Contents

Introduction

This guide is part of a series of 'How to…' guides on construction industry IT development.

This particular guide covers the subject of the 'What, Why and How for CAD Standards'. It is a high level document designed to give general help on the subject and is not intended to be a detailed manual. This approach has been taken because every company has different requirements depending on its size and activities and the nature of the IT projects with which it is involved.

Throughout this series of guides the principle adopted is that all IT development should be business driven. Consequently it should play a part in, and be integral with, construction activities and business processes.

The IT Development Process

While each guide is designed to be a stand-alone document, the reader is encouraged to think of a complete process of IT development. This process starts with the development of an IT Strategy that has been designed to support your business strategy and continues with the implementation of that strategy. To assist with the understanding of this process you are encouraged to refer to other Construct IT guides. Particularly helpful are:

How to Develop an Information Strategy Plan

This How to Guide details the processes involved in producing an information strategy that is aligned with your business strategy.

How to Implement an IT Strategy

This How to Guide details the procedures required to successfully implement your Information Strategy Plan.

An IT Self-Assessment Tool

This guide enables your organisation to make an assessment of its current IT capability and to plan future improvements.

Measuring the Benefits of IT Innovation

This document helps your organisation quantify the financial benefits of IT innovation.

Other How to Guides are being produced, which deal with specific aspects of the IT development process. Together with the IT Self-Assessment tool they are available from both Construct IT and through IT Construction Best Practice (ITCBP). Refer to www.construct-it.org.uk and www.itcbp.org.uk for up to date details.

Construct I.T. *Develop Your CAD Standards*

Use of the guide

This guide discusses the importance of CAD standards within the construction industry. Its main aim is to answer the 'What, Why and How' questions for CAD standards. The guide is intended for CAD users (in explaining why CAD standards are necessary) and CAD managers (in explaining how CAD standards can be developed and implemented).

The first section of this guide explains how to produce good quality data with CAD software. This part mainly looks at the differences between data and drawings in CAD. The next section clarifies what CAD standards are and why they are needed. This part mainly examines three key areas, namely single company, inter-company and client perspectives, to explain the need for CAD standards. The next section discusses the issues regarding what to standardise in the CAD environment and is supported with some examples such as layer naming and file naming.

Next, a step-by-step procedure for the development of CAD standards is presented. The following section then provides some suggestions for the implementation process. The guide concludes with three success stories that describe how some companies have successfully developed standards and made them part of their daily processes in their company.

1. What are standards?

The International Organisation for Standardisation (ISO) defines standards as follows:

Standards are documented agreements containing technical specifications or other precise criteria to be used consistently as rules, guidelines, or definitions of characteristics, to ensure that materials, products, processes and services are fit for their purpose.

There are many standards that we use intentionally or unintentionally in our daily life. They can exist for objects (like credit cards) or for processes (such as quality management systems). Generally, standards represent a deep level of know-how in a particular object or service. As a result of standards, consumers are able to purchase services and products that are not only consistent in quality, durability and ease of use, but are also safe and ecologically friendly[1].

2. What are CAD Standards?

'CAD standards' can be defined as the rules, guidelines and standard operating procedures that are used in the production, maintenance and sharing of CAD data / drawings in the electronic environment. With CAD use now widespread, there is a growing interest in CAD standards. It would be the ideal situation if all companies in the construction industry could agree on a single CAD standard and use it; however, realistically this is unachievable as there are so many CAD standards to choose from. Many design and engineering companies have defined their own standards and in addition, standardisation organisations from different countries such as BSI (British Standards Institution - United Kingdom), NIBS (National Institute of Building Sciences - United States), have also published national CAD standards. Most of these national standards are consistent themselves and they have helped the formation of the international standards, which have been published by the International Organisation for Standardisation (ISO).

[1] *Why Consumers Benefit from Standardisation. Available from: <http://www.iso.ch><http://www.iso.ch>*

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PRODUCING GOOD QUALITY DATA WITH CAD

CAD standards are part of producing **"good quality data"**. Some other issues relating to producing good quality data are as follows:

- **Drawings are snap-shots of the model graphic files, which contains "the data".**

  First of all we have to understand that in the efficient use of CAD, parties should use the concept of a **'single CAD spatial model'** [2]. Such a model covers the different aspects of the project and is divided into **'model graphic files'**. The model graphic files cover information from different parties such as project grid, column layout, ducting, etc. The graphical entities such as columns, walls, grids, etc. are created in graphical files and they are usually assigned specific aspects such as line-type, colour, etc. when they are created. These graphic files are brought together by the help of some reference points to produce the **'single CAD spatial model'**. The snap-shots of this model, with the necessary title block, borders and notations added, produce the drawings.

