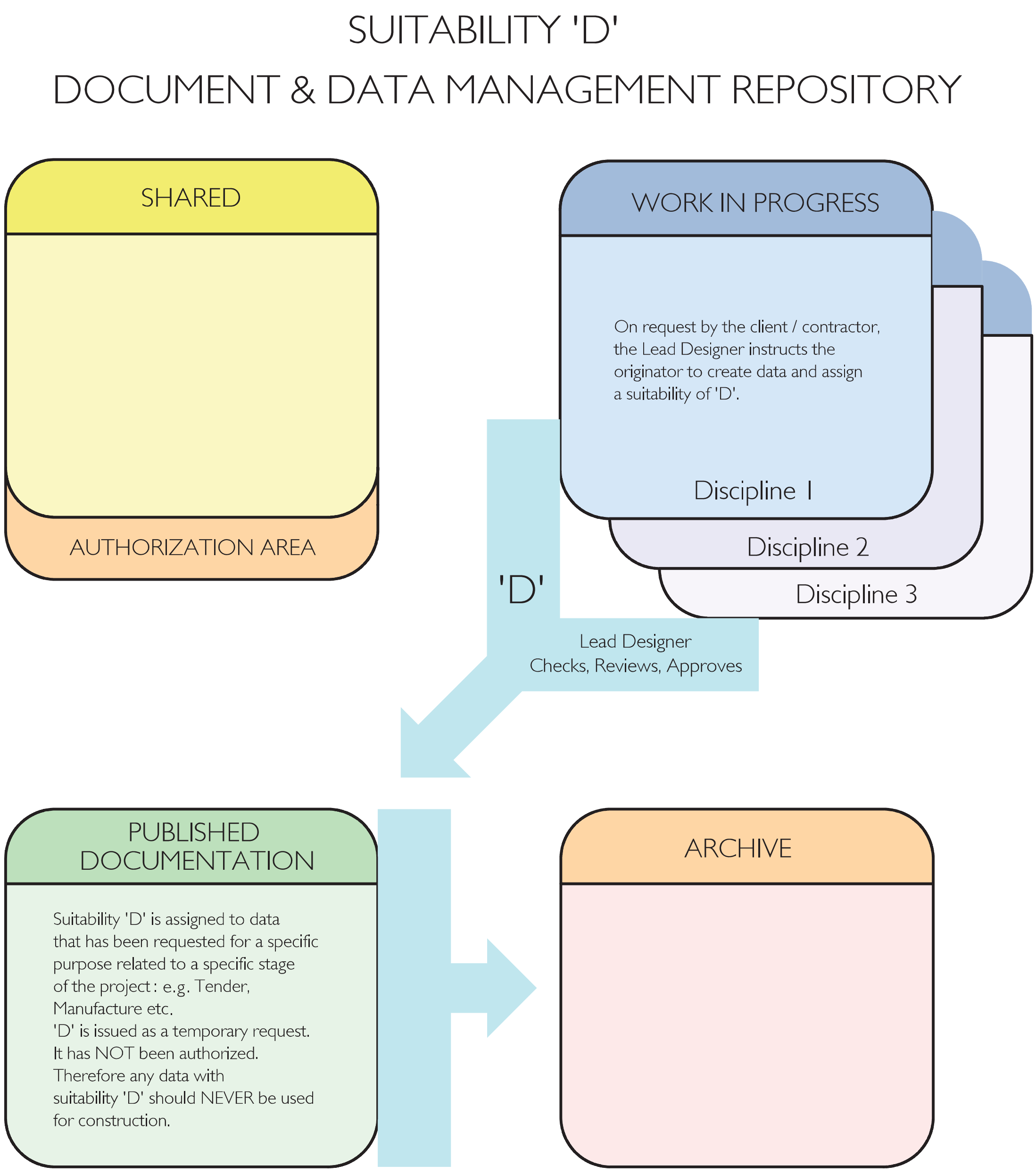


Figure 11: Status D

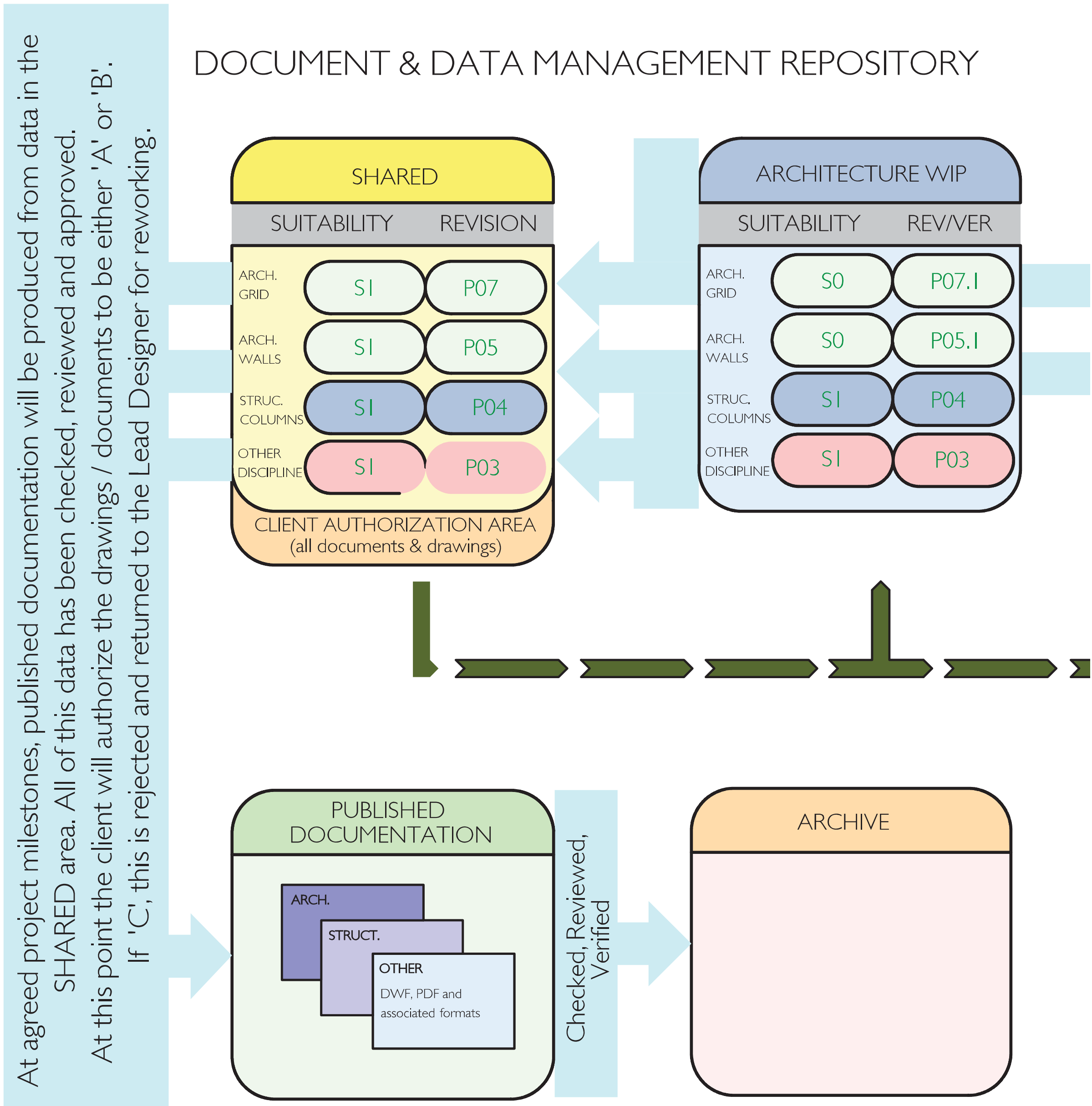
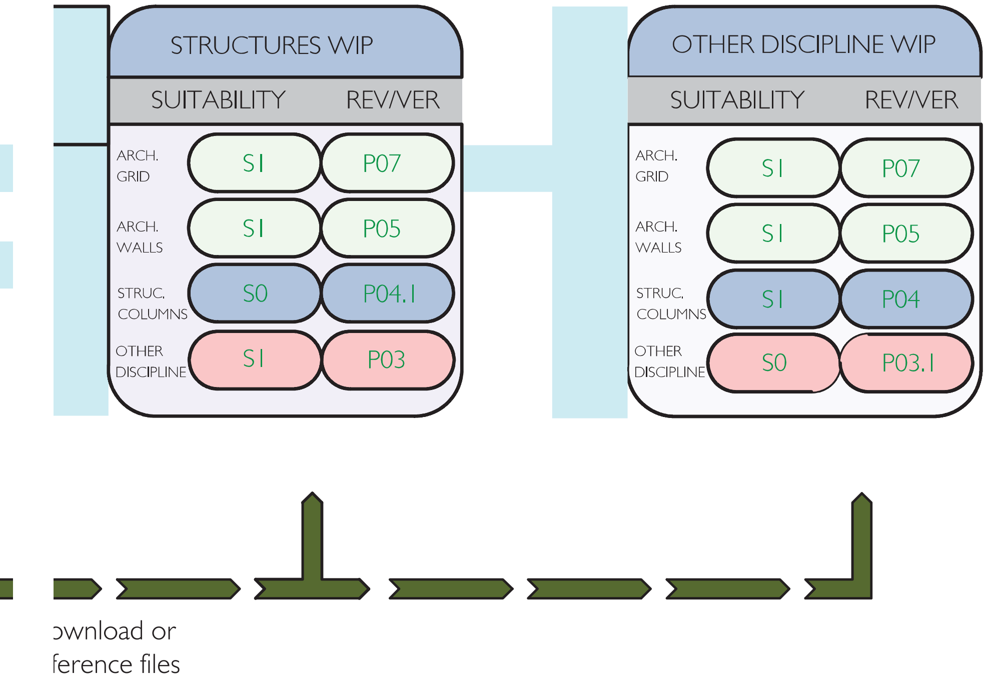


Figure 12: Archive section of the CDE


STRUCTURES WIP
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ARCH. WALLS
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P05
STRUC. COLUMNS
S0
P04.1
OTHER DISCIPLINE
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OTHER DISCIPLINE WIP
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STRUC. COLUMNS
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OTHER DISCIPLINE
S0
P03.1
ownload or
ference files

5.1.6 The distributed CDE for project and programme

- The diagrams and explanations above show the processes and systems in an ideal world, but the design team may need to modify them for individual projects.
- For the project management and the design management requirements beyond the plan of work, for example RIBA Plan of Work Stage D, the processes still hold.
- In the distributed 'Task Team' environment, as shown in Figure 13, each team operates to some extent as an independent team, but all teams still need access to the shared information.

Figure 14 shows the desired situation, with extra-team sharing, that should be used and managed with the right software, IT solutions and a revised management process.

5.2 BIM and the Common Data Environment

This document is intended to give guidance on a collaborative process for the delivery of consistent high-quality information and data, from which a project may be constructed and delivered with the minimum amount of effort in terms of cost and resource.

It also provides the foundation for the greater aspiration of Building Information Modelling (BIM) and a fully integrated Building Information Model (iBIM) and the delivery of the Major Projects Handover document. BS 1192 is fully scalable, and has been used successfully on small projects with a value from as little as a few hundred thousand pounds as well as multi-billion-pound contracts.

The basis of the guide is to provide an upgrade path from basic 2D CAD drawing production, 3D models and drawing production to the aspiration of the fully integrated BIM model.

Figure 15 shows the possible stages/phases of implementation and the benefits that can be achieved during the process. It also helps any organization or project team to assess their progress in their development and implementation of BIM.

Figure 15 also forms the basis of future development work that will enable the authors to add detail to each stage of development. Figure 15 is copyrighted and should not be used in any other way, copied, changed, altered or published in any other form, than that shown in the original.

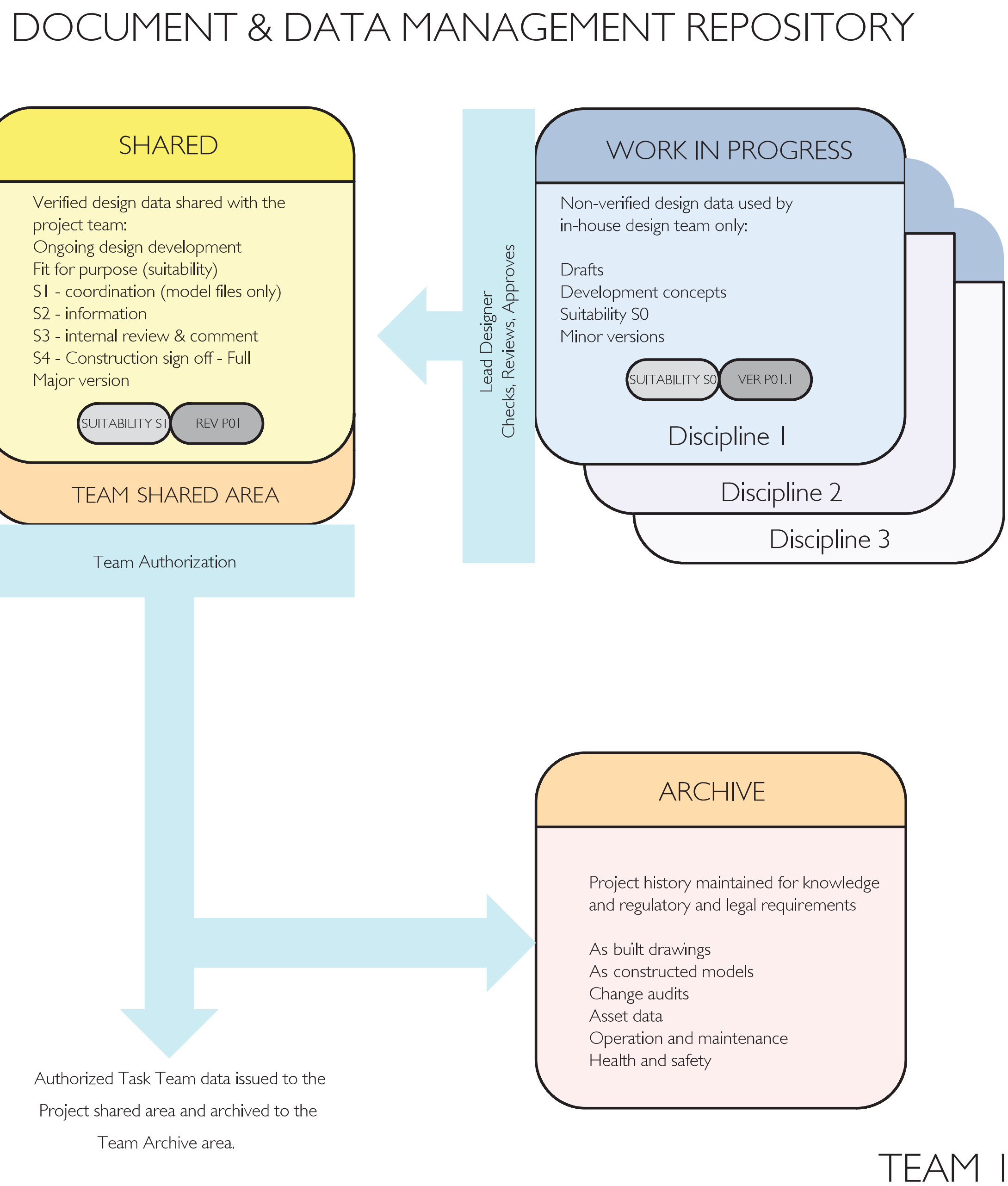
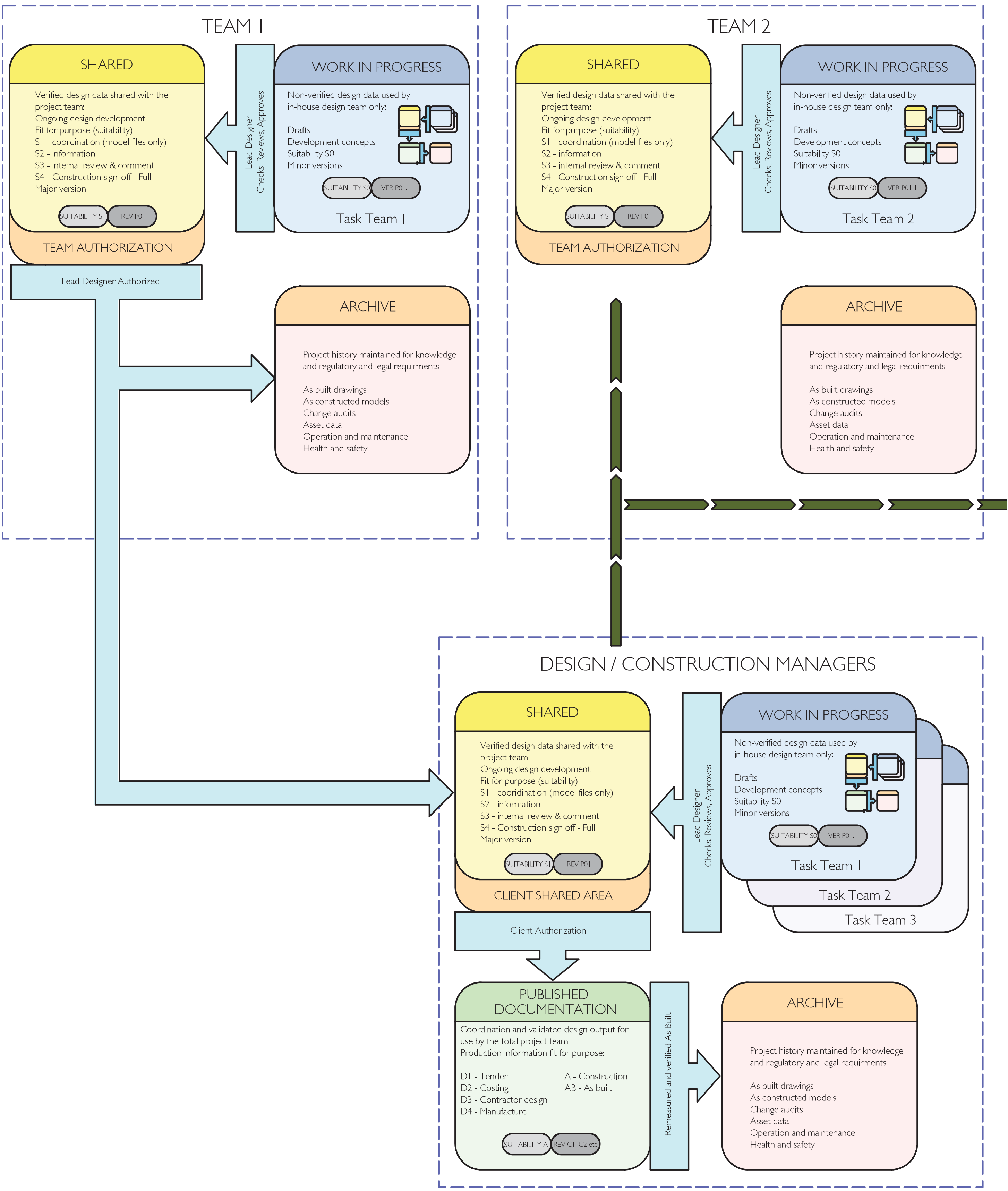


Figure 13: CDE in team environment


TEAM 1
SHARED
Verified design data shared with the project team:
Ongoing design development
Fit for purpose (suitability)
S1 - coordination (model files only)
S2 - information
S3 - internal review & comment
S4 - Construction sign off - Full
Major version
SUITABILITY S1
REV P01
TEAM AUTHORIZATION
Lead Designer
Checks, Reviews, Approves
WORK IN PROGRESS
Non-verified design data used by in-house design team only:
Drafts
Development concepts
Suitability S0
Minor versions
SUITABILITY S0
VER P01.1
Task Team 1
Lead Designer Authorized
ARCHIVE
Project history maintained for knowledge and regulatory and legal requirments
As built drawings
As constructed models
Change audits
Asset data
Operation and maintenance
Health and safety
TEAM 2
SHARED
Verified design data shared with the project team:
Ongoing design development
Fit for purpose (suitability)
S1 - coordination (model files only)
S2 - information
S3 - internal review & comment
S4 - Construction sign off - Full
Major version
SUITABILITY S1
REV P01
TEAM AUTHORIZATION
Lead Designer
Checks, Reviews, Approves
WORK IN PROGRESS
Non-verified design data used by in-house design team only:
Drafts
Development concepts
Suitability S0
Minor versions
SUITABILITY S0
VER P01.1
Task Team 2
ARCHIVE
Project history maintained for knowledge and regulatory and legal requirments
As built drawings
As constructed models
Change audits
Asset data
Operation and maintenance
Health and safety
DESIGN / CONSTRUCTION MANAGERS
SHARED
Verified design data shared with the project team:
Ongoing design development
Fit for purpose (suitability)
S1 - cooridination (model files only)
S2 - information
S3 - internal review & comment
S4 - Construction sign off - Full
Major version
SUITABILITY S1
REV P01
CLIENT SHARED AREA
Lead Designer
Checks, Reviews, Approves
WORK IN PROGRESS
Non-verified design data used by in-house design team only:
Drafts
Development concepts
Suitability S0
Minor versions
SUITABILITY S0
VER P01.1
Task Team 1
Task Team 2
Task Team 3
Client Authorization
PUBLISHED DOCUMENTATION
Coordination and validated design output for use by the total project team.
Production information fit for purpose:
D1 - Tender
D2 - Costing
D3 - Contractor design
D4 - Manufacture
A - Construction
AB - As built
SUITABILITY A
REV C1, C2 etc
Remeasured and verified As Built
ARCHIVE
Project history maintained for knowledge and regulatory and legal requirments
As built drawings
As constructed models
Change audits
Asset data
Operation and maintenance
Health and safety

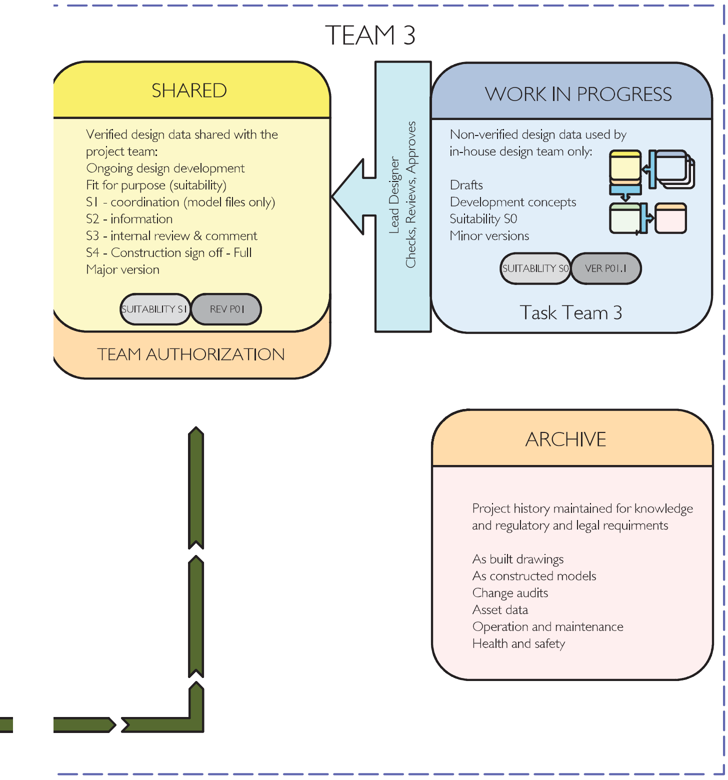


Figure 14: CDE in programme environment

Level	Description
0	Unmanaged CAD, probably 2D, with paper as the most likely data exchange mechanism.
1	Managed CAD in 2 or 3D format using BS 1192 with a collaboration tool providing a CDE, possibly some standard data structures and formats. Commercial data managed by standalone finance and cost management packages with no integration
2	Managed 3D environment held in separate discipline 'BIM' tools with attached data. Commercial data managed by an Enterprise Resource Planner. Integration on the basis of proprietary interfaces or bespoke middleware could be regarded as '*pBIM*'. The approach may utilize 4D Programme data and 5D cost elements.
3	Fully open process and data integration managed by a collaborative model server and could be regarded as iBIM or integrated BIM, potentially employing concurrent engineering processes.

In a fully integrated iBIM world the roles and responsibilities of the total supply chain will be known and their responsibilities for data delivery will be contractual. The clients need to establish what is required at the handover stage and appoint the appropriate members of the supply chain to deliver those requirements.

To ensure delivery, workflows and processes need to be established; BIM is a process not a product. It is about the collection, management, sharing and distribution of information at each and every stage of the concept/feasibility/design/construct and manage lifecycle.

It uses many different products used by different members of the supply chain to carry out the particular and separate (but not unrelated) activities that make up the total information generation process.

For the major part, current CAD vendor BIM solutions only generate graphical information with some attributed data. The major information or metadata content – perhaps greater than 90 per cent – is of a textual or alphanumeric nature; in addition to the information produced during the professional design activities and specialist design and manufacturing

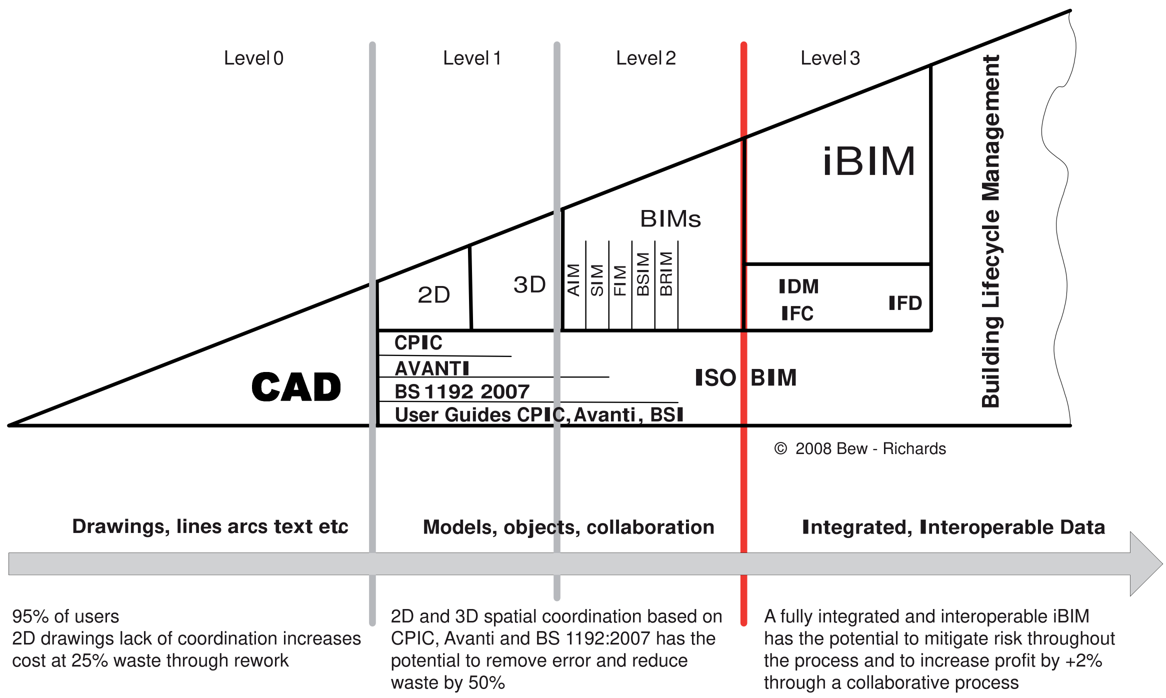


Figure 15: The BIM development process

activities, the client needs to define additional requirements for this data and metadata for particular projects and for facilities management. See the PIX Protocol on the CPIC website (www.cpic.org.uk).

Some information is common across construction projects, but the majority is specific to the type of facility (hospital, school, airport, etc.).

The roles and responsibilities of those who have to provide that information, and the type of information itself, are yet to be developed. In Figure 16 (overleaf), some forms of content are shown below the process line.

BS 1192 is the only published procedure that manages the design development, procurement and construction phases of a BIM delivery, and as such it should be implemented in the office and on projects.

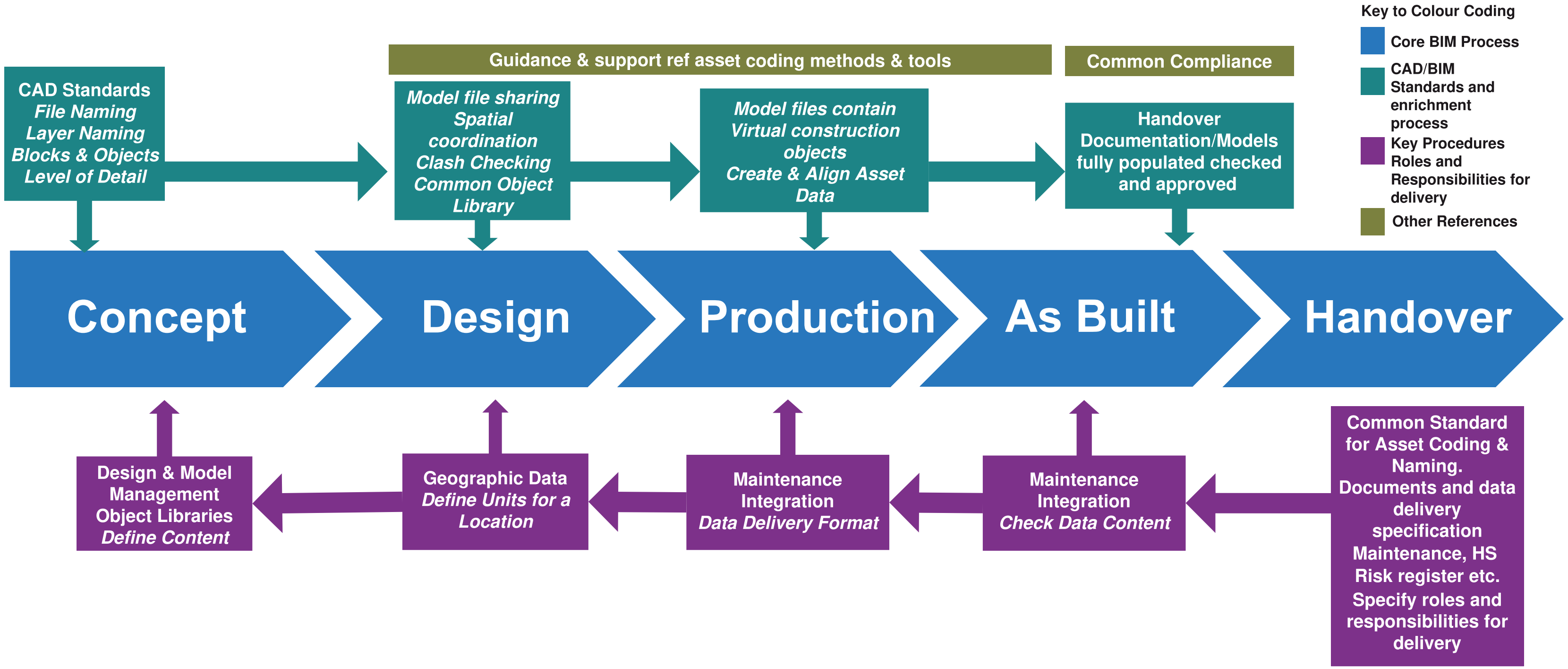


Figure 16: Development of iBIM content

6 Standard Method and Procedure

6.1 File naming

6.1.1 File identifiers

Research has shown that many problems occur because design team members cannot find the relevant information or the most up-to-date information. The file-naming convention has been developed to support the CDE process, and to allow fast searches for information through database management systems or folder-based storage systems. The number of fields has been kept to a minimum consistent with project requirements. The convention is not intended as a British Standard for document management.

A naming convention is required to deliver a rapid search capability for all relevant 'project' documents and data, including data files and BIM/CAD files, being managed through a repository such as an extranet, electronic document management system (EDMS) and document management system (DMS) solution. Since the search facility is in place to help all project participants, the naming convention should suit the needs of the project as a whole – not an individual, a designer, specialist or contractor. However, it does need to take into account the needs of the individual organizations in the wider team. It also takes into account the need to collect, manage and disseminate data/documents within a CDE.

If a document management system requires a more complex or all-embracing document-naming convention, this can be added as an additional document name on the digital, plotted or printed document – or even in the title block. If the data/document management system has the ability, then additional metadata can be associated with each file for more complex retrieval processes.

As the identifier forms part of the CDE management process, the standard should be applied as tested and published: it is all too easy to feel that your company or office has a better one. Experience has shown that there is not a better standard for the process being used – only a different one that usually ends up being unable to support the requirements.

Recommendation: adopt the following convention when defining a file identifier (container) – for example a model, drawing or any other related documents.

[Project]-[Originator]-[Zone]-[Level]-[File Type]-[Role]-[Number]

The 'Project', 'Sub project' (if specified) and 'Originator' fields define the project or building in a project and the responsible agent – not the owner – for the delivery of the information.

The 'Zone' and 'Level' fields in a file identifier locate information within the building or by linear location on civil projects. The remaining fields are used to uniquely identify the file.

Recommendation: in general, keep each field to the smallest number of digits; using hyphens enables you to use variable field lengths if required.

The use of hyphen (-) delimiters between the fields in a file identifier enable the use of varying-length codes. For example, a two- or three-character code could be used for the originator.

6.1.1.1 Document/drawing descriptor

Project		Originator		Zone		Level		File type		Role		Number
SM	-	BS	-	00	-	GF	-	DR	-	S	-	00001

The drawing descriptor and its rendition (DWF, PDF) are defined by the notation 'DR' in the file type field. The file extension (such as .PDF or .DWF) is not part of the descriptor.

6.1.1.2 Graphic/model file descriptor

Project		Originator		Zone		Level		File type		Role		Number
SM	-	BS	-	02	-	GF	-	M2 M3	-	S	-	00001

When the descriptor is used to name a model file, the notation M2 (2D model file) or M3 (3D model file) is used in the file type field.

Project		Originator		Zone		Level		File type		Role		Number
SM	-	CO	-	02	-	GF	-	M2 M3	-	M	-	00001
SM	-	CO	-	02	-	GF	-	M2 M3	-	E	-	00001
SM	-	CO	-	02	-	GF	-	M2 M3	-	E	-	00002
SM	-	CO	-	02	-	GF	-	M2 M3	-	E	-	00003

When model files are required by the same originator, but are from different disciplines (as is normal for the MEP (Mechanical, Electrical, Plumbing) consultant, and they exist in the same 'Zone' and 'Level' (location), you can use the 'Number' to create a unique file name when concatenated.

In the second and third examples above, there are three model files in the same Zone. One may be low voltage and another high voltage, or it could be that there are two low-voltage circuits at different levels within the same Zone, with a high voltage circuit. In these examples, the different requirement may be stated within the model file title as metadata to give a more detailed understanding.

6.1.1.3 All other documents

Project		Originator		Zone		Level		File type		Role		Number
SM	-	BS	-	02	-	GF	-	RF(I)	-	S	-	00001
SM	-	BS	-	02	-	GF	-	TQ	-	S	-	00001
SM	-	BS	-	02	-	GF	-	SP	-	S	-	00001
SM	-	BS	-	02	-	GF	-	SC	-	S	-	00001

The descriptor can also be used as a file name for any other type of document. The first three examples are for RFI (request for information), TQ (technical query) and SP (specification). The final example is for numbering structural calculations (SC).

For RFI, TQ and SP, the numbers can all start at 00001 for each type of document for each originator, role or contractor, as those fields themselves ensure that the file will be uniquely identified. Uniqueness is achieved by concatenating the whole file container name, not by dependence on the numeric number at the end of the convention. The number is to allow further subdivision for easy identification, as explained in the text. It also allows for the team or task team to control their own needs rather than having to worry about the usually complex problem of allocating a drawing or document number.

For numbering SC, the calculation may be a file containing a number of sheets of calculation, and can be numbered as one file. If the project requires individually numbered sheets, this should be done on each individual sheet within the file, and not by filing each sheet as a separate file. Table 7 gives a list of suggested document file type abbreviations.

The following sections describe in more detail the various codes that make up a file identifier.

6.1.2 Field name definitions

6.1.2.1 Project

The ‘project’ designation is an alphanumeric code that the project team uses to identify the project. The client may actually define a project code for all members of the project team to use. However, if each team member needs to have their own project code relating to that company, this can be added as attribute data in a separate box on the drawing title sheet. See the Drawing Template example Figure 33 on page 75.

For example, Table 3 defines some project codes where there are multiple sites within a project. Alternatively, the project code could also represent the actual project and sub-project.

Alternative methods would be the project abbreviation ‘Palace Exchange’ as PX and the sub-project ‘South Mall’ SM as PXSM.

Where an organization needs to use its own internal project numbers, these can be indicated in the drawing title block using a separate ‘project number’ box. This can be as attributed data or as metadata.

Table 3: Project codes

Code	Project
SM	South Mall
NM	North Mall
AW	Advance Works project

6.1.2.2 Originator

It is important to understand the responsible agent for each piece of information being shared among the teams. The responsible agent is the company contractually bound to be responsible – not necessarily the originator of the information. This may be produced by a subcontractor to the responsible agent.

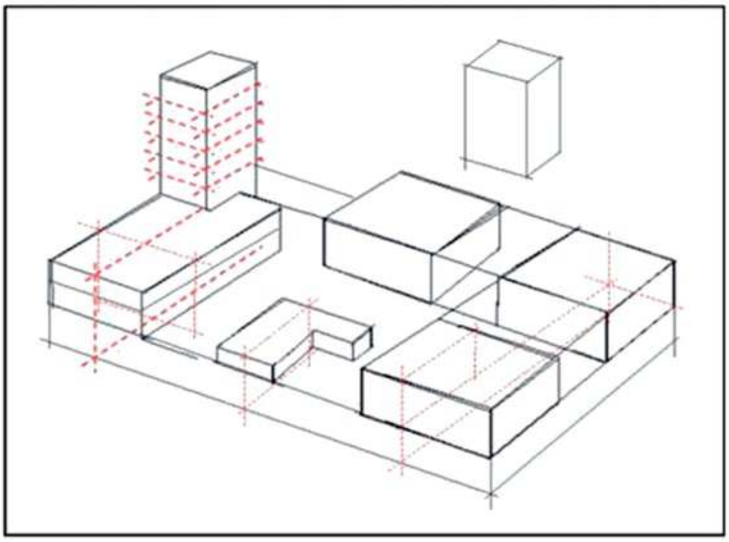
The 'originator' is an alphabetic code that represents the *company* responsible for that aspect of the work. The codes must represent the company name, and not the discipline.

Recommendation: use a two-character originator code in a project. However, the use of three-character codes for the subcontractors in the first and second tier supply chain allows meaningful codes to be chosen.

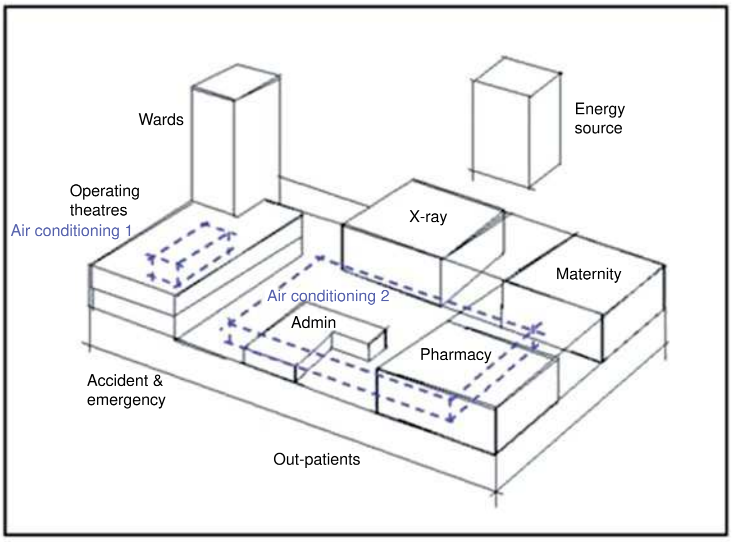
For example, Table 4 defines some 'originator' codes that relate to the companies working on a project.

Table 4: Example of originator codes

Code	Originator
UA	Unique Architects
GP	Good Practice (Engineers)
BS	Burnished Steel (Fabricators)
SG	Solar Glass (Suppliers)
CO	(Company Name)



Fire compartment zones

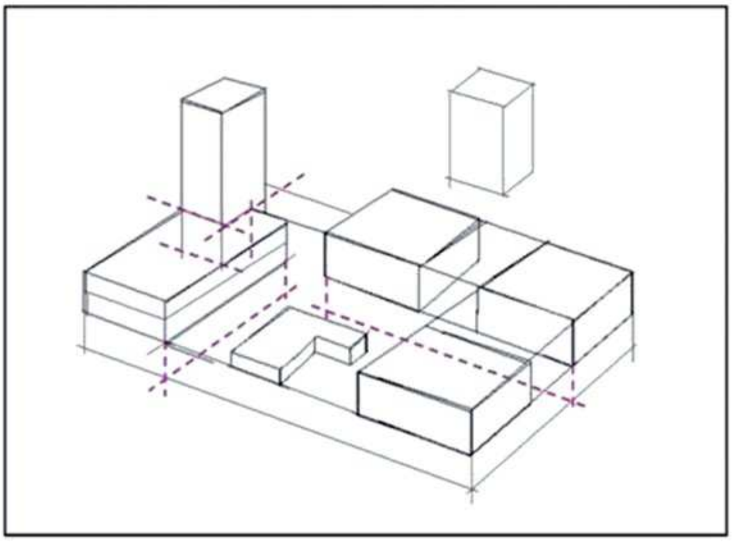


Air conditioning zones

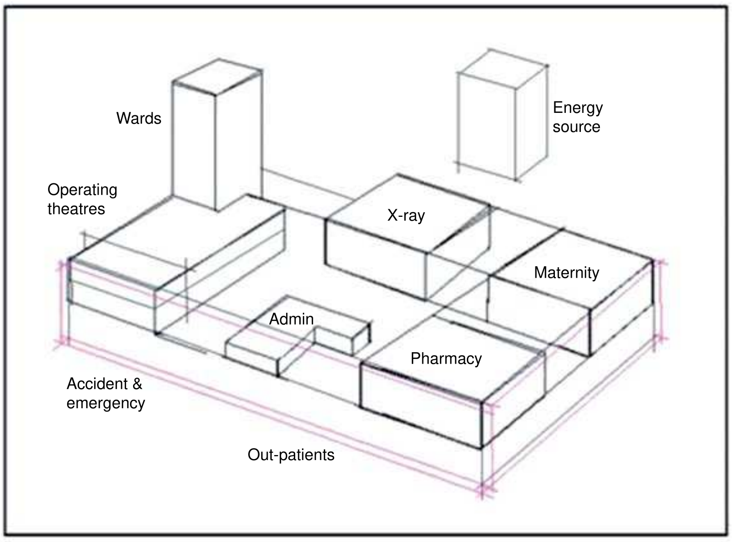
Figure 17: Examples of zones

6.1.2.3 Zone

The 'zone' identifier is used to split the project into manageable subdivisions; all members of the design team must agree zones at the start of a project and publish them as a shared document. Individual design team members may require alternative zones for their individual needs. Zones are not drawing areas, and do not relate to the amount of the project shown on any given drawing. They are the responsibility of the design team managers, not the CAD operators.



Movement–expansion joints generate zones that are structurally isolated



Cladding zones

The reason for splitting the project into zones is to enable multiple users to work on the project, as well as limiting the size of model files to prevent reduced performance of software or communication.