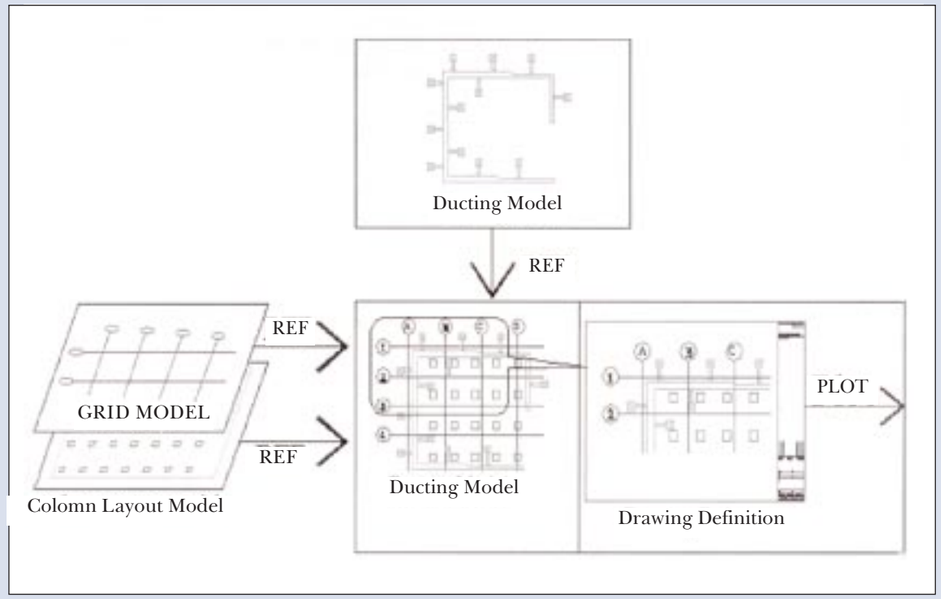


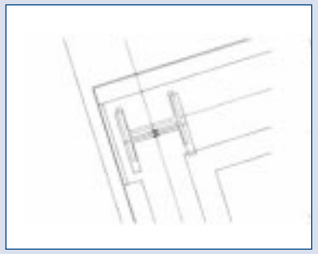
Figure 1: Typical drawing set up using model files

[2] *See BAA CAD Standards <http://www.baa.com/amanet> for more information.*

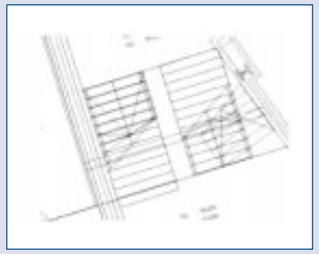
- **Accuracy and dimensional consistency are needed to produce good quality data within the graphic files.**

  All the data within the model graphic files should be produced considering the accuracy and the dimensional consistency. For example, in CAD you have to draw everything with its original dimension and then locate each item in the correct X, Y (and Z if 3D is used) coordinates in the space. The following example shows a mismatch between same versions of two drawings, which were drawn and edited by different parties without considering the accuracy.

The Problem 2D Spatial Coordination



Coloumn locations differ on architectural and atructual layouts



Staircases do not line up

Figure 2: Example of mismatches between architect's and structural engineer's drawings[3]

[3] *Richards, M. (2001) Construct IT Members Meeting Presentation, October*

3. Why do we need CAD standards?

There has been an increased use of CAD within the construction industry during the last ten years. The need to share CAD data / drawings in a digital format between different parties involved throughout the whole life cycle of a construction project and subsequent facility operation has become a very important issue. However, this process has been complicated since each party produces information according to their own work practices. It is very likely that different parties use different line styles, layer naming conventions, text heights, etc. If there is no agreed standardisation of all of these issues, the lack of standardisation can impact on losses in time and cost as a result of the clean-up work, redundant data entry, etc. The sharing of the CAD data / drawings between different parties requires that they are produced according to predefined guidelines in order to raise the quality of the production information, thereby reducing ambiguity and errors, whilst also facilitating more efficient information sharing.

3.1. Single company perspective

If implemented correctly, CAD standards can be beneficial to the single company. It is often the case that the departments in a company share CAD data / drawings. In the absence of consistent CAD standards each department produces the CAD data / drawings according to their own styles. When other departments receive these, substantial amount of time can be wasted interpreting what they have received and as the CAD data / drawings move from department to department, the lack of CAD standards causes data reformatting, which consumes labour hours and in turn increases costs.

CAD standards bring clear guidelines for the production of CAD data / drawings so that different parties do not need to rework the same data. Standardised layers and consistent data appearance saves you time, and consequently save your business money.

There may be the notion that working with strict guidelines such as CAD standards makes the draughting process painful and lengthy because the user has to comply with many rules during the drawing process. It may also take considerable time to make the necessary settings, such as layers, colours, line types, text heights, etc., to the drawing environment. However, the draughting process could be accelerated through the use of template files created according to your CAD standards. Some software applications could also facilitate this process by checking the data / drawings whether they satisfy the agreed CAD standards.

3.2. Inter-company perspective

Today, most project information can be produced in an electronic environment by using specific software applications such as CAD. Companies need to share this CAD data / drawings in a quick and efficient way. For effective collaboration and re-use of the project data within a diverse group of project parties, an agreed electronic method of producing drawings must be established.

For companies using the same CAD standards it is easier to understand the data in the graphic file. Parties do not lose time correcting the items that do not conform to the company standards. Moreover, there would be a consistency through the whole supply chain of how the data is structured, if a single standard is accepted. For maximum benefit from the data exchange, the standards need to be agreed at the beginning of the project and used throughout the different life cycle phases.

CAD standards also facilitate information-sharing between the parties since they have the capability to define the ownership of the data within the supply chain. Through the project life cycle, information about the same component goes to different parties for editing. For example, the architect draws and positions the column with an approximate size to a layer specified to this. At this point the column layer is under the control of the architect. The structural engineer then receives the CAD model and provides the final dimensions to the structural elements. The ownership of the column layer now shifts from the architect to the structural engineer. Therefore, the old layer, which belongs to the architect, should be deleted and be replaced by the engineer's new version to ensure that only one set of data exists for each component.

This kind of operation enables multi-disciplinary design to proceed in a managed environment, where the build-up of information follows some set of rules. The main advantages of such a working style is summarised as follows [4]:

- Ownership of the data remains with the originator even though it is used by other disciplines.
- Data is shared to reduce draughting time and cost.
- Data is finely structured according to different project life cycles and building elements.

3.3. Client perspective

Following construction, CAD data / drawings pass to the client for the operation and maintenance of the facility. Take the example of an external door: this component passes through the different life cycle stages, such as design and construction, and now it is at the stage of operation and maintenance. The client now has the right to edit the layer this component is in and if any changes are required for this component, the layer should be replaced with the one defined by the manufacturer or the client.

To make use of the project data in the operation period, either the client should make its CAD standards compliant with the project standards or vice versa. This is summarised in the following diagram, which describes BAA's view on compliance. According to the figure, each company in a project life cycle should adopt compliant CAD standards when interfacing with other project members as well as with the client – this is not to say that the organisation necessarily has to ensure compliance internally. Satisfying all these complex relationships could be difficult; therefore, the scope and definition of the CAD standards should be defined from the beginning of the project and within the views of the project parties as well as the client.

[4] *CPIC (2002) "Production Information: A Code of Practice for the Construction Industry"*

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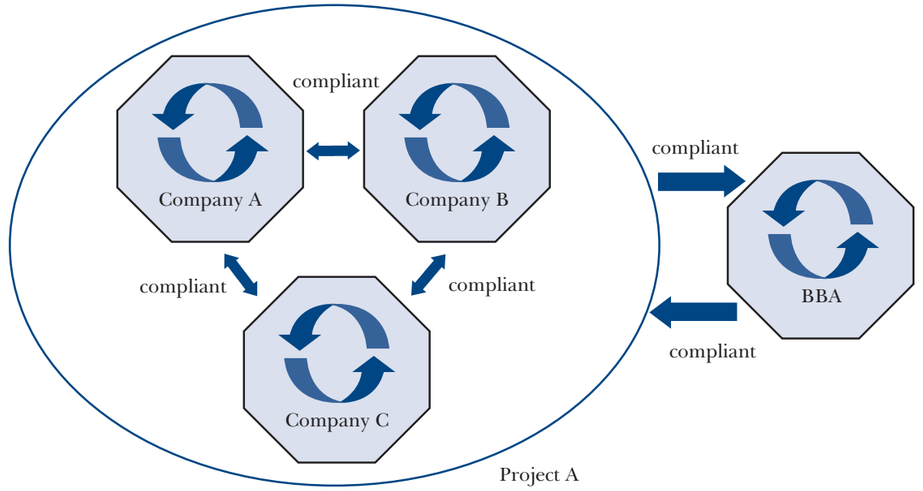

Figure 3: BAA CAD standards compliance system

The 'client perspective' shows us that the development and implementation of CAD standards should cover the design and construction stages as well as the post construction phases, such as facilities management. A holistic approach that examines the whole lifecycle of the project would provide greater benefits.

4. What to standardise?

Before moving onto 'How to Standardise' we should discuss 'What to Standardise'. CAD standards can cover just one item such as layer naming or it may cover many items from text heights to file names. You must decide the scope of your standards according to your company's or project's needs.