A zone may be based on an important aspect of design, such as structure, cores, specialized functions, HVAC (Heating, Venting, Air Conditioning) systems or strategic elements such as cladding. These are indicated in Figure 17.

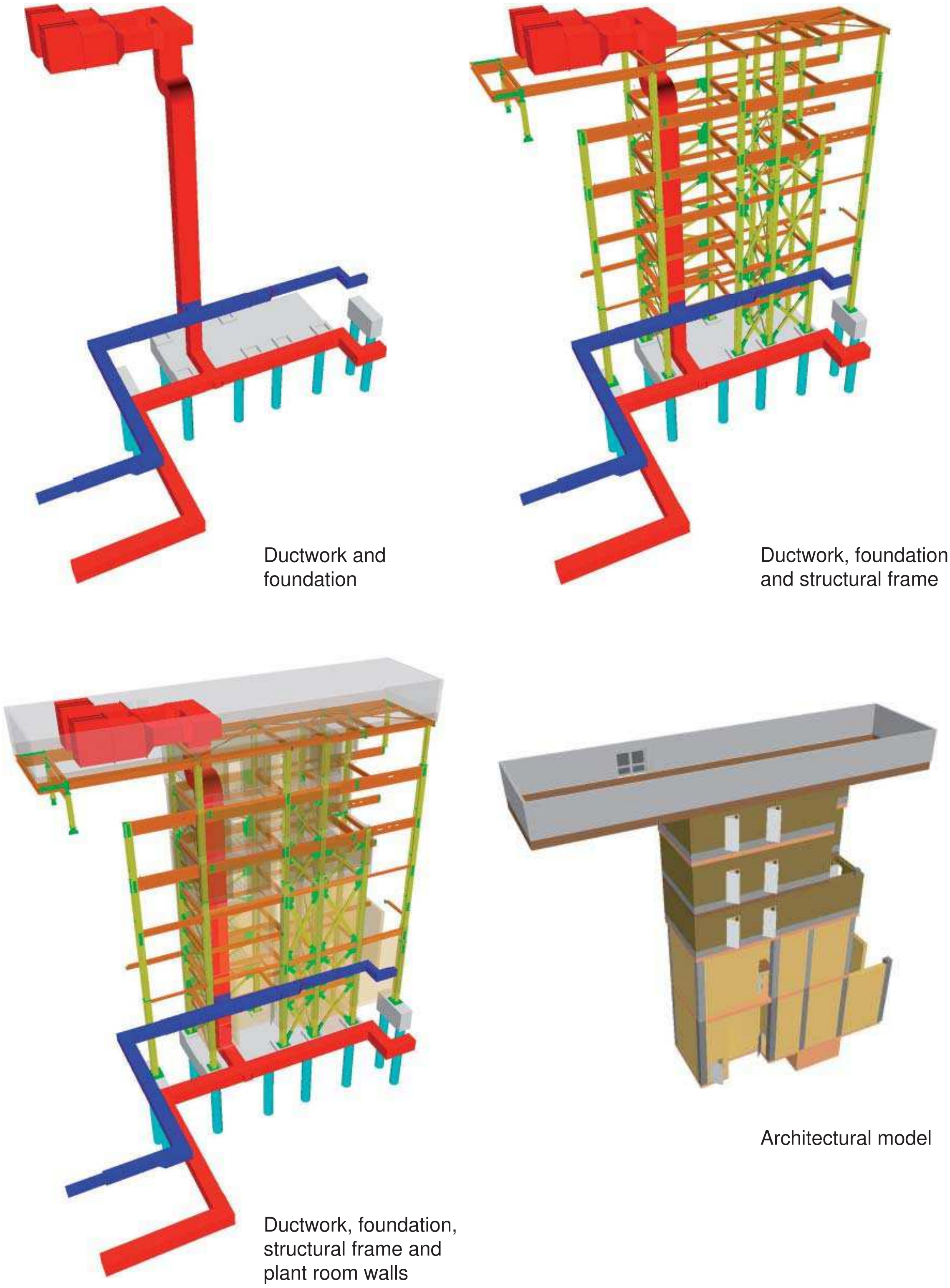


Figure 18: 3D models that relate to a zone relating to a core

Zones are rather like two- or three-dimensional jigsaw pieces. They are *not* a pastry-cut through the model so that every discipline's zones cover the same area. Different disciplines' zones can interface in different ways, as shown in Figure 18. They do not have to be square; they simply have to fit exactly with all the adjacent pieces of the same discipline, without overlapping or leaving any gaps. If other disciplines' zones are then overlaid, a composite of multi-authored information will produce the complete project model.

In other words, a *zone* defines the extent of model files, and one or more model files (xref or referenced files) can relate to a zone. More normally, a zone is restricted to a level or location, in a two-dimensional sense that does not combine multiple levels or locations.

The example given below shows the breakdown of a staircase core that would be drawn as a single element if defined on a drawing or a 2D extraction. In this example, each model file for all of the building elements is restricted to fit between each level – even for the staircase and columns.

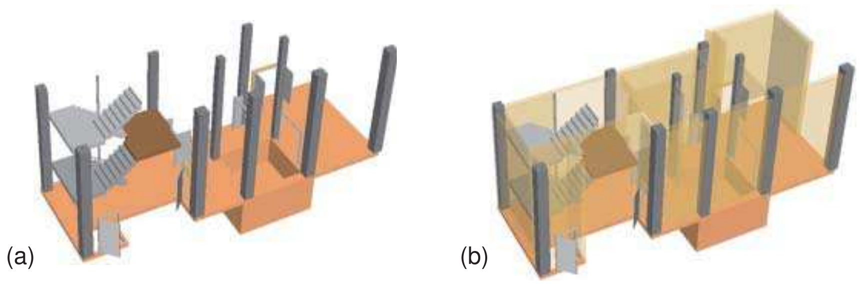


Figure 19: (a) Ground floor slabs, columns, stairs – (b) walls

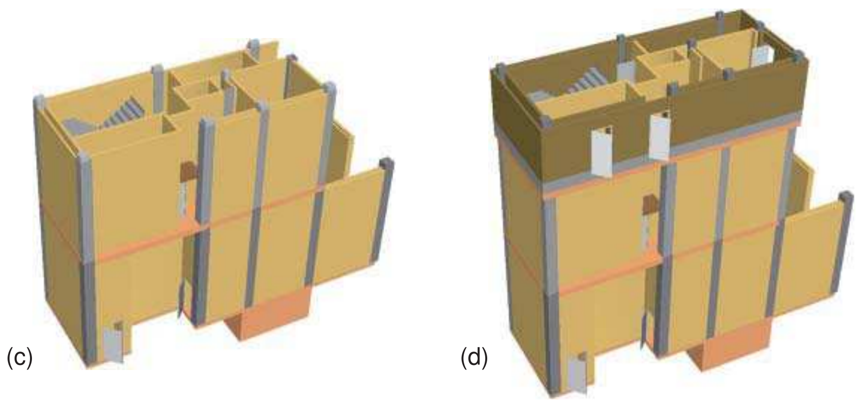


Figure 20: (c) Second floor as first – (d) and third floor – as separate reference files

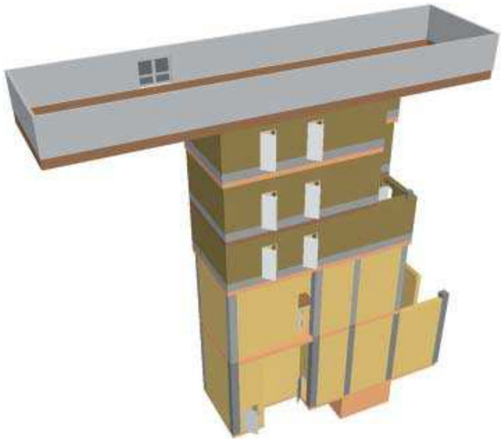
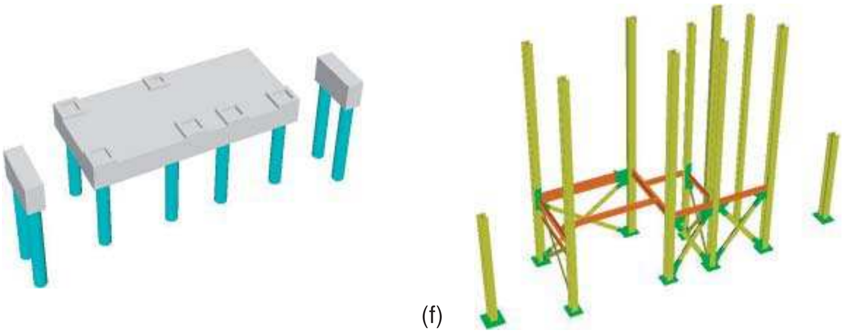


Figure 21: Completed architectural staircase core



(e) (f)

Figure 22: Structural – (e) foundations and (f) floor lift as defined by structural frame assembly

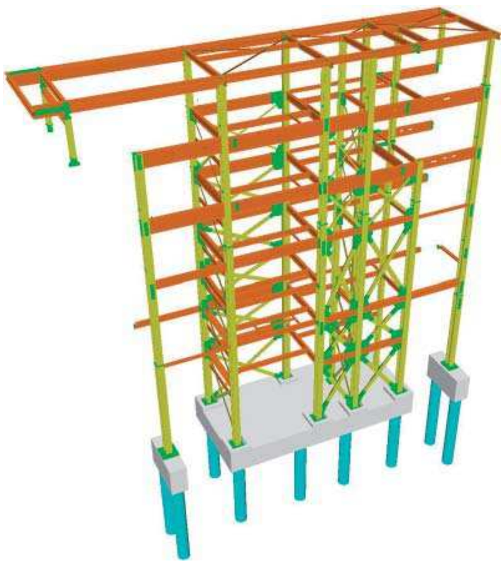


Figure 23: Completed structural staircase core

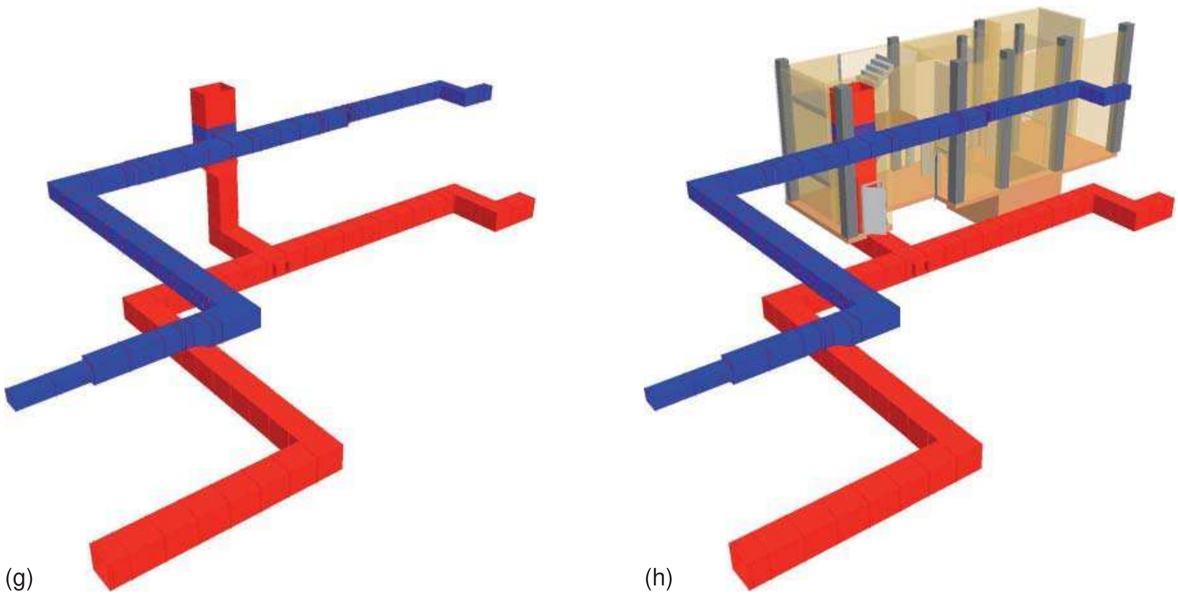


Figure 24: (g) Ground floor duct-work and (h) ground floor risers + architectural fabric

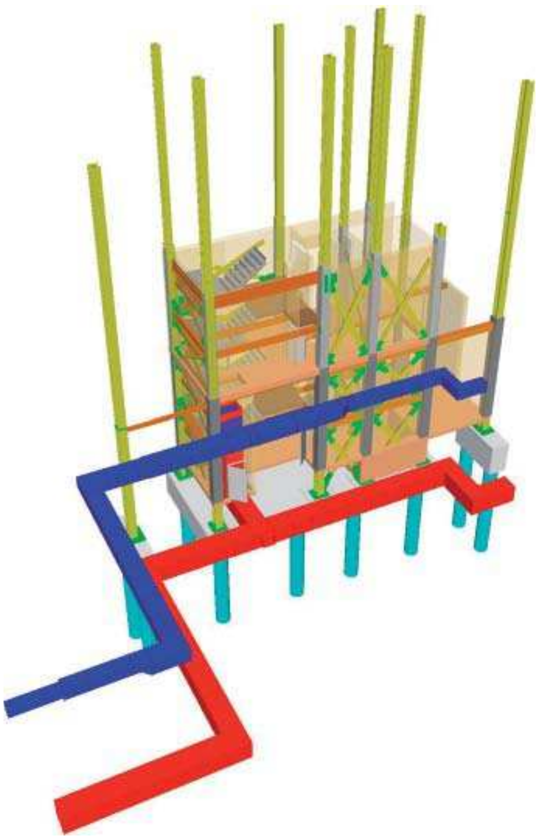


Figure 25: Ductwork + architectural + structural for two floor lifts

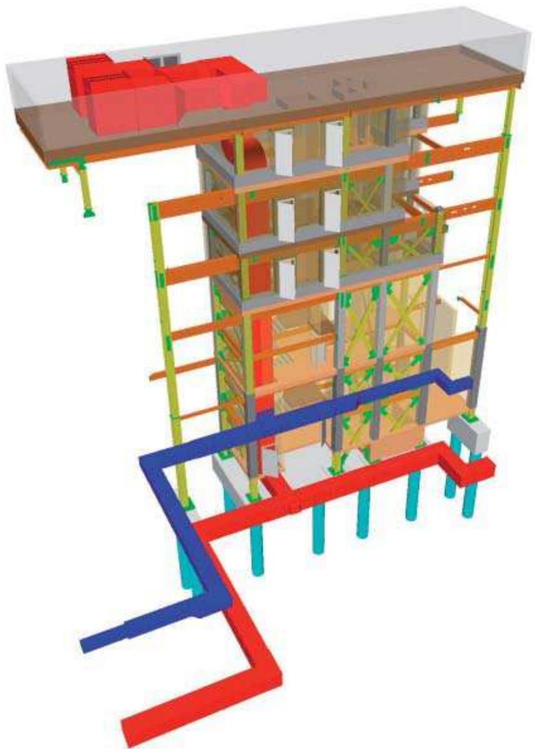


Figure 26: Complete core all disciplines

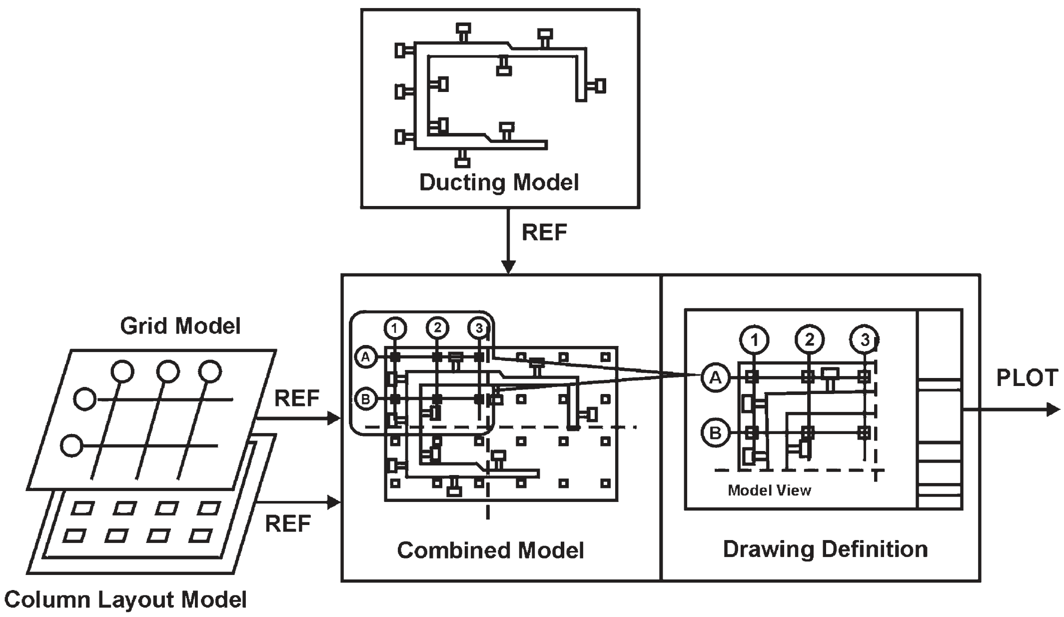


Figure 27: Examples of zones in a building

A simplified view of zones using 2D reference files is shown in Figure 27.

A model file represents a zone defined by each discipline.

Recommendation: a zone is named by a numeric code. Use either two- or three-character zone codes consistently in a project.

As indicated in the file-naming convention, the codes for each zone are simple: 01–99 for small, simple projects; or 001–999 for larger, more complex projects.

6.1.2.4 Level/location

The 'Level' code is a two- or three-character alphanumeric code that represents the level or storey of a building. Within civil engineering contracts the 'level' code may indicate different construction levels. It will also be applied to grade separated structures where the level on an interchange may be above or below the 'highway level'. In shafts, sewers and galleries we invariably encounter levels and so the notation will hold. On specialized infrastructure projects other notations may be necessary and these should be dealt with on a project-by-project basis.

Table 5 indicates examples of level codes.

BS EN ISO 4157-1 defines the naming convention for floor levels, and BS EN ISO 4157-2 defines the room naming for each floor.

In a civil engineering contract, the 'Location' may be indicated as a 'chainage' for roads and railways; on large ground-covering sites, such as oil refineries, a postcode or grid-location system should be adopted.

Define this on a project-by-project basis.

Table 5: Level codes

Code	Level
ZZ	Multiple levels
02	Second floor
01	First floor
MX	Mezzanine floor X
M2	Mezzanine floor 2
M1	Mezzanine floor 1
GF	Ground floor
LG1	Lower-ground level 1
LG2	Lower-ground level 2
F1	Foundation level 1

6.1.2.5 File type

The ‘File type’ is a two-character alphanumeric code that indicates the type of file. File types are used to identify the type of information in the file, for example, a CAD model file – not the format of the file content, e.g. .DWG, .DGN or .PDF.

Tables 6 and 7 list examples of typical file types. Agree additional file types with the document controller to ensure consistency within the project team and in any document repository that manages the project information.

The list of file types is likely to need extending to suit the exact requirements of the project team, and these should be defined and agreed at the start of the project.

6.1.2.6 Role codes

Table 8 shows a list of standard codes for roles as recommended in BS 1192.

Table 6: File types – for drawings and models

Code	File type
DR	2D drawing
M2	2D model file
M3	3D model file
MR	Model rendition file (Coordination model, e.g. NavisWorks)
AF	Animation file (of a model)
VF	Visualization file (of a model)

Table 7: File types – for documents

Code	File type
BQ	Bill of quantities
CM	Comments
CO	Correspondence
CP	Cost plan
DB	Database
FN	File note
HS	Health and safety
MI	Minutes/action notes
MS	Method statement
PP	Presentation
PR	Programme
RD	Room data sheet
RI	Request for information
RP	Report
SA	Schedule of accommodation
SC	Structural calculations
SH	Schedule

Table 7: File types – for documents (contd)

Code	File type
SN	Snagging list
SP	Specification
SU	Survey
TQ	Technical query

Table 8: Role codes (from BS 1192)

Code	Role
A	Architect
B	Building Surveyor
C	Civil Engineer
D	Drainage, Highways Engineer
E	Electrical Engineer
F	Facilities Manager
G	Geographical and Land Surveyor
H	Heating and Ventilation Designer
I	Interior Designer
K	Client
L	Landscape Architect
M	Mechanical Engineer
P	Public Health Engineer
Q	Quantity Surveyor
S	Structural Engineer
T	Town and Country Planner
W	Contractor
X	Subcontractor
Y	Specialist Designer
Z	General (non-disciplinary)

The 'role' code is a single character indicating the discipline or tier contractor responsible for content, not the individual or sub-subcontractor. On larger projects, it may be useful to extend the role code to two or three characters as dictated by the 'project' need. Titles such as 'structural steelwork detailer' or 'reinforced concrete detailer' are not acceptable, because the purpose is to identify the responsible agent contractually, not the individual – in these examples, this is usually the chartered or qualified designer.

Selection of roles or titles should, however, be controlled, otherwise meaningless codes for sub- or sub-subcontractors may proliferate.

6.1.2.7 Number

The 'Number' may be a four-, five- or six-character code to suit project requirements. The number is viewed in a number of ways:

- Each design discipline starts at 00001, and then allocates additional numbers to suit its own needs. This overcomes the problem of allocating numbers across the project team in an attempt to have contiguous numbering. In this process, it is the concatenated naming convention that creates uniqueness, not the number.
- The first two or three characters of the number could signify an 'element code' that further classifies the file. One classification code system should be chosen and consistently used by all project teams. BS 1192 and CPIC recommend the use of Uniclass. If Uniclass codes or another classification system are used in this way, it usually creates proliferation of duplicate drawings where only the classification differentiates it. In modern document management systems, the ability to distribute one drawing for many purposes is possible and desirable.

However, as explained at the start of section 6 of this guide, all file identifiers must be unique when the 'role', 'originator', 'file type' and 'number' codes are considered. The following examples indicate how this is achieved:

The 'number' is unique when joined with the 'file type'.