Some of the issues you may concentrate on are:

- Drawing sheet templates,
- Paper layouts,
- Text fonts, dimensions, line types and line weights,
- Layer naming conventions,
- File naming conventions,

The important issue is that the content and organisation of standards vary according to the companies' areas of expertise and intentions. You may wish to select some priority areas as described in the Development Flow Chart.

4.1. Examples of CAD standards: Layer naming

Why Standardise Layer Names?[5]

Production Efficiency: It is usually a lot faster to create data / drawings if everyone works with a prearranged, well-ordered set of layers. On the other hand, overly complicated or badly implemented layer standards can slow down production.

Plotting Consistency: All of the sheets for a project should be similarly formatted and read well. The key to this consistency is a reasonably standardised set of layers and layer properties, as well as a system whereby individual objects inherit their properties from the layers on which they reside. In CAD terminology, this means colour, linetype, lineweight, and plot style "by layer" rather than "by object."

Electronic Consistency: The consistency of drawing data inside the CAD file is increasingly as important as the consistency of plotted output.

Ease of Use by Other People or Companies: In the AEC professions, design firms frequently make use of each other's drawings. The drawings should be organised in a consistent way to prevent the parties reproducing the data for their own purposes. Layer naming conventions is one of the ways to standardise the shared data between the parties.

[5] *Middlebrook, M. (2001) "AEC Layer Debate - AIA Sets the Standard AEC Layer Standards and Practices Update". CADALYST [Internet] June. Available from: http://www.cadalyst.com/features/0601layer/0601layer.htm*

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The British Standards BS1192-5 is one of the layer naming standards used in the UK construction industry. This defines the structuring and exchange of CAD data / drawings. According to these guidelines, any layer name is broken down into a number of different fields, which can be mandatory or optional and together form the complete layer description. The following figure shows the layer naming convention that is described in BS1192-5.

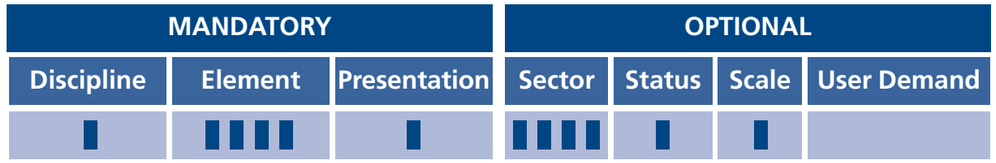

Figure 4: Example of layer coding according to BS1192-5

Discipline or Owner: A single digit that describes who owns the layer. For example, an architectural layer begins with the prefix "A." This field is mandatory.

Element: The element code describes the actual content of the layer. There are different classification codes for construction elements. For many years CI/Sfb has been the preferred code to describe building elements, however, the UniClass system is now being preferred by some organisations. Whatever code is selected, it is important that it is used consistently by the whole project team.

Classification Indexes[6]

All classification indexes work on a hierarchical approach, defining broad "general" sections into which most building works can be categorised, then working down through additional options until the exact specification can be found.

As an example, consider the representation of the same element (front door) according to three different classification codes:

CI/Sfb: The CAD layer containing the architect's front door has a name of A315_MDoor. The code 315_ is defined according to CI/Sfb and means "doorways, entrances, exits and doors to fill secondary element to external walls".

Uniclass: In Uniclass indexing system the CAD layer has a naming of AG251:G322MExternalDoors. G251 means external walls and G322 means External doors.

NBS: The same CAD layer could be represented such as AJ20MDoor according to NBS. NBS defines a door with the code J20.

Presentation: This field specifies the type of CAD data associated with the category. For example, model related data are defined as "M" and text related data are defined as "T". This field is mandatory.

[6] *Davies, N. (2002) "Making CAD Standards Your Standards". MSM Online [Internet] February. Available from: http://archive.msmonline.com/2002/02/cadstandards2.htm*

Sector: This is a four-digit element that defines the locations of elements according to floor, zone, building, etc. This field is optional and has no pre-defined values.

Status: The status of an element, whether it is existing (E), new (N), to be removed (R) or temporary (T). This field is optional.

Scale: Represents not the scale of drawn information, but the level of detail depicted. This field is depicted by capital letters (F = 1:100) and is optional.

User Defined or Description: To help users understand the codes listed here, the standard includes a description field to help explain in plain English what is on the layer.

Example of Layer Naming[6]:

MANDATORY			OPTIONAL			
Discipline	Element	Presentation	Sector	Status	Scale	User Demand
A	742_	M	01_	N	F	Shower

The layer containing a shower fitting could be named "A742_M01__NFShower" by using CI/Sfb classifications. This would be translated as the architectural layer (A) showing washing Fittings (742_), model related graphics (M) on the first floor of a building (01) with no unique reference (__) that are new (N) at a detail equivalent to a 1:100 drawing (F). In more common applications, this layer name would often be shortened to A742_M using only the mandatory fields, or A742MShower to help you understand the element type.