For example, this also enables one 'originator' to have model files and drawing files using the same number: 'SH-CA-02-01-M2-A-00140' and 'SH-CA-02-01-DR-A-00140'. Note that the model and drawing files do not necessarily correlate, as a drawing is often made up from many model files.

The ‘number’ is unique when concatenated with the ‘file type’ and ‘originator’.	For example, this also enables different ‘originators’ to use the same ‘file type’ and ‘number’: ‘SH-RW-06-01-M2-E-00140’ and ‘SH-NG-06-01-M2-E-00140’.
The ‘number’ is unique when concatenated with the ‘file type’, ‘originator’ and ‘discipline’.	For example, this also enables different ‘roles’ to use the same ‘file type’ and ‘number’: ‘SH-RW-06-01-M2-E-00140’ and ‘SH-RW-06-01-M2-M-00140’.

6.1.2.8 File-identifier examples

An example of a 2D model ‘file identifier’ would be:

SH-CA-01-LG1-M2-A-00001

‘SH’	is the project location
‘CA’	is the two-character code for the originator
‘01’	indicates that the model relates to Zone 01
‘LG1’	indicates that the model relates to the Lower Ground floor level 1
‘M2’	indicates that the model is a 2D model
‘A’	indicates that the discipline that created the model is an architect
‘00001’	is the unique model number

An example of a 2D drawing ‘file identifier’ would be:

SH-CA-00-LG1-DR-A-00001

‘SH’	is the project location
‘CA’	is the two-character code for the originator
‘00’	indicates that the drawing covers more than one zone
‘LG1’	indicates the drawing relates to the Lower Ground floor level 1
‘DR’	indicates the drawing is a 2D drawing
‘A’	indicates the discipline that created the drawing is an architect
‘00001’	is the unique number when concatenated with ‘file type’ and ‘discipline’

At the start of the project, a master document index (MDI) must be created that lists all the 'file identifiers' for models and drawings that are needed, along with their delivery dates and, if possible, intermediate milestones. The following document properties (metadata) should be included: project, location, originator, zone, level, file type, role, number, description/ title and delivery date.

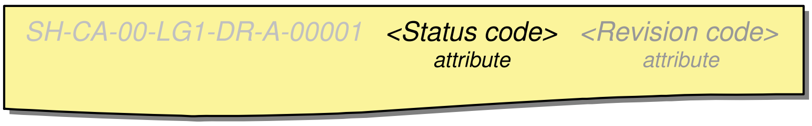
See Table 17 in Appendix A for an example of a template for a master document index spreadsheet.

6.1.3 File-identifier metadata

Status defines the '*fitness*' of information in a model, drawing or document. It allows each design discipline to control the use to which their information may be put. Unauthorized use of the data is not acceptable if control is to be maintained and errors or ambiguities avoided.

The 'status' is an attribute defined in the title block of the drawing sheet template, and will also be defined as metadata that is associated with the file identifier when the file is uploaded into the document repository.

> **Recommendation**: status and revision should **not** be included as part of the file name as this will produce a new file each time those elements are updated, and an audit trail will not be maintained.



All models, drawings and documents will have status codes defined as listed in Table 9.

An example of a drawing that has a status = 'fit for construction':

Status = A

Table 9: Status codes

Status	Description	Model files	Drawing files	Documents
S0	Initial status or WIP. Master document index of file identifiers uploaded into the extranet.	✓	✓	✓
In the Common Data Environment ‘shared’ section				
S1	Fit for coordination. The file is available to be ‘shared’ and used by other disciplines as a background for their information.	✓	×	×
S2	Fit for information	×	✓	✓
S3	Fit for internal review and comment	As required	✓	✓
S4	Fit for construction approval	×	×	✓
In the Common Data Environment ‘Documentation’ section				
D1	Fit for costing	✓	✓	✓
D2	Fit for tender	×	✓	✓
D3	Fit for contractor design	✓	✓	✓
D4	Fit for manufacture/procurement	×	✓	✓
A	Fit for construction. RIBA states that ‘A’ is noted as to ‘action for construction.’	×	✓	✓
B	Partially signed-off. For construction with minor comments from the client. All minor comments should be indicated by the insertion of a cloud and a statement of ‘in abeyance’ until the comment is resolved, then resubmitted for full authorization.	×	✓	✓
AB	As built	✓	✓	✓

6.1.3.1 Status

When the ‘status’ code does not sufficiently convey the *use* of the information, the information owner can define it in the ‘purpose of issue’ text string. For example, a drawing for ‘planning’ submission is likely to have a status ‘S2’ or a ‘D’ status – for information, if not fully approved at that stage – but the purpose for the information can still be clearly indicated in the ‘purpose of issue’ box on the drawing sheet as ‘for planning’. The purpose of issue should be the highest level of authorization. Table 10 defines some examples for ‘purpose of issue’ that can be allocated.

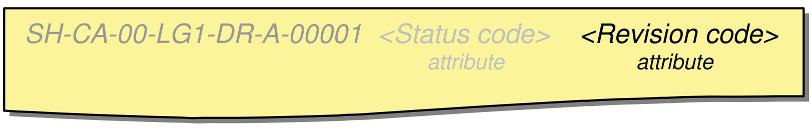
Table 10: Examples for purpose of issue

Purpose of issue
For planning submission
For building control approval

6.1.3.2 Revision

The ‘revision’ is an attribute defined in the title block of a model or drawing sheet template, and will also be defined in the document repository when the file is uploaded. The revision shows the iterative nature of the information as it progresses to completeness.

The revision and status is required to track the progression of a file or document to its completion and authorization. The revision and status code need to be part of the attributed metadata, not part of the file name. If it is included in the file name, then it effectively becomes another document when concatenated, and it cannot be tracked effectively. In a database solution, the metadata can be used to track and retrieve the files or documents in the most efficient manner.



The ‘Status codes’ and ‘Revision’ numbers are allocated as follows:

- During WIP (Status S0), preliminary revisions and versions are P1.1, P1.2, or P2.1, P2.2, etc. before release to ‘shared’.
- Before ‘authorized for construction’ (Status S1–Sn), preliminary revisions are: P1, P2, P3, etc.
- Once ‘authorized for construction’ (Status A), revisions are: C1, C2, C3, etc.
- The authorization status codes are specified in – ‘GREAT BRITAIN: JCT 05 – Major Project Subcontract (MPSub) – Subcontract. London: RICS Books’.

6.1.3.3 Version

The version is a subdivision of the revision, and shows the iterative progress of the file during WIP and before release to ‘shared’. It is necessary to track the iterative nature of the file, as extracts may be taken from the file as material schedules or area calculations. The extracted file needs to know what revision/version it belongs to.

In a database solution, it will be necessary to track versions when the extracted data is modified and reconnected to the spatial file. Tracking and updating will be a constant activity, and the changing of attached properties or attributes to a file may be carried out without changing the graphical or spatial nature of the file.

In WIP, the revisions and versions need to be tracked and, when released to the shared area, the revision will be used to track the use. For example, when a number of model files are combined/overlaid to create drawings, the model file names that were used to produce the drawings should be stated in the notes column of the drawing, along with the revisions of those model files.

6.2 Origin and orientation

6.2.1 Coordinates

CAD modelling systems assemble the model information needed to generate production drawings, which are based on Cartesian coordinates of all relevant points needed to define the project. In the following sections, we have shown a stylized 3D building to convey the requirements of a fully coordinated system, which is applicable to either a 2D or 3D design project.

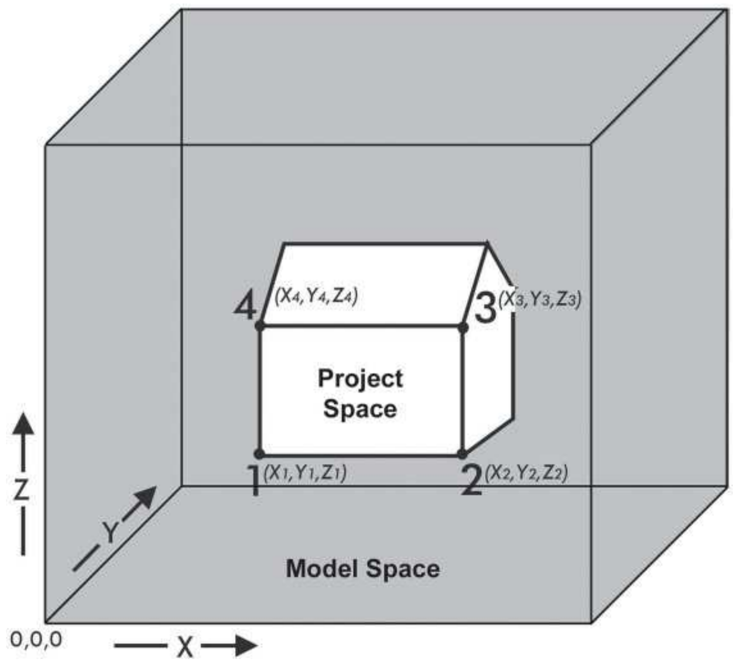


Figure 28: Cartesian coordinate system

In Figure 28, the points 1, 2, 3 and 4 can each be precisely located in space by three coordinates, which are given in relation to three planes (normally two vertical and one horizontal) at right angles. The point of intersection of the three reference planes is called the 'origin' of the coordinate system.

Generally, it is recommended that the location of the 'origin' is outside the area required by the project so that all coordinates have positive values. The coordinates are sometimes referred to as 'world coordinates', and the space defined by their positive values is known as 'model' space.

6.2.2 Spatial coordination

Spatial coordination is an essential requirement of good-quality production information.

6.2.3 Building grids

To achieve a fully coordinated set of production drawings across all design disciplines, a common building grid should be established and used by all members of the design team.

This will ensure that the different design disciplines' models achieve the same registration when coordinating the models that relate to each individual building.

It is common practice to define a building origin at the bottom left-hand corner of the building, in plan view, as shown in Figure 29. This building origin must then be related to a site grid where the site grid could be based on the Ordnance Survey (OS) grid or a site survey grid.

6.2.4 Site surveys

It is preferable for the site surveys to be based on Northings and Eastings that are related to the known geospatial coordinates, as shown in Figure 30. For example, the geospatial coordinates could be based on the OS grid.

In some instances, the survey origin may be based on an arbitrary site grid the surveyor has chosen. The levels will relate to a local OS benchmark, or to a local temporary benchmark (TBM) established for the project.

6.2.5 Alignment of the building to real-world coordinates

To enable the building to be correctly located in real-world coordinates, it is necessary to relate the origin and orientation of the building grid to the origin and orientation of the site grid, as shown in Figure 31.

It is recommended that a major axis of a building (typically its length) is used to set out the building grid relative to a site grid origin. The direction of true north should also be referenced.

Care should be taken when recommending OS coordinates. In a number of software systems, including CAD systems, large coordinates of six significant figures can produce erroneous information when calculating areas and lengths.

It is recommended that buildings be set out with reference to local site survey coordinates to overcome the problem. The site is usually set out using the surveyor's base lines and permanent monuments, and these should be used for setting out the CAD models. The site survey can be referenced or related to the OS grid, and the coordinates are easily transposed by the surveyor's software when generating the 'angle bibles'.

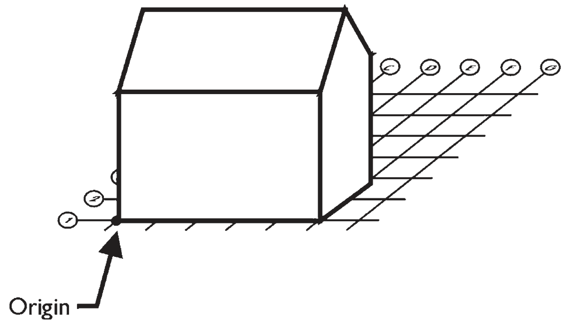


Figure 29: Building grid definition

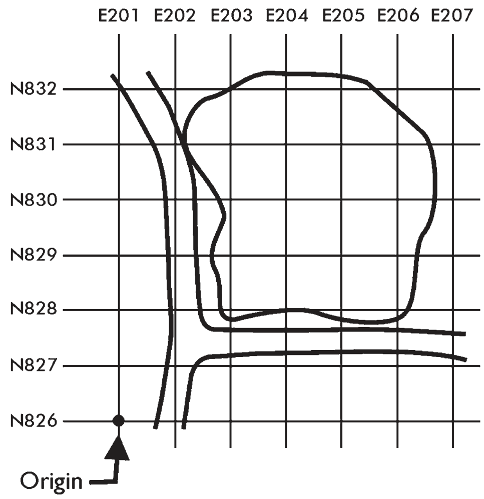


Figure 30: Site grid definition

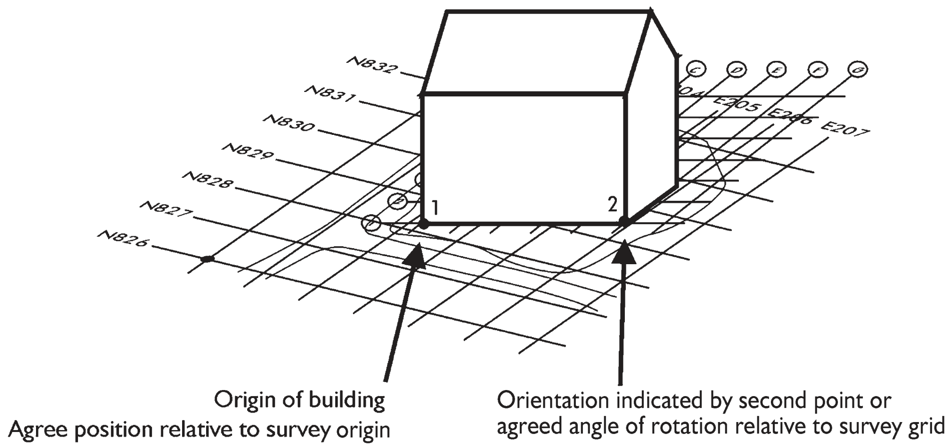


Figure 31: Alignment of the building to the real-world coordinates

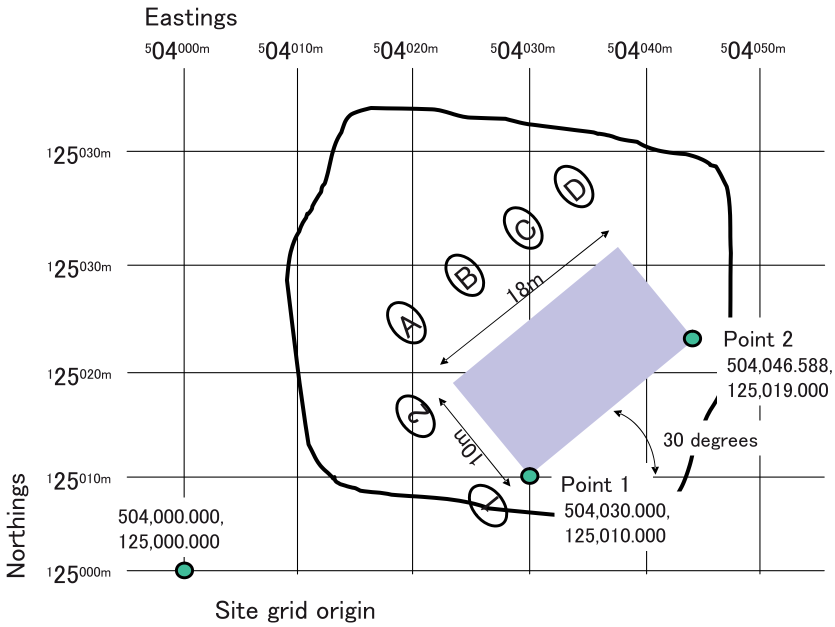


Figure 32: Building grid and setting out points

Table 11: Setting out a building grid

Point	Grid intersection	Easting (m)	Northing (m)
Site grid origin	–	504,000.000	125,000.000
1	A1	504,030.000	125,010.000
2	D1	504,046.281	125,019.400

6.2.6 Example of building alignment

Table 11 and Figure 32 show a typical example of the information that the lead designer should agree when setting out building grids relative to the Ordnance Survey Northings and Eastings.

6.2.7 Dimensional consistency

Many of the problems that arise on construction sites can be traced to errors and ambiguities in the dimensions. Such errors occur when information is entered incorrectly, or dimensions are added as text that is unrelated to the underlying coordinate system. The use of incorrect dimensional information will prevent effective spatial coordination.

Create all models at a scale of 1:1 using real-world coordinates, and base all drawings on the model information. Do not use ‘not to scale’.

Derive all dimensions automatically from the underlying CAD coordinates by using the ‘associative dimensioning’ function of CAD systems. Do not enter dimensions as ‘text’ as they are purely graphic characters with no relationship to the underlying CAD coordinates, and will compromise the relative positions of elements in a drawing.

The project team should agree common units of measurement. These should include distance (e.g. metres and millimetres) and angles (e.g. degrees/radians measured clockwise or counter-clockwise).

6.3 Drawing sheet templates

The drawing sheet templates must be used as the starting point for all drawings, with the necessary model files referenced into a view created in the drawing.

Drawing sheet templates in A0, A1, A2, A3 and A4 sizes are available. See Appendix E for an example of a drawing sheet template. Appropriate information that is specific to the project can be inserted into the title block of the drawing sheets, for example:

- client name and logo;
- originator name and logo;
- project name; and
- project number.

A project number required by each team office can be added to the drawing template as a company project number, but it is not part of the file name.

6.3.1 Drawing title block attributes/tags

Attributes in the drawing title block contain metadata that is specific to each individual drawing. The metadata that relates to the ‘file identifier’, ‘revision’ and ‘status’ has been described in detail in section 6.1 of this guide.

The drawing number on a drawing sheet title block must contain the 'file identifier', with the other metadata information being presented in the remaining sections of the title block as follows:

- project name;
- drawing title;
- revision;
- status;
- purpose of issue;
- client authorization information; and
- revision description (including what has changed and why) with check and approval dates by the originator.

Figure 33 shows a drawing title block containing the metadata information for the drawing examples described in section 6.1 of this guide.

Note that drawing files should not be named freely, but should follow the convention for defining a 'file identifier' to avoid duplicate or inconsistent descriptions. To ensure that valid file identifiers are used, create a master document index (MDI), which defines all model and drawing files and their associated descriptions so that a document controller can pre-upload the files into the document repository. See Appendix A for an example of a template for creation of a master document index.

When compiling any type of construction document, ensure that the document is cross-referenced accurately with other documents or specifications, so that the full intent of the document will be carried out.

With this in mind, label all drawings clearly with the file name and revision of any reference models or documents used to compile them, and list them clearly in the notes column of the drawing title block, as shown in Figure 33.

In this example the 'project number' has been included in a separate box.

6.3.2 Model title block

By definition, a model file is either an 'M2' or 'M3' file type and will only contain the actual model information; therefore it will not contain any drawings or views of the model. A view of the model will be created in a drawing file with a 'DR' file type.