Example 2 of Layer Naming[7]:

MANDATORY			OPTIONAL			
Discipline	Element	Presentation	Sector	Status	Scale	User Demand
A	244_	D	02BD	_	E	Stairs

The layer containing the stairs could be named "A244_D02BD_ESTAIRS" by using CI/Sfb classifications. This would be translated as the Architectural layer (A) showing spiral stairs (244_; using CI/Sfb), dimensions (D) on level 2 block B, zone D (02BD) with no status (_), at a detail equivalent to a 1:50 drawing (E). In more common applications, this layer name would often be shortened to A244_D using only the mandatory fields, or A244_DSTAIRS to help you understand the element type.

British Standards allow the use of any recognised classification index. It does not, however, recommend which one you should use. You should define the index that best suits your company's operations and processes.

[7] *BS 1192 Part 5: "Construction drawing practice. Guide for structuring and exchange of CAD data".*

Construct I.T. Develop Your CAD Standards

4.2. Examples of CAD standards: Model file naming

According to BAA's CAD Standards, the model file naming shall consist of six different sections. These sections are as follows:

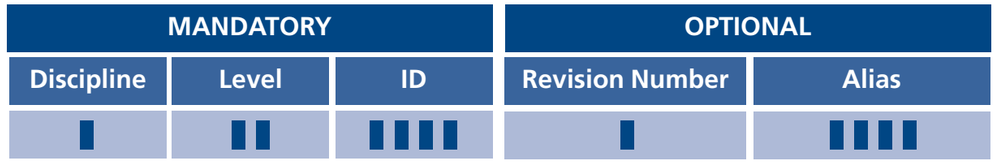

Figure 5: Example of model file naming according to BAA CAD standards

Discipline: The discipline consists of 1 character and is deemed to be the design discipline or trade contractor discipline.

Level: The level consists of 2 characters, which will be project specific.

ID: The ID consists of up to 5 characters, which may be alpha, numeric or both. These codes are used to create a unique model file reference.

Revision Number: The revision number represents the current revision status from preliminary to final 'as built' issue.

Alias: The alias consists of up to 20 characters, which may be alpha, numeric or both.

Example of Model File Naming[8]

MANDATORY			OPTIONAL	
Discipline	Level	ID	Revision Number	Alias
A	00	12345	P01	_Ground Floor Plan

Model file name: A0012345P01_Ground Floor Plan.

This would be translated as the ground floor plan, whose owner is the architect (A), having a level number 00, ID number12345, and revision number P01.

[8] *BAA plc (2003) "Computer Aided Design: 2D & 3D CAD Standards". January. [Internet]. Available from: http://www.baa.com/amanet*

5. How to develop your CAD standards?

The development of CAD standards may entail a considerable length of time, as it requires the referencing of many available documents. This process should be undertaken by a responsible person - usually by the CAD manager within the companies.

The user of this guide must be aware that different types of CAD standards have been published by various organisations. You have the option of either producing your own documents or choosing a widely accepted organisation according to your area of expertise. For example, Mott MacDonald have produced their own documents for visual elements (linestyles, fonts, etc.) but followed an industry initiative for the issues of data structure (file and layer names). BAA plc. is another example in which they have produced their own documents in the guidance of the British Standards (BS 1192-5), ISO Standards (ISO 13567) and the Uniformat System. BAA now requires that all parties in their supply chain confirm to these standards when submitting CAD data / drawings to BAA.

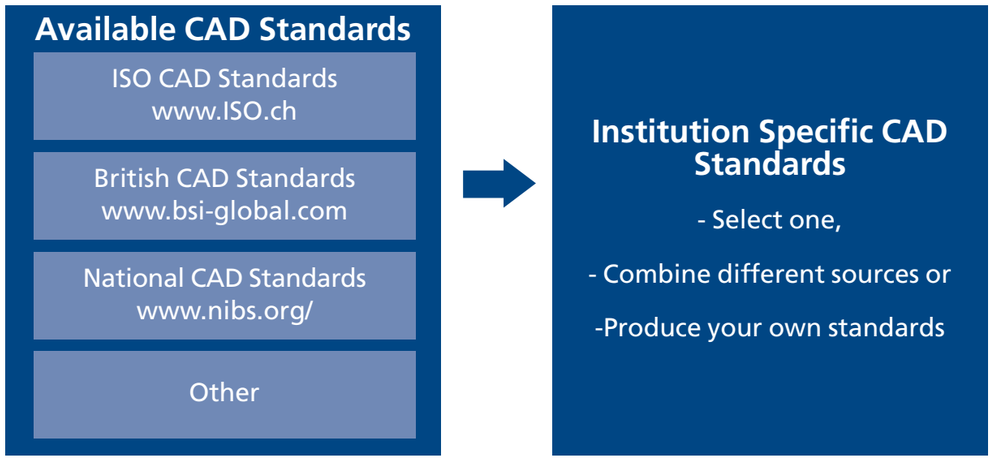

Figure 6: Different standards are available for your company

It should be noted at this point that each standardisation organisation has different advantages / disadvantages regarding CAD standards. For example, NIBS covers the U.S. practices and for some points does not comply with ISO standards (e.g. layer naming conventions). BSI takes some sections of its CAD standards from ISO. ISO standards are intended to represent world practices but some parts may differ from UK practices.