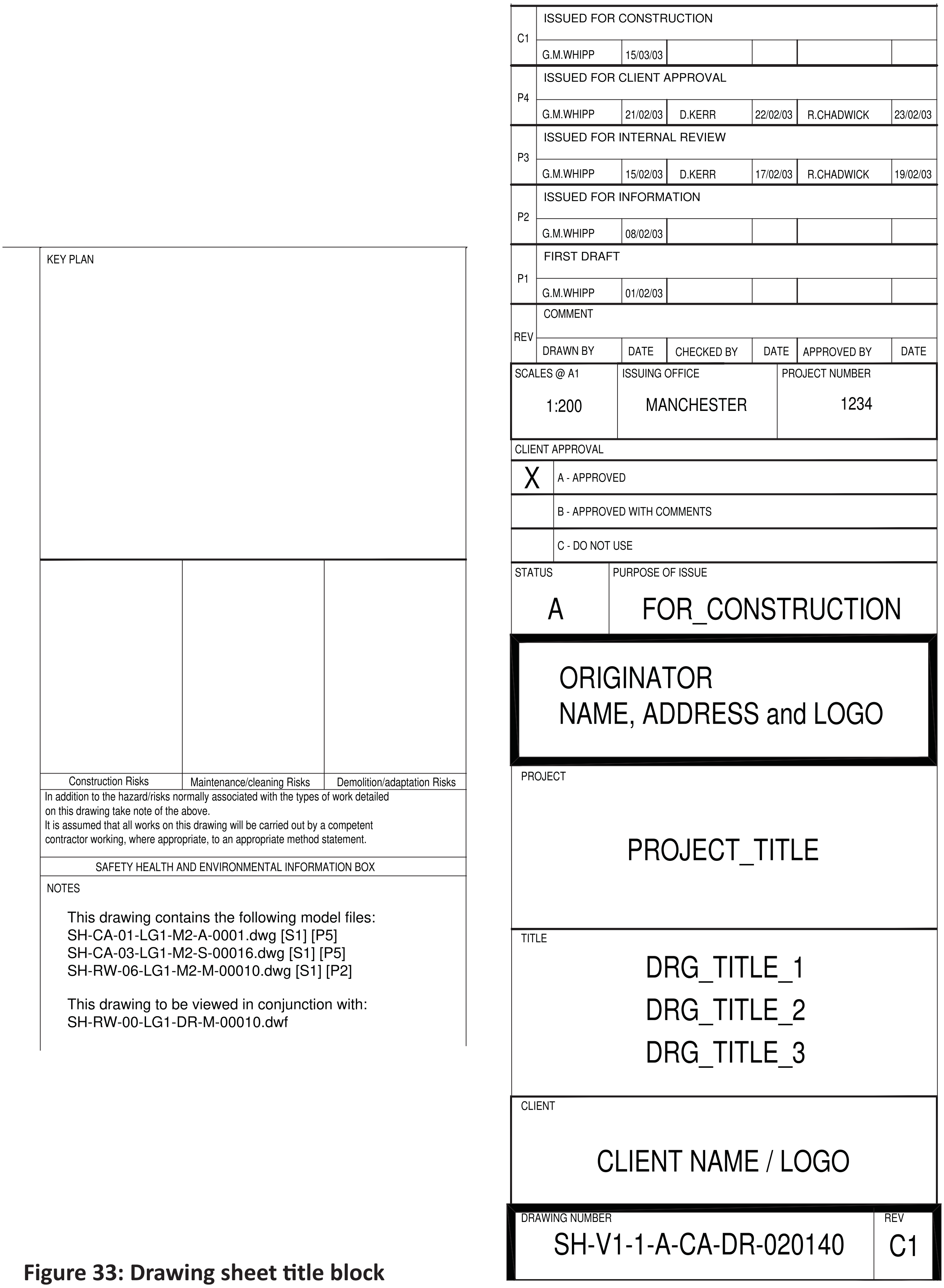


Figure 33: Drawing sheet title block

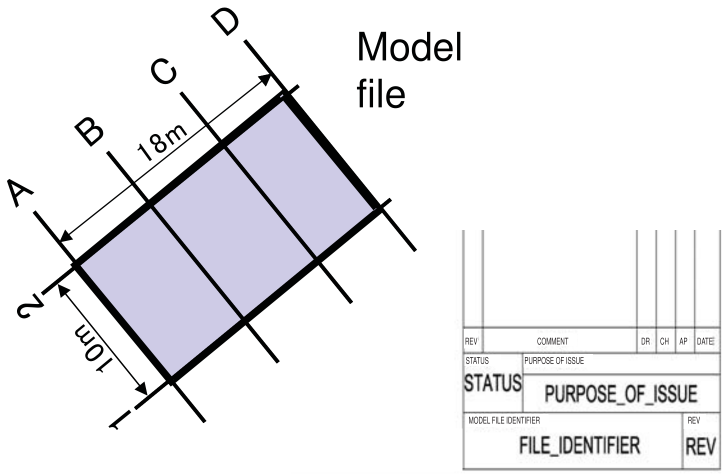


Figure 34: Model file

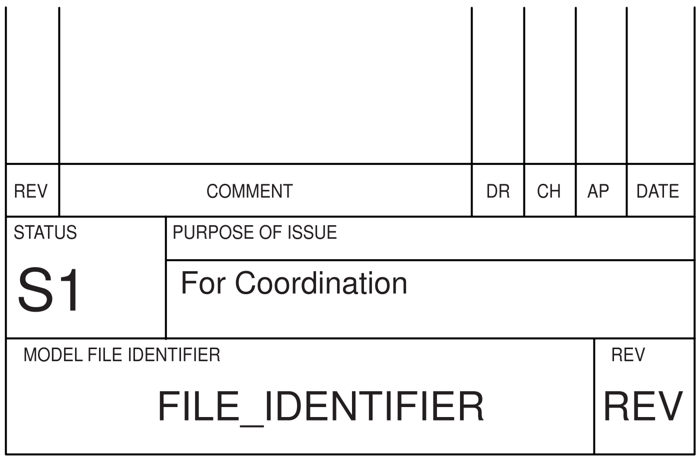


Figure 35: Model file title block

It is important to identify such model files with respect to their ‘revision’ and ‘status’ when they are accessed or viewed in an environment, for example, a document repository that is not managing a model’s metadata.

Figure 34 shows a typical model file that relates to a ‘zone’, with a model file title block located in the bottom right-hand corner of the model.

Figure 35 shows the model file title block with its associated text attributes in more detail.

6.3.3 Drawing sheet sizes

Table 12: Drawing sheet sizes

Size	Dimensions
A0	1189 × 841 mm
A1	841 × 594 mm
A2	594 × 420 mm
A3	420 × 297 mm
A4	297 × 210 mm

6.3.4 Drawing sheet scales

All drawings must be rendered and presented at one of a number of approved scales, which are typically defined by the 'CAD Manager'. Scales other than those approved should not be used.

Table 13: Drawing sheet scales

Scale
1: 2500
1: 1250
1: 1000
1: 500
1: 200
1: 100
1: 50
1: 20
1: 10
1: 5
1: 2
1: 1

Table 14: Example of layer name codes

Field		Role		Element/ classification		Presentation		Description/ alias
Name		A	-	G23	-	M2	_	Stairs
Example		Architect		Stairs (Uniclass)		Model graphics (2D)		

6.4 Layer standards

A layer naming standard will be applied to all 2D and 3D CAD models that will be shared among the design teams.

The following convention based upon BS 1192 should be adopted to define a layer name. Note that there are hyphen '-' delimiters between the first three mandatory fields, and an underscore '_' delimiter is used between the mandatory and the alias.

[Role] - [Element] - [Presentation] _ [Alias]

Mandatory fields:

- role: the discipline for the owner of the information;
- element/classification: using Uniclass classification codes for construction elements or drawing elements; and
- presentation: indicates the way in which the element is displayed.

An example of a typical layer name code is shown in Table 14.

The fields that form the layer names are described in detail below.

6.4.1 Role

Table 8 in section 6.1.2.6 of this guide lists the single-character 'role' codes recommended in BS 1192.

Table 15: Presentation codes from BS 1192

Code	Description
D	Dimensioning
H	Hatching and shading
M	Model related elements
P	Plot/page related elements
T	Text

Additional to the BS 1192 definition, the M code can be extended to define specific requirements of M2 to mean 2D and M3 to mean 3D graphic files.

For large projects, a two-character 'role' code may be more appropriate. See section 6.1.2.6 of this guide above for a 'caveat'.

6.4.2 Element/classification

The 'classification' is a varying-length alphanumeric code.

Base the 'element' code on the Uniclass classification system, which allows for the full classification of element, specification, materials, construction aids, etc. See www.uniclass.org.uk or www.CPIC.org.UK Uniclass Request Tool for details of the element codes when using the Uniclass classification system. Also see the Guidance Commentary from BS 1192 below.

6.4.3 Presentation

The 'presentation' is a single or two-character code. Table 15 shows the presentation codes recommended in BS 1192.

6.4.4 Description/alias

Recommendation: append the 'description' code to the layer name to assist layer identification.

Following an underscore delimiter character '_', the 'description' or 'alias' directly correlates to the 'Uniclass classification'. The 'description' should not be treated as a user-definable field, but must be agreed and used consistently by the project team – even though this is noted as 'optional' in BS 1192. For Uniclass, this will be controlled by the 'Uniclass Request Tool', and the aliases are consistent throughout with no ability to user-define.

Inconsistent use of aliases creates problems of expanding the material schedule, because the naming of the alias has been user-defined.

6.4.5 Extract from BS 1192

Table C.1 compares the layer naming required in 5.4.4 with those recommended in BS EN ISO 13567-2.

Table C.1 Differences between international and British layer naming fields

Mandatory/ optional field	Field name and order in BS EN ISO 13567-2	Number of characters	Field name and order in BS 1192	Number of characters
M	1. Agent responsible	2	1. Role	1 then hyphen
M	2. Element	6	2. Classification	2–5 then hyphen
M	3. Presentation	2	3. Presentation	1
O	10. User defined	Unlimited	4. Description	Underscore then unlimited

C.2 Managing the relationship between British and international structures

A UK organization working on an international project, to which BS EN ISO 13567-2 code conventions for layering are to be applied, can convert layers for export in a straightforward manner because the layer structure in 5.4.4 is a subset of the

ISO structure. Data received from overseas organizations can be converted to this structure, but some loss of layer structuring information is likely to occur. UK organizations might therefore be obliged to use a more complex and unfamiliar structure. In such circumstances, it is useful for the project teams to agree at an early stage how they will allocate named containers for specific projects, and document these. It is likely that software will be used for converting between the standards.

NOTE BS EN ISO 13567 parts 1 and 2 contain many detailed recommendations on how to exchange data internationally.

GUIDANCE COMMENTARY on 5.4.1 of BS 1192

BS 1192 Tables 2 and 3 specify that the Description in the layer containers is optional; in practice, and when using the Uniclass codes, the description should be consistent with the classification. In the revised Uniclass structure (see www.CPIC.org.uk Uniclass Request Tool), the granulation of the classification requires the classification code and the description to be consistent to allow for specific reuse of the data for material scheduling and the application of the specification.

Because extracts from CAD/BIM files use the layer container as a means of producing lists of elements, the schedule can be misleading. Example: a project defined a specific number of bathroom module types (six). A library of the sub-models was made available to the project teams. Each project team changed the description associated with the classification number; it became user defined, which led to a schedule being produced of over 36 different types of bathroom module. This required the models to be checked and the element layer names had to be amended to get the correct schedule result.

It should further be noted that when converting between international and BS 1192 conventions, problems will arise because there may be inconsistencies between the description fields of the ISO that could lead to multiples of the descriptions in the BS, leading to further problems.

6.5 Annotation

The ‘CAD Manager’ should agree the text style and fonts to be used in drawing title blocks, and any other annotation that is added to a drawing.

6.5.1 Dimensions

All dimensions *should* be generated as associative dimensions and never added as text. Dimension text must not be modified, and automatic or associative dimensions should *never* be broken into their constituent parts.

6.5.2 Abbreviations

Historically, abbreviations were used frequently in construction documents as part of standard practice. They were part of the drawing symbology, but led to errors of interpretation by contractors.

Abbreviations should therefore be controlled by an agreed ontology, since they are frequently part of the normal vocabulary used by different roles. For instance, 'LTHW' is used to refer to a low-temperature hot-water heating system.

Rules for use of abbreviations:

- use upper-case lettering, without full stops;
- do not use spaces within an abbreviation; and
- use the same abbreviations for singular or plural.

Abbreviations must be consistently applied by the design teams, and therefore a table of abbreviations should be maintained. See Table 18 in Appendix G for an example of a list of commonly used abbreviations.

6.5.3 Symbols

Standard symbols should be agreed by the project team. Some typical examples of standard symbols are shown in Figure 36.

Recommendation: establish a full symbols library for the project so that all parties use the same notation and understand their meaning.

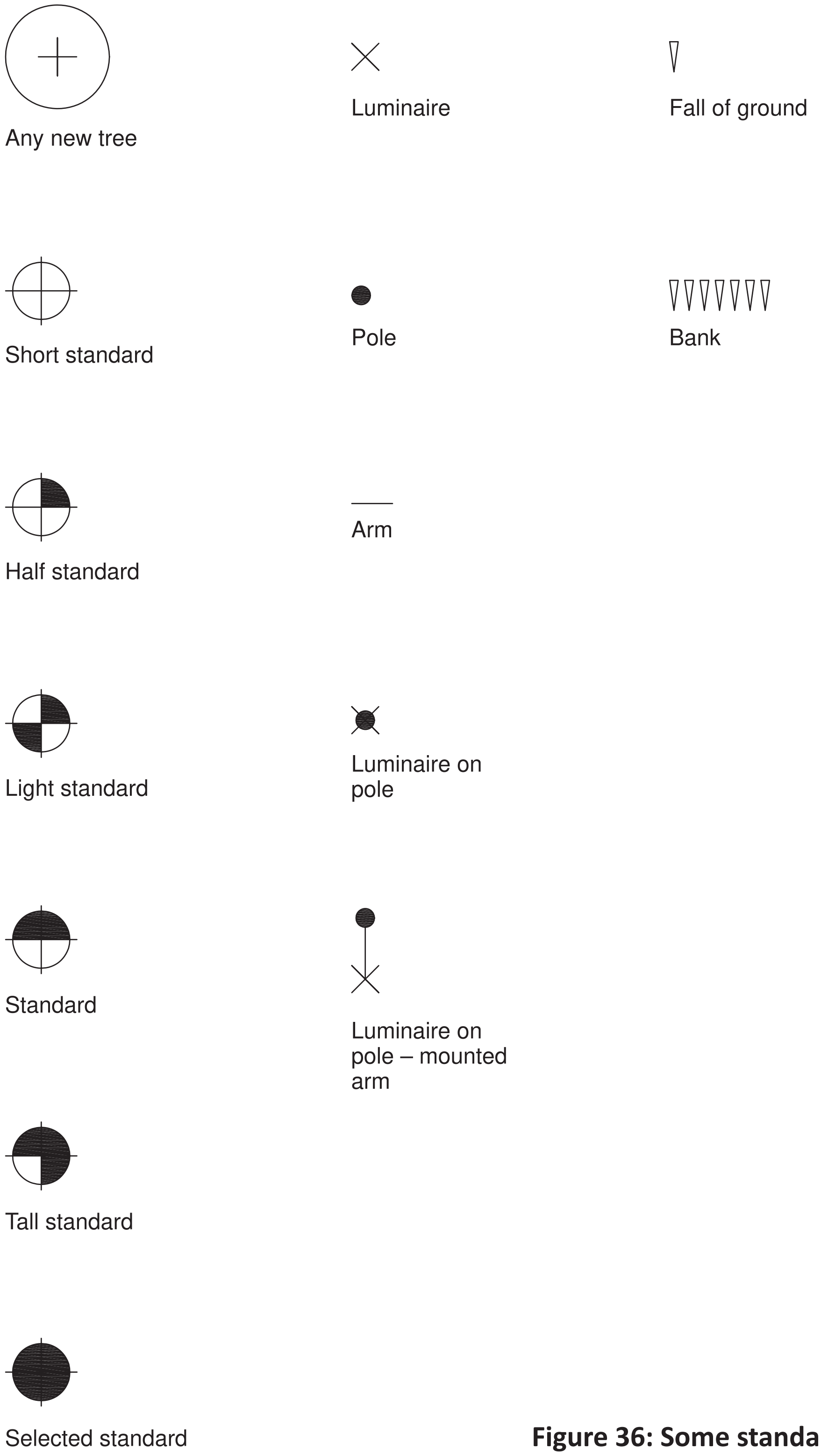


Figure 36: Some standard symbols

Useful sources for architectural and building services symbols are:

BS 1192-3:1987 (withdrawn), *Construction drawing practice – recommendations for symbols and other graphic conventions*

ISO 7000:2004, *Graphical symbols for use on equipment – index and synopsis*

ISO 10488:1991, *Graphical symbols incorporating arrows – synopsis*

ISO 17724:2003, *Graphical symbols – vocabulary*

IEC 80416-1:2008, *Basic principles for graphical symbols for use on equipment — Part 1: Creation of graphical symbols for registration*

IEC 80416-2:2001, *Basic principles for graphical symbols for use on equipment — Part 2: Form and use of arrows*

IEC 80416-3:2001, *Basic principles for graphical symbols for use on equipment — Part 3: Guidelines for the application of graphical symbols*

NHS Estates publication – Engineering symbols and drawing conventions – A catalogue for the use in health care premises

7 Specification

Most projects will employ several design disciplines, each of which should prepare the work sections of the specification for which they have design responsibility – just as they prepare their respective drawings.

Within each discipline, the ideal authors of the relevant work sections will be technically experienced personnel, with detailed knowledge of the project and experience in preparing specifications, and who will be responsible for this work. Very often, the authors will be the project architects and engineers.

Other possible authors include dedicated in-house specification writers, consultant specification writers (rare in the UK), and consultant technical experts (e.g. manufacturers, fabricators or in-house specialists). More than one of these authors may be used on a given project.

Irrespective of the specifier, careful checking is needed to ensure that all work sections are consistent and coherent, reflect the particular design requirements of the project, and are also consistent with the drawings.

As noted, wide knowledge of construction technology is needed. The specification for a building project of average size and complexity contains a large amount of information, and reference to a much larger volume of published material (e.g. to British Standards).

An even larger amount of information, not included or referred to in the specification, needs to be consulted during the specification process. This mass of published information changes constantly – about 15 per cent annually for British standards relating to the construction sector, for example.

The sheer volume of this information means that an individual designer cannot assimilate and remember it all. The design office should therefore:

- encourage individuals to develop and maintain expertise on certain topics, and to give advice to others;

- maintain a suitable master specification system; and
- maintain an efficient technical library, supplemented by appropriate information systems.

7.1 Master specification systems

Researching and writing good-quality specification clauses from scratch is difficult and time-consuming, but sometimes it is unavoidable. Careful reuse of standard clauses can save a great deal of time, and also improve the quality of project specifications.

A comprehensive set of standard specification clauses is called a master specification system. To be effective in use, it needs the following features:

- It should follow the principles set out in this guide.
- The work sections should be arranged by CAWS (Common Arrangement of Work Sections).
- Clauses should be arranged within work sections to follow the design and construction sequence.
- The clauses should present a comprehensive and clear set of alternatives that relate well to the available design choices, with gaps left for insertion of variable (project-specific) information.
- It should provide helpful guidance for selecting and completing individual clauses and for each section as a whole.
- Clauses and guidance should be thoroughly researched, well written and kept up to date.
- It should cover all commonly occurring construction systems and products.
- Alternatives offered should suit various project sizes and complexities, various procurement routes, and new-build and work-to-existing.

Preparing and maintaining such a master specification system requires a huge amount of effort, and most offices should consider subscribing to a commercially available master specification system. Offices should be able to use such a commercial system directly for the preparation of project specifications.

However, the system should also enable the office to pre-edit the basic text, to produce an office-specific master specification system. Such an office master will:

- relate more directly to the technical preferences of the office, client or project type, e.g. by standardizing the choice of many products; and
- reduce the time taken in preparing project specifications, by reducing the number of options to be considered and the amount of technical investigation to be undertaken.

Pre-editing can involve adding or varying sections, clauses and values in the commercial master. It can also involve inserting supplementary guidance covering preferred proprietary products, products and practices to be avoided, additional advice on use of clauses, and suggested text for supplementary clauses.

Modifying the commercial master specification system in this way can involve a lot of work – not least in coping with updating. Offices should consider carefully the extent and nature of such modification to ensure that the effort will be repaid.

7.2 System software

A few specifiers still use commercial master specification systems by marking up a print copy of the clauses, having it word processed by administrative staff, then checking it for accuracy (if time permits).

The recommended practice for the majority of UK specifiers is to edit the text on screen, using software supplied with the commercial master specification system. The usual features of such software include:

- navigation and manipulation of the content with only limited computer and keyboard skills;
- specification begins by selecting work sections relevant to the project;
- clauses and related guidance display automatically side by side;
- the status of text is displayed during preparation of a specification, e.g. ‘selected’, ‘deleted’, or ‘decision not yet taken’;
- highlighting or reporting of clauses that have been selected but not completed, e.g. they require insertion or deletion of text;
- automatic numbering of user-generated clauses;
- easy insertion of data from other sources at any point, e.g. drawn details, spreadsheets and clauses from other projects;
- automatic update of data and software, once the decision to update has been made;
- good range of word-processing and output features, e.g. printing functionality;
- adequate software help is built in; and
- embedded hyperlinks, to enable users to access sources such as websites, online documents and resources, other work sections.

Additional features of the software (which some offices may regard as essential) may include:

- ability to create office master specifications, with clauses and/or guidance added, deleted or amended;
- highlighting or reporting of clauses and guidance included in user-generated specifications that are affected by a system update, to facilitate review;
- ability for the office to control access by different people, e.g. to 'view only' or 'edit' user-generated specifications; and
- audit trailing of user-generated specifications – who made what decisions, and when.

In the future, we can expect commercial master specification systems to be compatible with building information modelling (BIM). This requires new functionality such as:

- bidirectional linkage between the specification and other project documents;
- interrogation of the specification by third-party software (e.g. for cost estimation and acoustic simulation);
- automated assembly of the specification;
- integration of the chain of written documentation tools along the entire project timeline;
- automated compliance and error checking of the specification; and
- support for a wide range of reports and views, including specifications geared to the needs of a particular audience.

8 Implications of design management

As far as possible, detailed design of the building should be complete before production information begins, and drawings and the specification should be complete before tender action and construction. However, in practice the preparation of production information will often overlap both detailed design and construction.

Sometimes, overlap can be advantageous – for example, in compression of overall project programmes and making best use of the design skills of specialist constructors. However, overlap can also give rise to poor technical and dimensional coordination, resulting in wasteful reworking and defects.

Design is a highly iterative process, with many complex dependencies between elements, and many 'review and revision' cycles.

A basic principle is that the production information for any given element or type of work must be free from subsequent design dependencies before it is prepared and used for construction.

This principle should be fundamental to the preparation of a detailed production plan for the preparation of the model files and drawings listed in the drawings register or master document index.

The plan should follow the principle of multidisciplinary build-up of drawings described in section 8.1 of this guide. It should consist of a sequential series of actions, each stating the information to be added, in order to guard against omissions and wasteful 'backtracking' during preparation of the building models and drawings.

The plan should thus define the required model files, structured to give the required degree of flexibility and potential reuse of the information. The plan should also show the transfer of files from one design discipline to another, and the times for model file and drawings availability (if used, see section 8.1 of this guide).

The plan should take into account the required sequence for completion of drawings for 'work packages', if used. The completed plan should be checked to ensure that it provides for the completion of all drawings in the drawings register.

The multidisciplinary build-up of drawings from a BIM follows a similar pattern from project to project, and there will be much commonality between the production plans for different projects of similar type and size.

Design offices may find it useful to prepare template checklists to help ensure that all items of information to be added at each stage are remembered. Wherever possible, such templates should be multidisciplinary.

8.1 Time and resource programming

The Production Plan should have determined the optimum sequence for preparing the models and drawings, and this should be the basis for allocating resources and programming.

These decisions will be based on the availability of suitably skilled personnel from the various design team organizations, and the requirements of the overall project programme. The outcome of this process should be a time and resource programme (see Figure 37).

Historically, detailed programming has been based on estimates of time for each drawing, but this will be unrealistic for the multidisciplinary build-up procedure recommended for model file and drawing development.

Base estimating on the activities set out in the production plan, grouped together as required to give an appropriately coarse 'grain' to the programme.

A simplified but basically sound programme is far more valuable than a highly detailed but cumulatively inaccurate one. Detailed planning of smaller sections of the master plan does have advantages (last planner, lean processes, etc.).

The programme should make appropriate allowances for the detailed design and documentation inputs of all consultants and specialist constructors, and should be coordinated with the programme for producing the specification. It should be agreed with all parties, including the major constructor (if known).