The following diagram depicts how you can develop your CAD standards. During development it should be remembered that there is a continuous change in the technology. Therefore, your CAD standards need to be updated as and when required.

Construct I.T. *Develop Your CAD Standards*

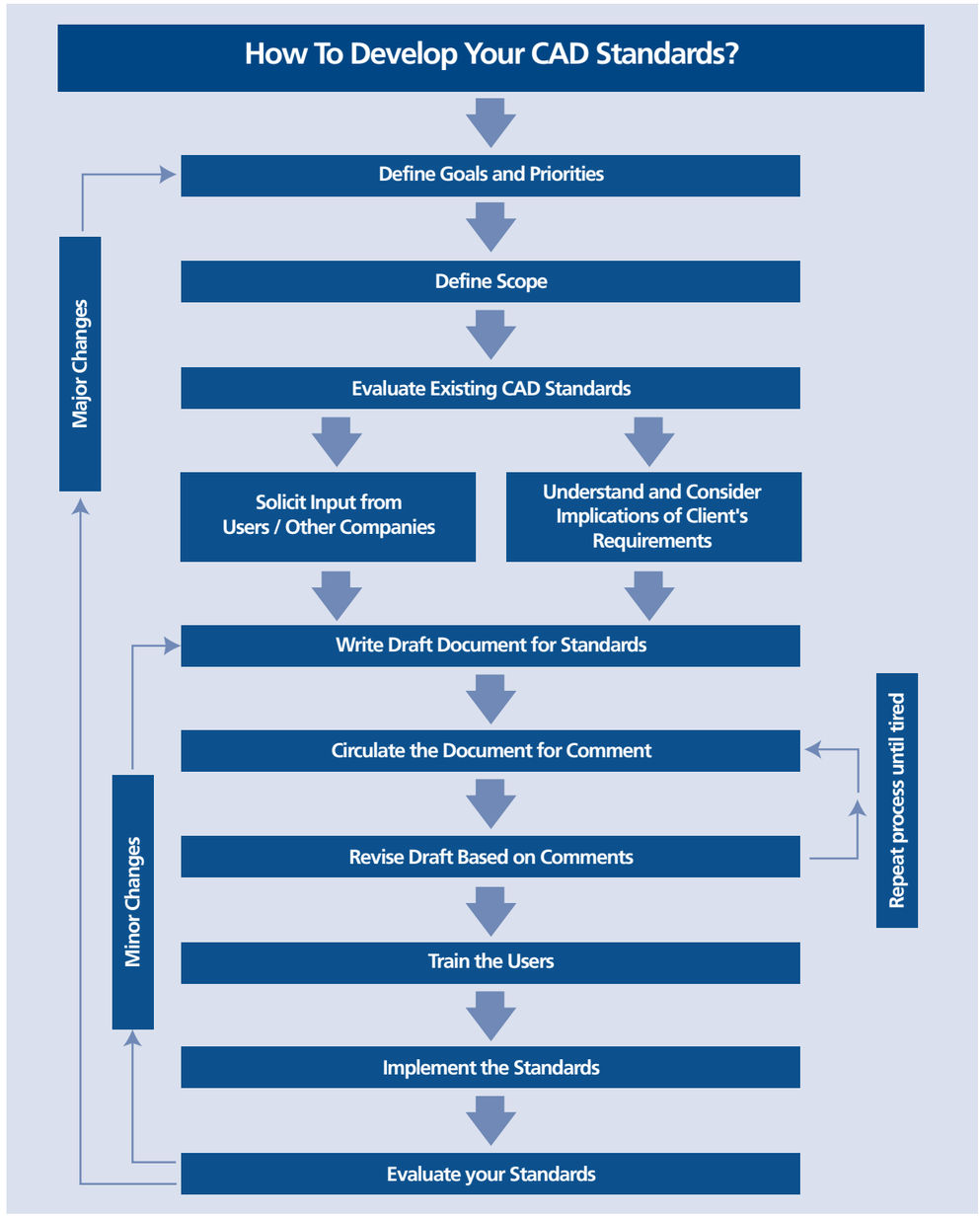

Figure 7: Flow chart for CAD standards development [9]

[9] *Adapted from: Middlebrook, M. (2000). "CAD Standards Development: Road Map Charts Process", CADALYST April. [Internet]. Available from: http://209.208.199.147:85//features/standards/standarddev.html*

Define Goals and Priorities: Companies often expect that CAD standards will do everything, i.e. improve quality, enable better data extraction from drawings, etc. You will be more successful if you can articulate your most important goals and develop your standards according to them.