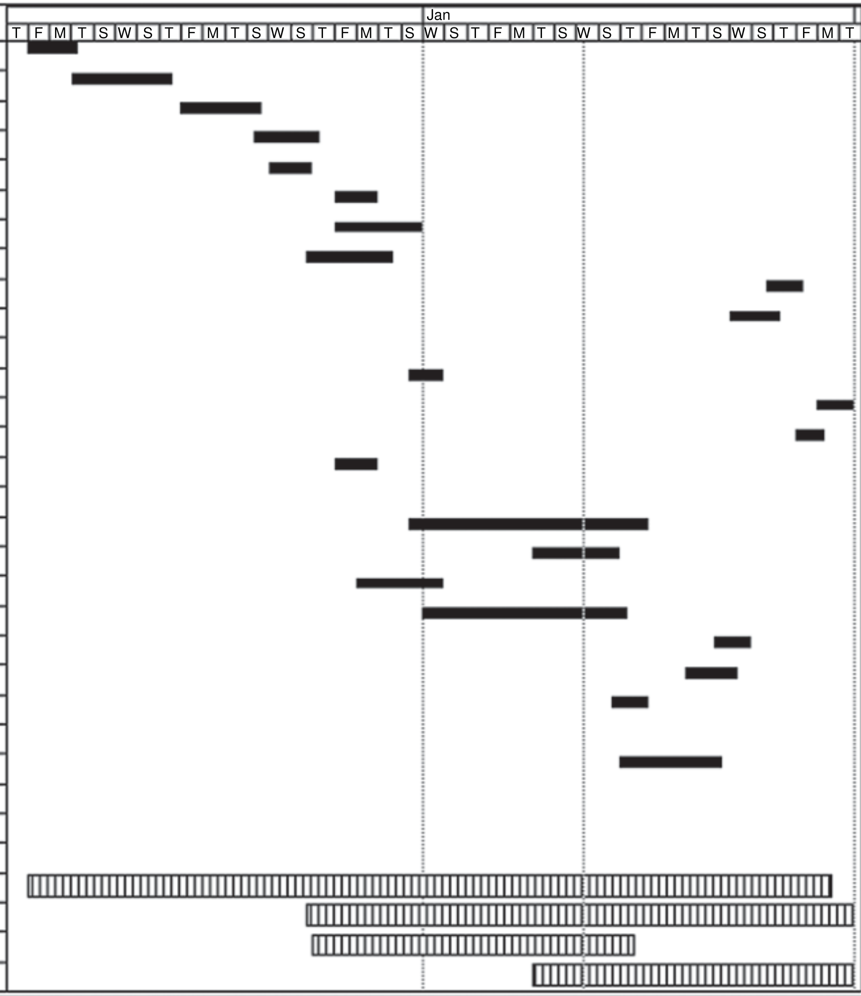
In order to make the change to the multidisciplinary Common Data Environment (CDE) method described above, normal planning of model and drawing production giving total number of models and drawings, production time and resource allocation should be used in the early stages of learning. However, as experience of the method is gained, it will become apparent that drawing production is delayed while the model files are established and

PROJECT NAME:

DRAWING PROGRAMME

PROJECT VALUE:

ID	Draftings	Name	Duration	Resource Initials
1	L1	Site Location Plan	5 days	BT
2	L2-L4	Floor Plans: Block A	10 days	BT
3	L5-L6	Floor Plans: Block B	7 days	BT
4	L7-L8	Factory Process Layout	7 days	BT
5	L9	Roof Plan: Block A	4 days	LS
6	L10	Roof Plan: Block B	4 days	LS
7	L11-L12	Sections	8 days	BT
8	L13-L14	Elevations	10 days	SS
9	L15-L17	Ceiling Layouts: Block A	5 days	VS
10	L18-L20	Furniture Layouts: Block B	5 days	BT
11			0 days	
12	S1-S2	Door Ironmongery Schedule	5 days	SS
13	S3	Sanitary Schedule	5 days	VS
14	S4	Window Schedule	2 days	SS
15	S5-S6	Finishes Schedule	4 days	SS
16			0 days	
17	A1-A35	Walls Assembly	25 days	BT
18	A51-A60	Stairs Assembly	8 days	VS
19	A101-A119	Roof Assembly	10 days	LS
20	A151-A180	Openings Assembly	20 days	SS
21	A201-A213	Ceilings Assembly	5 days	VS
22	A251-A260	Fittings Assembly	5 days	BT
23	A301-A311	External Walls Assembly	5 days	VS
24			0 days	
25	C1-C50	Doors/Windows Components	10 days	SS
26			0 days	
27			0 days	
28			0 days	
29	B. Tie	Project Architect	78 days	
30	S. Suit	Architect	55 days	
31	L. Skirt	Architectural Technologist	32 days	
32	V. Scruffy	Architectural Technologist	32 days	



NOTES:

Figure 37: Simplified time and resource programme

coordinated. The delay is more than compensated for by the ease of generation of large batches of good-quality drawings in a short space of time.

This is because the final stage of drawing activity consists of simply selecting, saving and annotating views and filling in title blocks. This methodology does not limit the drawing set to the initial Drawings Register: further drawings at greater or lesser scales can be produced swiftly from the same data. Experience will lead to improved time and resource programming.

8.2 Approval of information

To ensure that model and drawing files are adequately checked, some form of approvals process needs to be in place to enable the design teams and the contractor (or client) to approve and sign off the development of the design information for a project. The design approval process should be specified, agreed and documented as early as possible in the project.

This process should also include a full check of the data coordination and registration across the whole data set before the design check proceeds. It should also include an assurance that the data to be approved has been checked for compliance with the agreed Standard Method and procedures. The physical method of checking should be adopted for the release or publication of M2 and M3 models, as well as DR files.

Table 16 shows the approval stages for getting a model to a status that is 'fit for internal review'. At this stage, the model files can be used to create drawings.

Table 16: Approvals stages for a model file

Approval route	Description	Revision	Status
N/A	Peer check	PP1	S1 – Fit for coordination
Stage 1	Lead Designer and Design Coordinator sign off	PPn	S3 – Fit for internal review

To move a document to a status of ‘fit for construction’ requires it to be submitted for contractor/client approval. Once the design is deemed ‘fit for construction approval’, the originator will submit all documents to the contractor or their representative, this may be the Lead Designer. When the contractor or representative is satisfied that the document completely fulfils its purpose and is ready for use as a construction document, they should sign off the document as a fully coordinated piece of information, and issue it.

Status ‘A’	The document is approved for construction purposes.
Status ‘B’	The document requires minor revisions before being moved to full construction status.
Status ‘C’	The document requires major work before resubmitting for approval.

It is common for the following designations of approval to be given:

Note that in addition to approval statuses A, B and C, status D is used for unapproved documentation that is required by the contractor for some use other than construction (see Figure 13).

Having reached status ‘A’, a document will be returned to the Originator who will enter the status in the relevant status box on the document and issue for construction with the revision series ‘C1’ being noted. Further construction issues will then be marked as Rev C2, C3 and C4, etc.

Further issues and amendments will be marked with a revision cloud and the appropriate description for the revision entered in the revision box. For subsequent issues, the preceding revision cloud should be removed so that only the revision under the revision amendment is highlighted.

For a more detailed view of the approvals stages, see the process diagrams in Appendix B and in particular B.7 and B.8.

Appendix A
Master document index template

A master document index (MDI) should be produced at the start of the contract. The Design Coordination Manager or the CAD Coordination Manager should establish the deliverables for the project and agree these with all team members. This should be coordinated with the plan and resource allocations in the design management section above.

The MDI with its milestones and delivery dates should be used to manage the timely delivery of the model files and documents/drawings otherwise serious delays will result in delivery of the detail production information. The milestones and delivery dates will need to be coordinated with the project and plan delivery requirements.

When the MDI is uploaded to the Project extranet, the ‘Revision’ code should be set to = P0 and the ‘Status’ code set to = S0.

Table 17: MDI template

File identifier							**Model or drawing title**	**Delivery dates**				
Project	Originator	Zone	Level	File type	Discipline	Number		Milestone 1	Milestone 2	Milestone 3	Milestone 4	Etc.
WH	RW	01	LG1	DR	M	00002	Lower Ground Floor 1 Plant room and Riser Location					
WH	RW	01	GF	DR	M	00003	Ground Floor Plant room and Riser Location					
AW	NG	02	GF	DR	E	10001	Electrical Services Containment Layout					
AW	NG	02	GF	DR	E	10001	Electrical Services Containment Layout					
AW	NG	03	ZZ	DR	E	10002	Power Distribution & Earth Schematic					
SH	CA	00	LG2	DR	A	00001	1:500 Level LG2 Plan					
SH	CA	00	LG1	DR	A	00002	1:500 Level LG1 Plan					
SH	CA	00	GF	DR	A	00003	1:500 Level G Plan					
SH	CA	00	01	DR	A	00004	1:500 Level 1 Plan					
SH	CA	00	02	DR	A	00005	1:500 Level 2 Plan					
SH	CA	00	03	DR	A	00006	1:500 Level 3 Plan					
AW	AR	12	F1	DR	S	08001	Foundation layout					
AW	AR	14	F1	DR	S	08002	RC Retaining wall, ramp and slab layout					

Appendix B
Process maps

B.1 Creating a model file

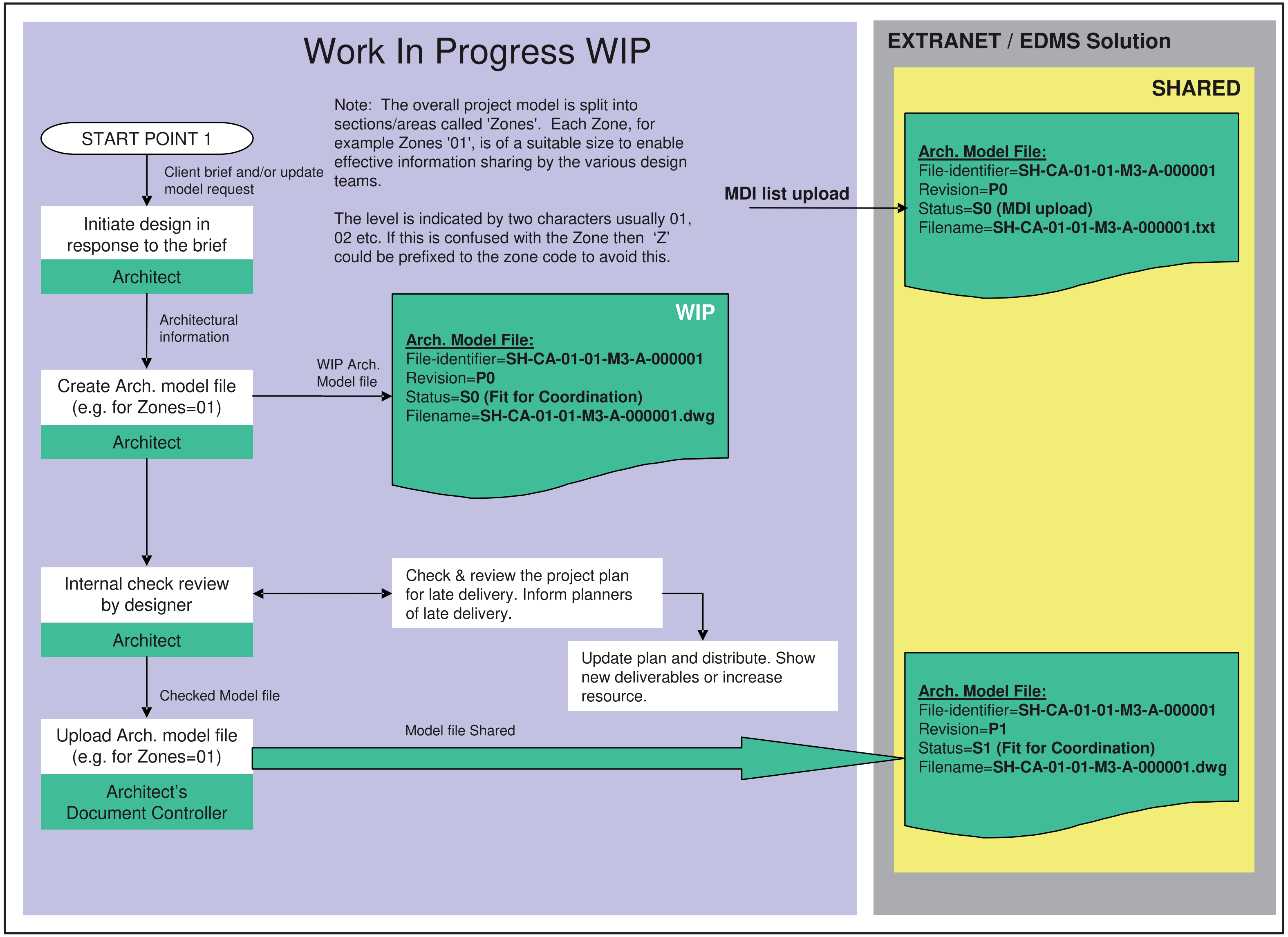


Figure 38: Creating a model file

B.2 Sharing a model file

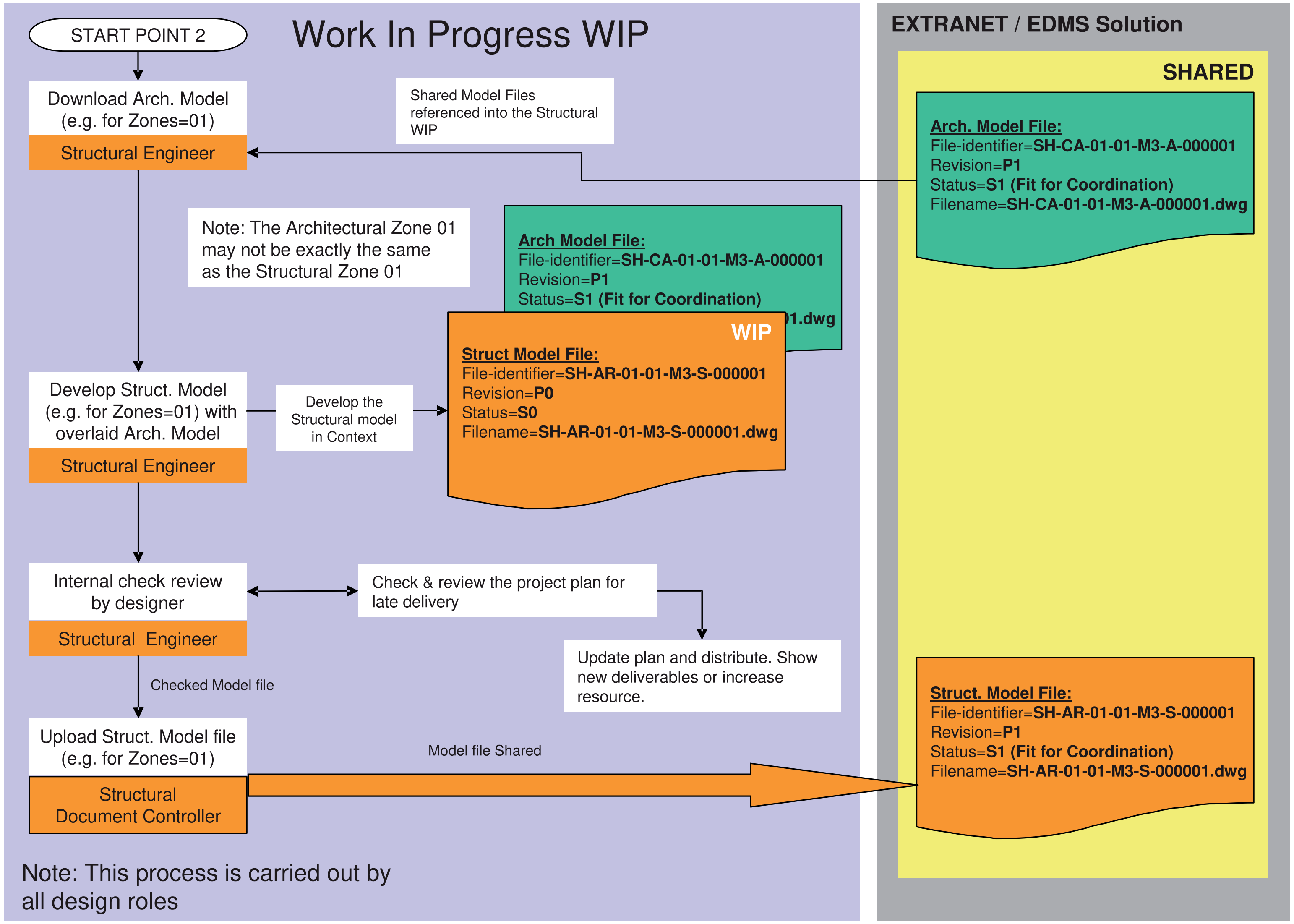


Figure 39: Sharing a model file

B.3 Coordinating model files

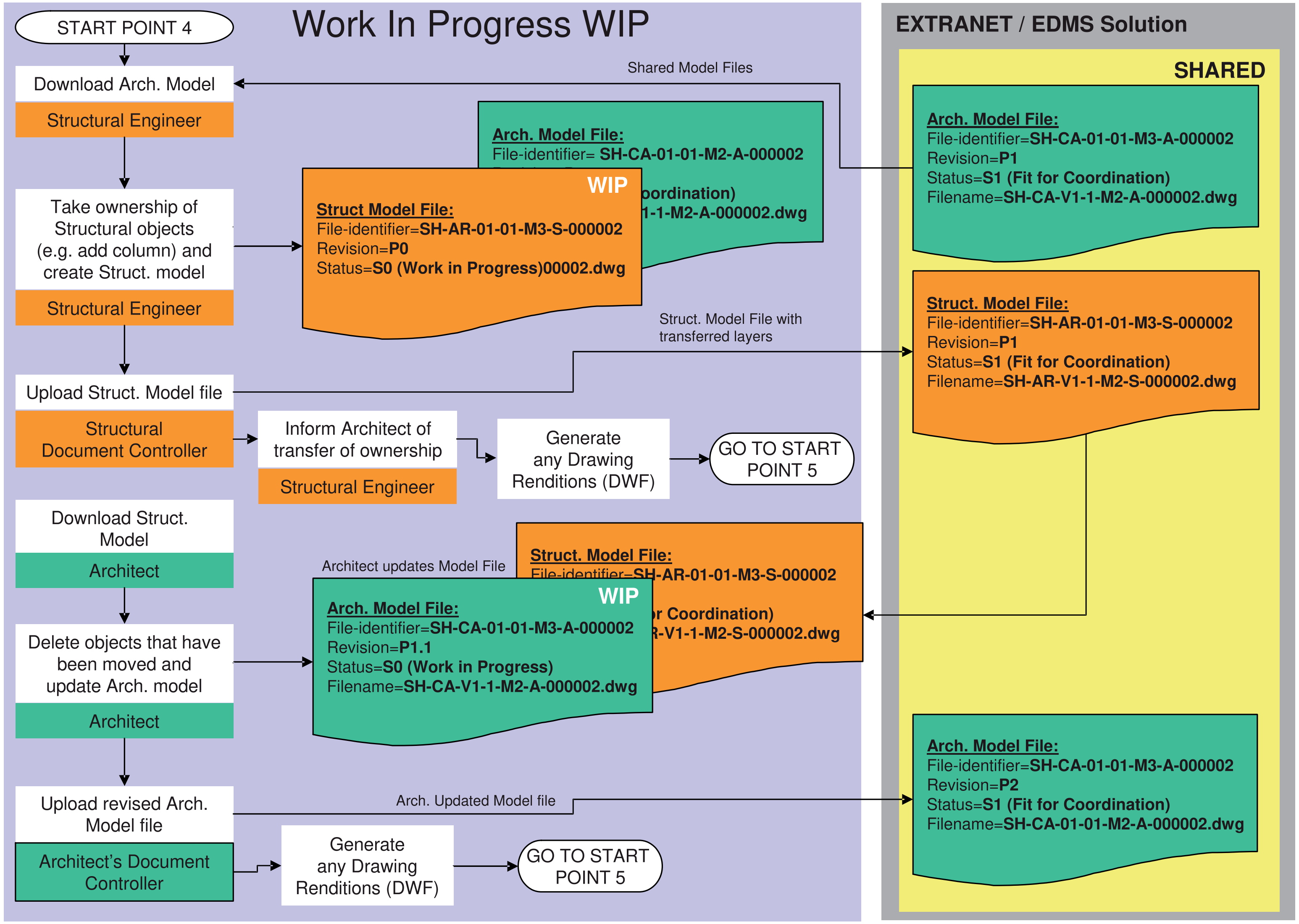


Figure 40: Coordinating model files

B.4 Transfer of ownership

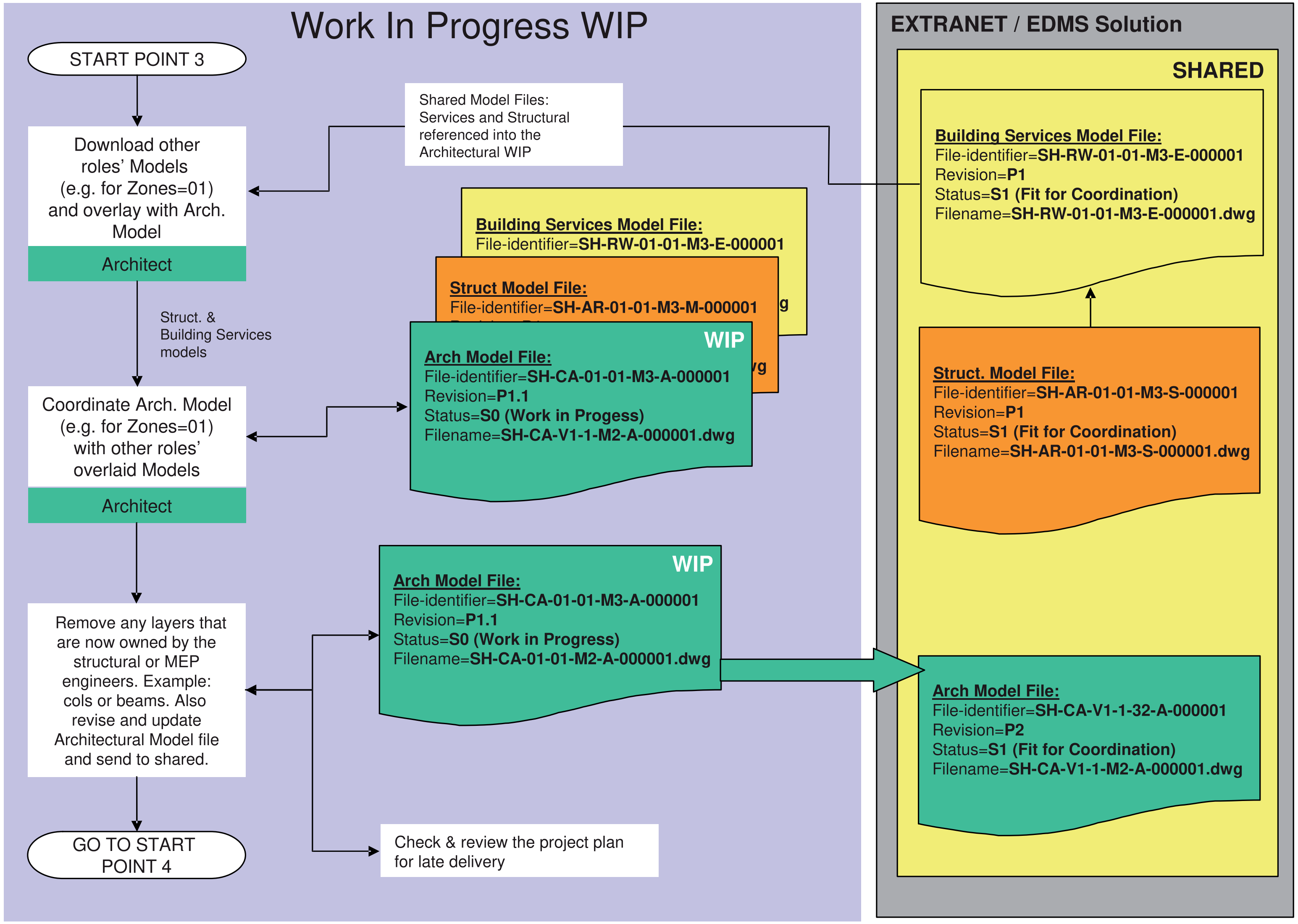


Figure 41: Transfer of layer ownership

B.5 Creating a drawing rendition

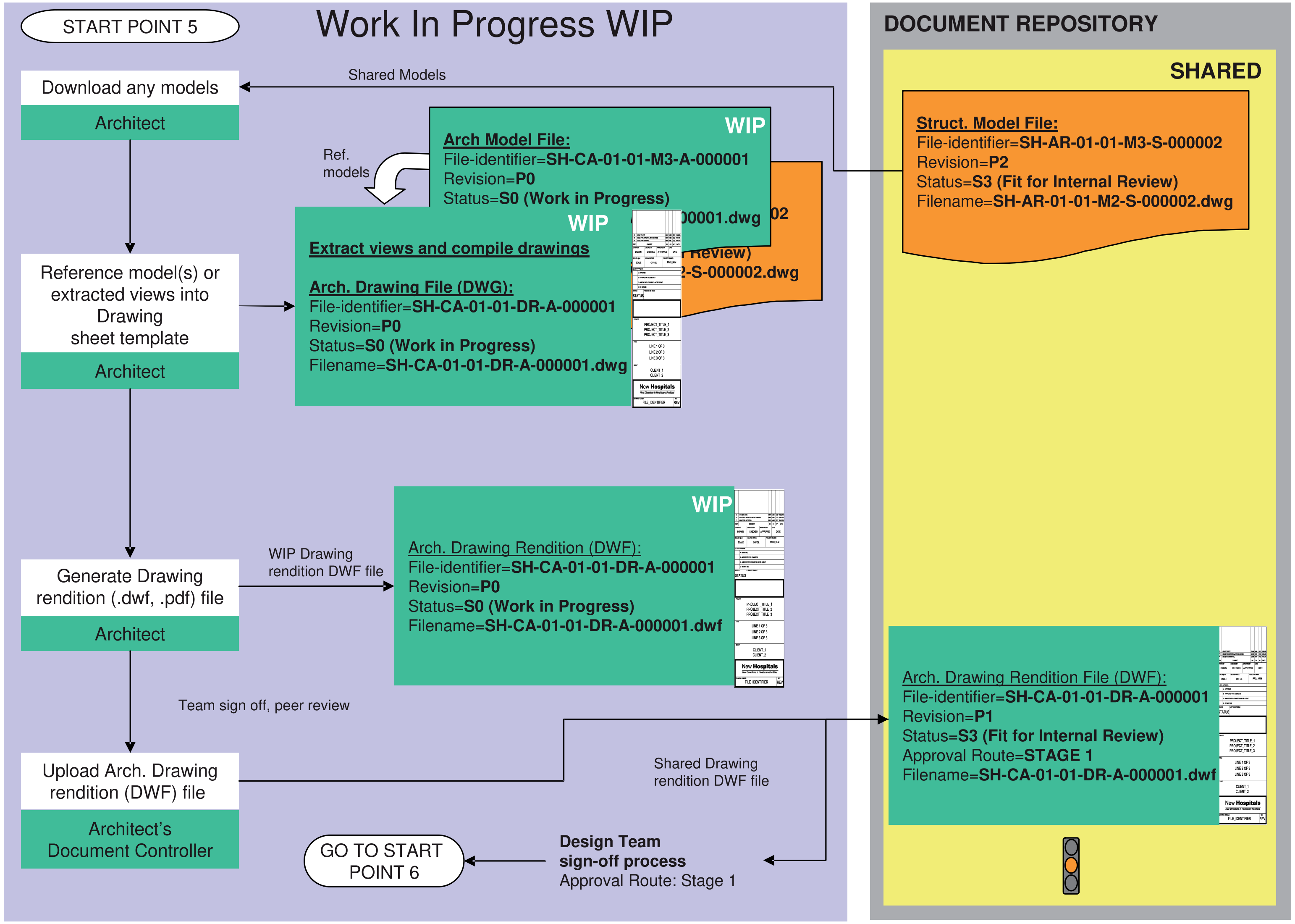


Figure 42: Creating a drawing rendition

B.6 Design team sign-off process

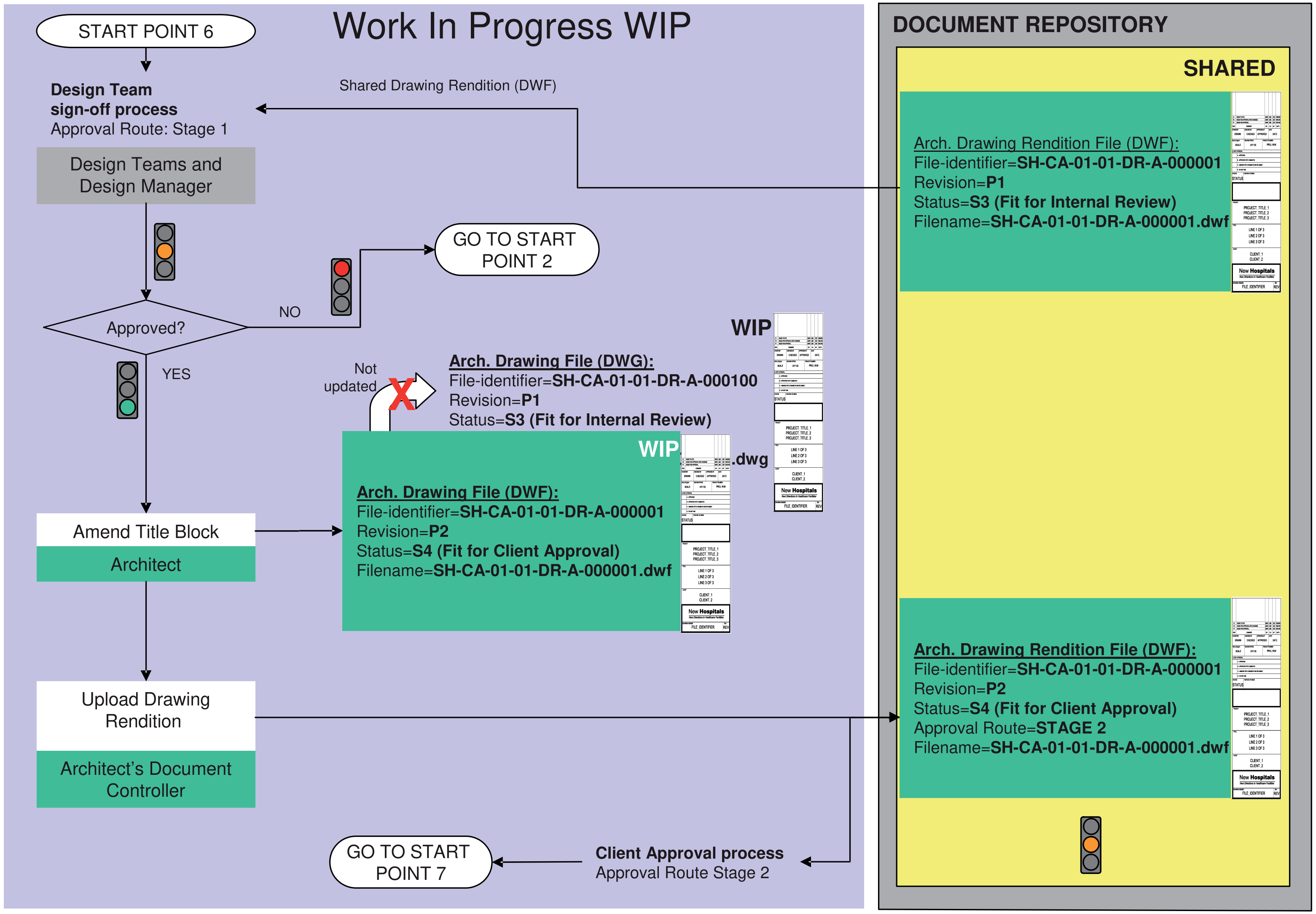


Figure 43: Design team approval stage 1

B.7 Approval route – stage 2

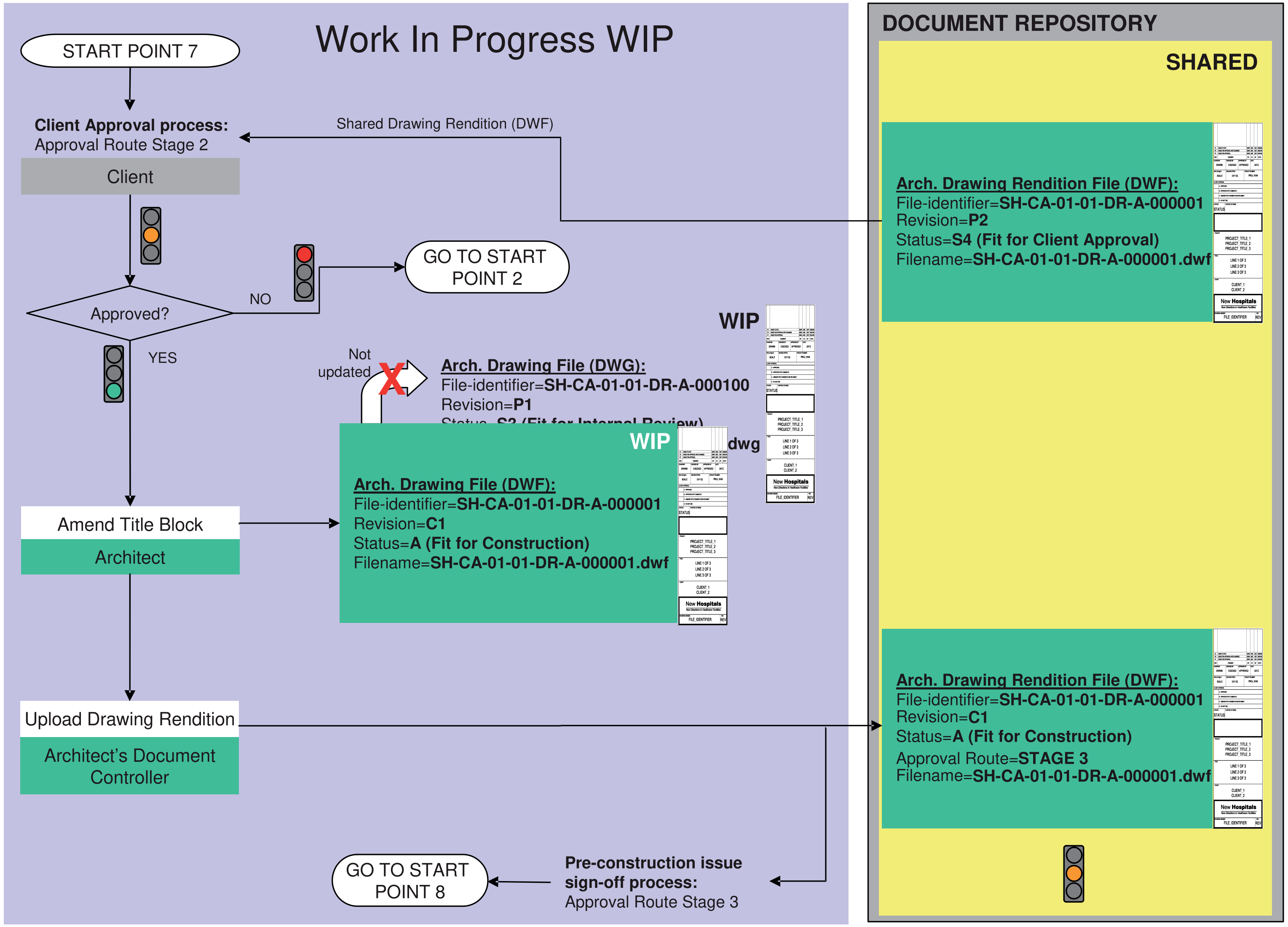


Figure 44: Approval route: stage 2

B.8 Approval route – stage 3

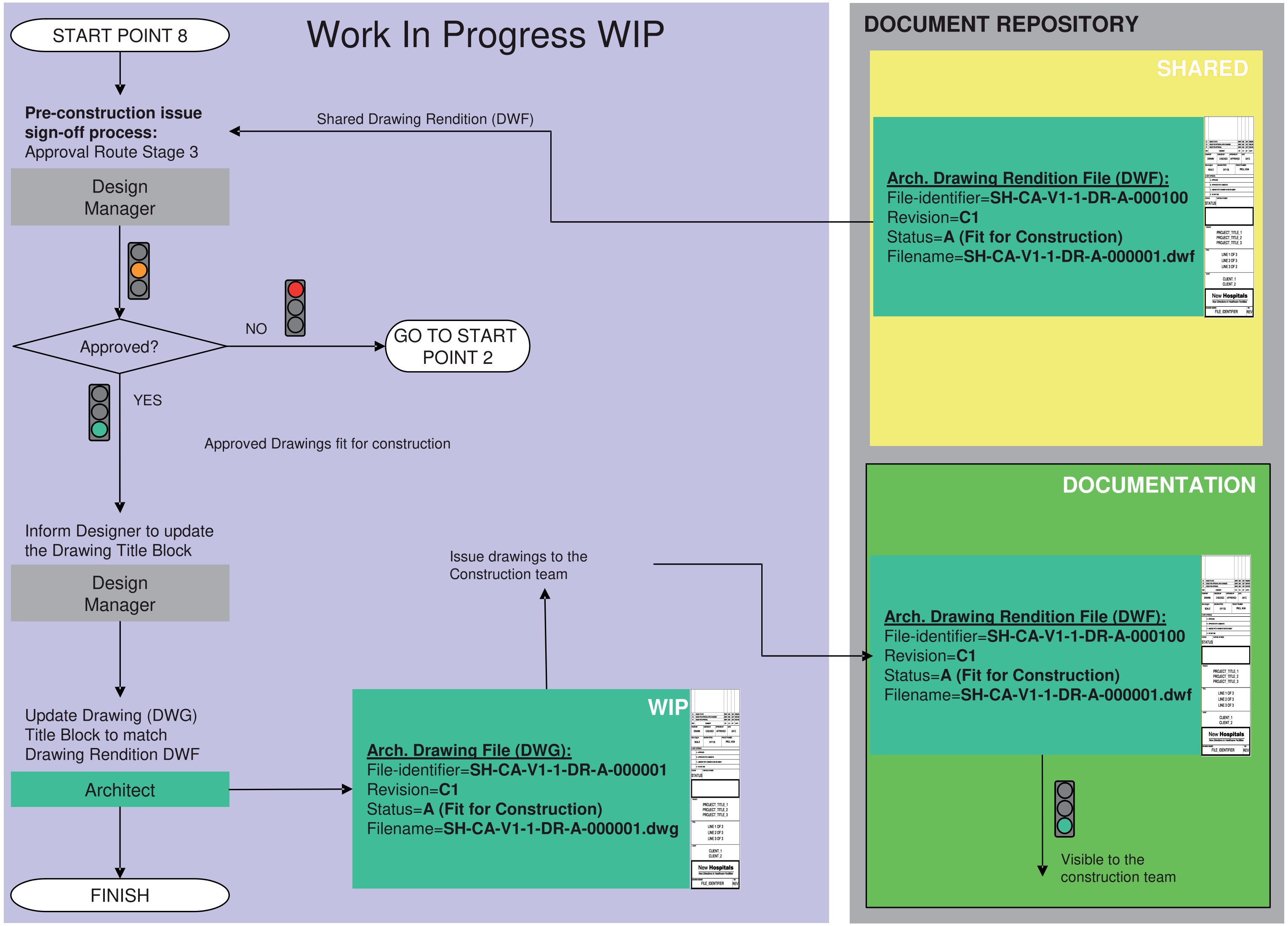


Figure 45: Approval route: stage 3

Appendix C
Consultant's technical systems questionnaire

Refer to the PIX Protocol currently available on the Construction Project Information Committee (CPIC) website.

Appendix D
Project team member questionnaire

Refer to the PIX Protocol currently available on the Construction Project Information Committee (CPIC) website.

Appendix E
Drawing sheet template

KEY PLAN

Construction Risks	Maintenance/cleaning Risks	Demolition/adaptation Risks

In addition to the hazard/risks normally associated with the types of work detailed on this drawing take note of the above.
It is assumed that all works on this drawing will be carried out by a competent contractor working, where appropriate, to an appropriate method statement.

SAFETY HEALTH AND ENVIRONMENTAL INFORMATION BOX

NOTES

This drawing contains the following model files:
SH-CA-01-LG1-M2-A-0001.dwg [S1] [P5]
SH-CA-03-LG1-M2-S-00016.dwg [S1] [P5]
SH-RW-06-LG1-M2-M-00010.dwg [S1] [P2]

This drawing to be viewed in conjunction with:
SH-RW-00-LG1-DR-M-00010.dwf

REV	COMMENT	DRAWN BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
C1	ISSUED FOR CONSTRUCTION	G.M.WHIPP	15/03/03				
P4	ISSUED FOR CLIENT APPROVAL	G.M.WHIPP	21/02/03	D.KERR	22/02/03	R.CHADWICK	23/02/03
P3	ISSUED FOR INTERNAL REVIEW	G.M.WHIPP	15/02/03	D.KERR	17/02/03	R.CHADWICK	19/02/03
P2	ISSUED FOR INFORMATION	G.M.WHIPP	08/02/03				
P1	FIRST DRAFT	G.M.WHIPP	01/02/03				

SCALES @ A1	ISSUING OFFICE	PROJECT NUMBER
1:200	MANCHESTER	1234

CLIENT APPROVAL

X	A - APPROVED
	B - APPROVED WITH COMMENTS
	C - DO NOT USE

STATUS	PURPOSE OF ISSUE
A	FOR_CONSTRUCTION

ORIGINATOR
NAME, ADDRESS and LOGO

PROJECT

PROJECT_TITLE

TITLE

DRG_TITLE_1
DRG_TITLE_2
DRG_TITLE_3

CLIENT

CLIENT NAME / LOGO

DRAWING NUMBER	REV
SH-V1-1-A-CA-DR-020140	C1

Appendix F
Measurements and benefits

The benefits of using the BS 1192 approach have been measured over many years. Hard money, soft cultural and social benefits have been achieved. The measurements are reported in a number of case studies, some from the Avanti project and some from previous government-funded research and live projects. Some examples are made available in this appendix below.

F.1 Project results – overview report

F.1.1 Introduction

This report has been produced for the Avanti programme Management Board and summarizes the headline results of the independent 'Measure & Monitor' undertaken by Capita Symonds. The intention is for this document to be reviewed by representatives of the Board so that they can provide any 'accompanying or overview' commentary they feel appropriate.

The measured impacts are presented with no significant 'post processing' in order that they can withstand rigorous examination by third parties (as is anticipated) and be directly supported with audit trails back to the source data. As a result, the measurements tend to reflect impacts upon business or project processes rather than summarized to high-level project outcomes, i.e. impact on 'design coordination' rather than 'impact upon overall project cost'.

To process these findings into high-level project outcomes would require a number of assumptions to be made, for example:

- *Numeric* – number of drawings per project, time taken to issue each drawing, number of issue activities, chargeable rates per person per day.
- *Commercial* – all potential savings would be directly translated into cashable savings; all such savings would be aggregated at the project level rather than by participating companies.

It is felt that such assumptions would tend to undermine the quality of the results and so this exercise has been excluded from this report.