Define Scope: Once you have established your goals and priorities, define the scope of your current standards. You should focus on the most important goals and leave lower priority items for the next pass. For example, you might set layer use and plot settings in the standards but leave other items such as the appearance of a north arrow for later.

Evaluate Existing Standards: Search the national and international market to determine the most suitable standards for you. The last section of this guide, 'Further information', details some useful information that can be used in this process. It is important to decide whether you accept one organisation's standards or develop your own documents from the start.

Solicit Input from Users / Other Companies: CAD users would probably know the problem areas and be able to advise you on how to improve the standards. Meetings with users and some Internet discussion tools could help you gather this information.

Understand and Consider Implications of Client's Requirements: In current work practices, companies should make their CAD standards compatible with the client's requirements. Therefore, understanding and considering the requirements of clients is an important step in your development phase.

Write Draft Document for Standards: Developing actual standards involves creating some sort of documents, usually in a word processor or HTML format to be published via the Internet.

Circulate the Draft for Comment: Gain feedback from users regarding the prepared draft. In addition to your own company, you may wish to also gain feedback from the other companies in your supply chain.

Revise Draft Based on Comments: Iterate this step until you and your parties are satisfied with the content of the manual.

Train the Users: Train your employees and your partners if necessary, to get the best results from the implementation of your CAD standards. Publishing your manuals over the Internet can be a cheap and effective way of training your employees and other parties in your supply chain.

Implement the Standards: Once you have prepared your CAD standards, the next phase is the implementation. Encouraging all the parties in your company or supply chain to adopt the same language immediately may not be easy. It is your decision whether to start to use the standards immediately or try it in a pilot project.

Evaluate Your Standards: Remember that CAD standards are not static. There must be a continuous refinement of your standards. Your standards could also be open to change in terms of projects. However, once you have decided on the standards, you must continue with them during the whole project life cycle.

Construct I.T. *Develop Your CAD Standards*

6. How to implement CAD standards?

The main difficultly surrounding CAD standards is not creating them but getting them implemented in your company or in your supply chain. There are several factors that inhibit the implementation:

- Lack of senior management support
- Lack of agreement about what CAD standards should cover
- Departmental or inter-company resistance

Human related problems can be overcome via training programs that describe why standards are necessary. One of the reasons for the lack of support from upper management may be that they do not see clear benefits from CAD standards. However, managers have to realise the gains the company could achieve in terms of savings in time and money by implementing CAD standards. Only by getting upper management on board will the implementation process receive political power within the company.

The reason you want to accept CAD standards should also be described to the CAD users within your company and to the people you work with. Users may feel that implementing CAD standards is an unpleasant task since it contains many rules that need to be applied during the production of the CAD data / drawings. The acceptance can however, be made easier by using software tools that automate the implementation. Customising your CAD software is one of the easiest ways - you can create template files that predefine most of your CAD standards, such as line types, text heights, etc.

It is good practice to document the company's CAD standards in the form of a CAD manual. The purpose of this manual is to educate your staff and your partner companies. The CAD standards manual could also be a part of the company's Website/Extranet/Intranet. Distributing documents via the web reduces the training costs. PDF file format is a good solution for publishing standards in an electronic format as they have the ability to be easily published electronically. This file format also provides good printout quality.

An important issue is that CAD data / drawings produced within the company and by your supply chain should also be checked for compliance to the accepted standards. To achieve this, CAD standards should be a part of a wider 'quality assurance' system. There are special programs (which can be separate or embedded in common CAD applications) that validate whether the CAD data / drawings are compliant to the specified standards. These programs can help you and your supply chain to check drawings prior to submissions. The latest versions of popular CAD packages include such applications that check for conformance to CAD standards, such as checking layer names and other items against your company CAD standards. These programs may also fix the problems that do not conform to your standardisation. However, be aware that these programs may have some limitations as they do not cover everything.

The implementation of CAD standards within a supply chain may be difficult. If your company is the dominant member of the project team/supply chain then perhaps you could enforce the use of standards. However, it is quite possible that you have to conform to someone else's standards on certain projects. Therefore, how you use standards should be flexible enough to be adapted to different environments. The decision to adopt CAD standards should be stated in the contractual documents to make the implementation compelling.

7. Success stories

This section intends to provide some of the success stories that highlight how a number of companies have successfully implemented CAD standards.