The summary has been broken down as follows:

- key measured impacts – investment required, return on investment, commentary;
- emerging themes – 11 themes emerging from interviews, analysis and discussion;
- Appendix 1 – 'dashboards' for core projects; and
- Appendix 2 – measurement reports for core projects.

F.2 Key measured impacts

F.2.1 Investment required

If CAD rework is required because the design team implemented the procedures late and/or original information was poorly coordinated costs of up to £60,000, and possibly more may be required. This will be typically self-funded by the individual company.

Where additional support, third-party audit, is required for compliance checking and 2D/3D spatial coordination checking the investment may be of the order of £100,000. This would be typically funded by the client and/or the contractor, depending upon the form of contract (see below for more information).

Does not include for:

- Investment during general disruption/reduced productivity/paid-for training or software required while getting up to speed with Avanti methods.
- Direct and indirect redesign effort where lack of coordination were spotted during rework process – as this is correcting an inherent flaw rather than pure 'rework due adoption of Avanti'.

F.2.2 Return on investment

- 50–85 per cent saving in cost and time related to issuing and receiving information;
- 50–80 per cent saving in design coordination and builders work coordination;
- 50 per cent quicker turnaround of subcontract design packages;
- '£100,000 design rework "'savings"' (see below);

- '£500,000+ site remedial work "savings"' (see below).

Does not include for:

- Return on investment from reduced disruption where fewer design/coordination issues need to be dealt with on the critical path as they have been revised earlier (or by default of reusing others' information).
- 'Soft issues' benefits, for example more satisfying work, less abortive/confrontational work. See below for more examples.

F.3 Commentary

F.3.1 Investment required

The self-funded costs of CAD rework are extremely variable and the sooner Avanti is implemented, the less CAD information that has been generated that then needs to be reworked in order to be 'Avanti CDE/SMP compliant' (e.g. common origin, orientation, scale, layer names and file names). Three examples are noted for reference:

- £10,000 investment where adopted early in project lifecycle on small/medium-size development of medium–low complexity.
- £60,000 investment where adopted at a later stage on a project of medium size and complexity where the legacy information was not significantly coordinated.
- £24,000 investment where adopted late on a project of large scale and complexity, but where scope excluded some key areas of the site, design and some legacy drawings that would not be significantly reused by others.

The 'additional support for compliance checking and 2D/3D spatial coordination' noted in the above findings refers to where those roles are supported by resources outside the traditional project team service suppliers i.e. client, designers, contractor, subcontractors.

On the case study the design had evolved over a number of years and in an uncoordinated manner. To bring the information up to date and coordinated such that a full set of signed off information was available at contract sign off the client paid for the check to be carried out.

Consultancy services are available for use in such situations and there is some evidence that suggests such a role is effective in achieving significant savings on a project. This impact and the extent to which such a role can be deemed 'part of the Avanti method' is a point of debate and further comment is included in the next section.

Disruption during the adoption of Avanti is impossible to predict 'generically' as there are so many factors affecting this criterion, for example: when Avanti is adopted, the strategy for adoption (push or pull), the level of change for the company and level of change for the individuals effected. This cost is noted as being significant on at least some of the projects reviewed and should be forecast in order to contribute to the decision to sign up to such a business/performance improvement activity. *To be very clear, this criteria has the potential to 'make or break' the adoption of Avanti so needs to be properly managed to keep it to a minimum.*

It is noted that this type of investment would be required for almost any such activity and is not specific to the Avanti methodology if change is to be adopted.

Direct and indirect redesign effort where lack of coordination, where spotted during the rework process, is not included in the cost of implementing Avanti as this is viewed as correcting flawed design information rather than pure 'rework due adoption of Avanti'. It could equally be seen that the level of investment required in this activity is a direct – and positive – measure of the benefit gained through Avanti highlighting design coordination issues that had previously not been spotted and may have caused disruption and delay on site.

F.3.2 Return on investment

The savings in the processes of issuing and receiving information are a direct result of the effective use of a project Extranet; however, the savings emerge from more than one process:

- agreement to issue one set of paper information rather than 7–8 copies means saving in the printing, preparation and posting activities;
- agreement to issue electronic information in lieu of paper information for all but key contract documents further enhances this saving;
- access to latest versions of documents is seen as advantageous, as is freedom to access 'all' information rather than only that considered relevant to the participant; and
- lack or reliance on the post for receipt of key information accelerates the sharing of information.

It is noted, however, that if project Avanti Standard Method and Protocol are not set up and adhered to the process can become extremely frustrating.

Examples include: not being able to find information, having to download 'all' information and lack of well-managed revision control. It is also noted that any savings achieved might be reduced if excessive amounts of ad hoc prints are generated by project staff.

F.3.3 Request for information (RFI) analysis on a single core project

Though not included at this stage as results were not available from the Contractor, some comment is required as there is a debate as to how and how much these results can be attributed to the Avanti methodology. Key points for discussion are noted below.

Subsequent measurements were made available from one contractor and the impact of the Avanti method is fully attributed to savings in excess of 10 per cent of construction cost.

- '£100,000 design rework (potential) savings'
  - This measure is noted as a potential saving (only) in this case as the issues were identified (through compliance checking and spatial coordination) on this project rather than avoided at source. Comparison to other similar projects may show that 'all this and more' problems may typically have happened – hence the attribution as potential savings on other future projects where full compliance would mean the rework is *not* required.
  - This value does not include any measure of initial rework activity during adoption of Avanti, which flushed out many more design coordination issues that required rework – as mentioned in section F.2.1 of this appendix. On this core project, the value of this rework was put at approx £100,000+ fee.
- '£500,000 saving in avoiding remedial works'
  - This value of £500,000 is in lieu of the final analysed value and can be seen as a saving; however, some consideration is needed as to the likelihood of how many of the identified issues would have had 100 per cent of the impact noted. It is likely that many would be caught before needing remedial work. There were two key types in issue noted:
    - Clashing information (approx 30 per cent of issues) – this is clearly within scope for 'compliance with Avanti CDE/SMP' as it stipulates reuse of package owners own CAD layers. For example, the issue about there being three conflicting locations for rainwater downpipes would have been avoided if reuse of layers had been fully complied with.

    - Missing information (approx 70 per cent issues) – for example a dimension missing from the setting out of a steel beam centre line. This issue is less intrinsically covered other than in the catch-all statement of fit for purpose. If anything the lack of dimension should not concern those reusing the information as the CDE/SMP states all information should be drawn in the actual location, to common scale and orientation – so it should be in the right position.
- It is further noted that conflicting information within a single discipline is also not specifically covered as Avanti CDE/SMP typically focuses on the processes for interdisciplinary sharing of information.
- Where missing or conflicting information has been identified between plans and elevations. However, if the spatial coordination exercise was undertaken – possibly in 2D but definitely in 3D – those issues would have been spotted.

F.4 Emerging themes

F.4.1 Belief

There is a significant level of belief that Avanti is a good way forward, even if most temper that belief with the practical reality that there is a more or less significant pain barrier to get through. Examples are noted below:

- *Client* – Slough Estates/Wates have procured a subcontractor where the final decision was significantly influenced by their ability to collaborate using IT.
- *Contractor/client* – Taylor Woodrow have committed to further projects using Avanti as part of a corporate strategy to roll out Avanti as their standard.
- *Design team* – Capita Symonds/Capita Percy Thomas are adopting it and other companies are upbeat (for example Reid Architecture, RW Gregory LLP).
- *Contractor* – Costain committed to using Avanti on more projects and Wates are pleased with its impact.
- *Supply chain* – some companies are a little indifferent; however, some, such as NG Bailey and ACL are showing interest in accommodating Avanti.

F.4.2 Achieving payback on a single project

There are some potentially interesting trends here that would warrant further investigation if more core projects are monitored as the benefits appear to ‘follow the information flow’ through a project:

- *Architects* – they seem to break even soonest and most certainly on a single project, likely because they are the highest creators and reusers of others' information, so they stand to gain if it works well.
- *Engineers (Structural and Mechanical & Electrical)* – it is not certain that they will reach full payback on the first project; however they are likely to 'approach' break even.
- *Subcontractors* – limited/early results suggest that the experience for subcontractors is not 'significantly negative' with some showing that they are 'approaching break even' and others low investment and return means 'indifference'.
- *Contractors* – results vary with some showing net gains, some less optimism while still going through the adoption process, and others reporting 'indifference'.

F.4.3 Fixed, single industry-wide Avanti CDE/SMP or a flexible approach?

This needs to be bottomed out among Avanti partners and then made clear to the industry.

- Project view – is the team procured on the basis of complying with Avanti?
- Yes – then they have the opportunity to take a commercial view in bidding for the work and should be required to comply (including any investment required as a result).
- No – then possibly some flexibility to make them converge on an 'Avanti-esque' standard as a stepping stone to full Avanti compliance. This position should enable them to agree a partial Avanti/Avanti-oriented CDE/SMP on the project without larger investment/risk that would have required agreement prior to contract award.
- Corporate/framework view
  - For this scenario there can only be one sensible long-term position and that is to be fully compliant with the industry standard. Any variation from the standard will mean inefficiency and disruption when working with others that are fully Avanti compliant. There would need to be a very good reason for *not* going with an industry standard.
  - However, the only issue here is where a company works on a project where a partial implementation of Avanti has been rolled out that they have worked to accommodate in their corporate standards. Such a company may be reluctant to go through a further change process.

F.4.4 Model files and their impacts

This appears to be one of the main 'technical' impacts for project participants as it improves their ability to share well-structured CAD data. It is also an area where many of those involved need coaching as it was a new principle (see item on necessity of coaching). Examples of how it helped include:

- Avoiding the need to spend large amounts of time preparing information for interim 'design development' drawing issues as, instead of 'tidying up everything for formal paper issue', the team can simply issue their CAD model files without *any* significant preparatory work.
- This not only saves significant time – often on the critical path – but also reduces the amount of demotivating and immediately superseded work that those designers would otherwise have spent on that activity.
- For the subcontract design packages there is a suggestion that increased ability to reuse design team and 'other subcontractor' design information means the effort required to prepare the base drawing is significantly reduced.
- Many or most manual dimensional checks can be replaced with a visual check as all parties working in same orientation scale and origin means design elements are in their 'real' position so gross errors are easily spotted visually.

F.4.5 Level of challenge

For many there was discomfort experienced during the adoption of the Avanti method. The level of discomfort varied and we do not, as yet, have any clear data on this; however, there were three positive results that are worthy of note:

- Bourne Steel was concerned that the scope of Avanti was not as challenging as they had hoped. Bourne Steel's view on collaboration around design information is that they prefer for share 3D models. Steel contractors have been using 3D steelwork modelling systems for a number of years and Structural Engineers are increasingly using similar systems to develop their designs for issue to and reuse by the Steelwork contractor. The feeling is almost 'why bother doing all this 2D-oriented process change when we can simply share 3D models?' As it happens Avanti is fully extensible to 3D models and the same issues apply when more than one 'discipline/package' needs to share information.
- The Architects on Voyager Park had already implemented a corporate environment that was based upon a predecessor to Avanti, CPIC 'Code of procedure': 2003, and as a result there were minimal changes required by them to be able to benefit.
- Solaglas felt that while Avanti appeared to be a daunting method to implement, on closer inspection they felt it readily usable without significant discomfort.

F.4.6 Increase in quality of information

There are two aspects worthy of note here:

- The Avanti CDE/SMP provides a mechanism for ensuring good-quality information is created and shared among the team. Often on projects there is no contractual or procedural mechanism for addressing underperformance in this respect and as a result many parties will waste significant amounts of time 'cleaning up' others' CAD data, or simply 'redrawing it' from the paper copies.
- Also, where such information is co-located from both plans and details, the increase in quality of information due to inherent coordination through reuse of others' CAD information/layers for both of these levels of details is equivalent to an amount of effort that would not be feasible (programmatically or commercially) to invest in or reproduce traditionally.

F.4.7 Consequential benefits

Although the value of disruption during change could add significantly to the 'cost' element of the cost–benefit equation, the 'consequential benefits' arising from adoption of Avanti are potentially enormous. The benefits include:

- Avoiding disruption of delay on the critical path – for any activity in design or construction. The highest tangible impact of this is with construction activities. If disruption due to lack of design coordination delays, for example, weather sealing of a site, then the impact can be the costs of delays to packages not starting, cost of acceleration of works to try and catch up and potential cost associated with late aquired defects (L&AD).
- Ripple/wake effect – in addition but less tangibly, the above scenario will distract all involved from the activities they were programmed to be undertaking. This can cause further problems where the planned activities become rushed (while fire-fighting the initial problem) and as a result may create new issues to be dealt with later. The alternate view on this means having the time to do the job 'properly' meaning other packages more likely to go smoothly.
- Less time spent on paperwork/issue resolution means all parties spend more time doing the job they enjoy and so are more motivated.
- Fewer 'risk events' on a project will generally mean all parties are more likely to achieve their expected profit margins.

- Over time, lower risk projects will attract lower risk contingencies from all involved and so pass on a saving to the client in more commercially competitive fees/tenders.

The final statement above is consistent with experience from the steelwork supply chain where 3D models have been used to prepare design information.

F.4.8 Which projects are most likely to benefit from Avanti?

Some interviewees have suggested that smaller and/or one-off projects are less likely to benefit from Avanti. Others have suggested that where the complexity of the work is low and the team well established they will not need Avanti. There will certainly be projects where the cost of change may well be more than is commercially feasible for individual companies unless either paid for by others (e.g. the client) or as part of self-sponsored corporate change (i.e. companies deciding to go that way anyway). Avanti could do with advice in this area to support teams investigating whether to implement Avanti on their projects.

Additional measurement outside the Avanti project show that the process and procedure once implemented can show significant savings on even small housing projects.

Larger projects and those where there is repetition – either of design or of project team (e.g. design team/supplier frameworks) – appear to lend themselves to adoption of Avanti as there is a greater number of opportunities to 'redeem the value' of the investment made.

F.4.9 Benefits and risks of a <100 per cent Avanti implementation

It is evident that on the three core projects the base/core Avanti CDE/SMP has not been adopted 100 per cent. Areas of the site, packages of work, legacy design information, aspects of layer/file naming, use of common origin, 'actual' reuse of CAD data/layers … all these have been excluded in some way across one or more of the core projects. By inference, therefore, there are significant benefits to be generated from a 'partial implementation' of Avanti. This is not something that the custodians would advocate; however, the suggestion is that a less than 100 per cent implementation may be an appropriate 'stepping stone' to full implementation where there is an acceptable level of risk and investment for the project team.

The risk in the above statement is that, once the initial step has been taken, no further steps towards complete Avanti compliance are made and – even worse – the teams involved felt that they are fully compliant. Scaling this up from a single project to a wider industry view, the risk is that we end up with a proliferation of 'partial Avanti' implementations.

Or even worse 'my version' of the standard. Personalization of the standard is a constant problem where the team's lack the background knowledge or acceptance of the problem that the standard is rectifying. The teams do not see or are not willing to see the holistic view only the 'what's in it for me' and my responsibilities.

To counter this, we suggest some restriction or monitor be placed upon the level of compliance with the Avanti 'core CDE/SMP' so that even if teams comply 100 per cent with a partial implementation, they are aware that there are additional aspects that would need to be addressed to become 100 per cent compliant with the core Avanti CDE/SMP.

F.4.10 Need for active, independent support and coaching

Some of the parties that have been involved in the adoption of Avanti have been less high-end users of CAD to date and as a result are not familiar (either at operational or management levels) of certain concepts – such as reuse of CAD files, 'xrefs' or reference files, use of layers, etc.

In addition, in some instances there are real and specific technical issues that the users or their CAD management do not have the skills to address. Examples include set-up of specialist applications based upon AutoCAD; and use of 'look-up tables' to translate automatically established layer names to Avanti-compliant ones on issue to the rest of the team.

Appendix G Abbreviations

Table 18: Example list of abbreviations

Term	Abbreviation
Above Ordnance Datum	AOD
Back inlet gully	BIG
Beam	B (preceding a beam reference)
Benchmark	BM
Blockwork	BLK
Bore hole	BH
Brick work	BWk
British Standard	BS
California Bearing Ratio	CBR
Catch pit	CP
Centre line	CL
Centres	CRS
Chainage	CH
Circular hollow section	CHS
Column	C (preceding a column reference)
Combined manhole	C (preceding manhole number)
Concrete grade	C (preceding grade)
Control point	CP
Cover level	CL
Cross-sectional area	CSA
Cut-off level	COL
Damp proof membrane	DPM
Datum	DAT

Term	Abbreviation
Dead load	DL
Degree	DEG
Dense bituminous macadam	DBM
Depth or deep	DP
Diameter	DIA
Disused	DIS
Drawing	DRG
Easting	E
Electricity or electrical	ELEC
Equal angle	EA
Equally spaced	EG
Existing	EX
External	EXXT
Figure	FIG
Finished floor level	FFL
Finished road level	FRL
Foul manhole	F (preceding a manhole number)
General Arrangement	GA
Gradient	GRA, 1 in 4, or 25 per cent
Grid line	G/L
Ground level	GL
Gully (unknown type)	G
Height	H
High point	HP
High tensile steel	T (preceding bar diameter)
Hot rolled asphalt	HRA
Hot rolled section	HRS
Inspection chamber	IC
Internal	INT

Term	Abbreviation
Intersection point	IP
Invert level	IL
Lamp column	LC
Left hand	LH
Level	LVL
Live load	LL
Long	L
Low point	LP
Manhole	MH
Maximum	MAX
Medium density polyethylene	MDPE
Mild steel	R (preceding bar diameter)
Minimum	MIN
Northing	N
Number	No
Offset	O/S
Overhead	O/H
Petrol interceptor	PI
Point load	PL
Radius	RAD (following a dimension)
Rainwater downpipe	RWP
Rectangular hollow section	RHS
Reference	Ref
Reinforced concrete	RC
Right hand	RH
Road gully	RG
Rolled steel angle	RSA
Rolled steel channel	RSC
Rolled steel joist	RSJ

Term	Abbreviation
Roof level	RL
Section	SECT
Setting out point	SOP
Sheet pile wall	SPW
Soffit level	SL
Soil vent pipe	SVP
Specification	SPEC
Square	SQ (following a dimension)
Square hollow section	SHS
Standard	STD
Station	STN
Storm manhole	S (following manhole number)
Structural slab level	SSL
Tangent point	TP
Temporary benchmark	TBM
Thick	THK
Tolerance	TOL, or +5 –5
Top of section	TOS
Tree Preservation Order	TPO
Trial pit	TP
Typical or typically	TYP
Under ground	U/G
Unequal angle	UA
Uniformly distributed load	UDL
Uniformly varying load	UVL
Universal beam	UB
Universal bearing pile	UBP
Universal column	UC
Volume	VOL

Term	Abbreviation
Waste vent pipe	WVP
Water level	WL
Weight	WT
Whole circle bearing	WCB
Wide or width	W
Wind load	WL
Yard gully	YG

Appendix H
References and further reading

Standards publications

EN ISO 128-21:2001, *Technical drawings — General principles of presentation — Part 21: Preparation of lines by CAD systems*

BS 1192-1:1984 (withdrawn), Construction drawing practice — *Recommendations for general principles*

BS 1192-3:1987 (withdrawn), *Construction drawing practice — Recommendations for symbols and other graphic conventions*

BS 1192:2007, *Collaborative production of architectural, engineering and construction information — Code of Practice*

BS EN ISO 4157-1:1999, *Construction drawings — Designation systems — Part 1: Buildings and parts of buildings* (It is identical to ISO 4157-1:1998)

BS EN ISO 4157-2:1999, *Construction drawings — Designation systems — Part 2: Room names and numbers* (It is identical to ISO 4157-2:1998)

BS EN ISO 4157-3:1999, Construction drawings – *Designation systems – Part 3: Room identifiers* (It is identical to ISO 4157-3:1998)

BS EN ISO 5455:1995, *Technical drawings — Scales* (It is identical to ISO 5455:1975)

BS 6100-1.0:1999 (subclause 1.5.7), *Glossary of building and civil engineering terms — General and miscellaneous — General*

ISO 7000:2004, *Graphical symbols for use on equipment – Index and synopsis*

BS 7000-4:1996, *Design management systems — Part 4. Guide to managing design in construction*

BS EN ISO 7518:1999, *Construction drawings — Simplified representation of demolition and rebuilding*

BS EN ISO 8560:1999, *Construction drawings — Representation of modular sizes, lines and grids*

ISO 10488:1991, *Graphical symbols incorporating arrows – Synopsis*

BS EN ISO 11091:1999, *Construction drawings — Landscape drawing practice*

BS EN ISO 13567-1:2002, *Technical product documentation — Organization and naming of layers for CAD — Overview and principles*

BS EN ISO 13567-2:2002, *Technical product documentation — Organization and naming of layers for CAD — Concepts, format and codes used in construction documentation*

ISO 17724:2003, *Graphical symbols – Vocabulary*

IEC 80416-1:2008, *Basic principles for graphical symbols for use on equipment – Part 1: Creation of graphical symbols for registration*

IEC 80416-2: 2001, *Basic principles for graphical symbols for use on equipment – Part 2: Form and use of arrows*

IEC 80416-3:2001, *Basic principles for graphical symbols for use on equipment – Part 3: Guidelines for the application of graphical symbols*

Other publications

Avanti, *ICT Collaborative Working: Toolkit documents*, CPIC

CAWS – *CPIC Common Arrangement of Work Sections*, London, RIBA Publications

CI/SfB – *Construction Indexing Manual/Samarbetskommitten for Bygganadsfragor*, London, RIBA Publications (1991), Abridgement of Third (1976) edition

NHS Estates publication – *Engineering symbols and drawing conventions – A catalogue for the use in health care premises*, London, HMSO, ISBN 01 1321488X

PIX Protocol Guide and Toolkit, Building Centre Trust (March 2004)

Production Information – *A code of procedure for the construction industry*, CPIC (2003) ISBN 0-9512662-6-8

Uniclass – *Unified Classification for the Construction Industry*, RIBA Publications

Appendix I
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