7.1. BAA case study

BAA plc is the largest single privatised airport owner and operator in the world and is therefore a major client to the construction industry. BAA owns and operates seven airports in the United Kingdom and has a financial stake in, and/or manages, all or part of eight further airports around the world. Some of the major projects such as new airport infrastructures bring together BAA with many construction organisations. Managing CAD data in such a complex environment is a difficult task and needs specific guidelines.

BAA's previous experiences have showed that the data received was not in a usable format. Specifically some of the problems were:

- Layer standard not used
- Title block inadequate
- Linestyles many and too varied
- Text styles many and too varied
- Valid CAD files not received
- Data not bound in

To improve efficiency of data transfer throughout BAA's Acquire and Maintain Assets process and to avoid the main problems identified above, BAA decided to develop and implement guidelines for CAD data production. The thrust for the collation and publishing of the BAA CAD standards came out of opportunities offered by the T5 project in 1998 with a BAA version being issued for use on 13th October 1999.

During the development of the standards, BAA first made a requirement analysis of the company's needs and those of the supply chain's, then a team of experts from both areas were employed to produce a draft outline of the CAD standards. This team consisted of in-house expertise, a CAD specialist company and the expertise of their supply chain. The standards are based upon BS1192-5 and ISO 13567 plus the Uniformat System. The process BAA adopted in developing and implementing their CAD standards was as follows:

1. Agree needs
2. Agree format
3. Undertake learning process from experts in the field
4. Produce draft
5. Agree draft
6. Test with selected users (which form the BAA CAD user group)

7. Release and communicate draft
8. Run risk workshop and undertake risk assessment
9. Release and publish CAD standards for mandatory use
10. Receive and evaluate comments/issue/requests
11. Re-release, risk assess and publish on a regular basis (6 months in their case) to ensure continuous improvement

BAA communicates the CAD standards with their supply chain through the web. The manual for standards is available via the web in PDF file format. This allows easy distribution of the core data to the partner companies. The company also encourages other organisations not associated with BAA to access and use these standards should they wish and also provide feedback. The company runs regular coaching/training sessions and a launch event for every new version of the BAA CAD standards.

7.2. Laing case study

In the mid 1990's BAA Lynton commissioned the first use of six similar office buildings. Each was approximately 70-80.000 sq. ft., over three or four floors, and was to be let as general office space. The project team had previously had similar design criteria and some of the problems that arose in these projects were:

- Lack of spatial coordination
- Poor appreciation of manufacturing and construction tolerances
- Poor management of data, drawings and documents
- Poor management of information flow

To overcome these problems, the construction managers decided to use 3D CAD modelling. The Stansted project was put forward and accepted as a suitable 'demonstration project'. The building is a four-storey office development of 64.000 sq. ft. and was built at Stansted Airport between 1998 and 1999.

For 3D modelling to be effective it was necessary to take control of how the data was produced. To produce these guidelines, the project team carried out a survey among the project members. As a result of this survey, the project team agreed on certain rules most of which are related to CAD standards:

- An agreed spatial origin and grid orientation so that all co-ordinates are positive.
- The working units to be used in all drawings.
- Common drawing sheets with attributes title blocks.
- Layering standards based on BS 1192-5.
- Drawing numbering and revision convention.
- Drawing scales.

- Standard blocks and symbols
- Text and dimension appearance and presentation.
- Standard use of abbreviations
- Approval process
- Mechanisms for data sharing.

By agreeing these rules, the project members needed to adjust how they structured their data. All CAD data / drawings passed through an approval process before being issued electronically via an ISDN line to Laing Construction, who acted as the Document Manager for the project.

In order to ensure that the design team was complying with the agreed rules, the modelling team developed software to check the structure of the data being received. This software checked the following areas for compliance:

- File names
- Drawing and sheet names
- Title block attributes
- Layer names
- Text styles, width and heights
- Dimensions

While the agreed rules did not guarantee the quality of the design content itself, it did ensure that the data was structured correctly, whilst also helping the design team members isolate data they wished to reuse more easily.

One of the important conclusions from this project was that if the design teams use an agreed set of rules (CAD standards) during the project life cycle this would enable them to work collaboratively on a single set of project data and manage the flow of data effectively.

7.3. Mott Macdonald case study

Mott MacDonald is a major global multi-disciplinary consultancy. The company has recently carried out a major exercise to replace its drafting manual, last revised in 1996, with a more modern document covering different topics such as electronic file exchange alongside which linestyles to use. The key goals were to:

- Improve profitability,
- Facilitate work of high quality and consistency,

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- Improve technical efficiency by maximising the use of electronic tools,
- Simplify the transfer of CAD data / drawings and staff between offices, in UK and overseas,

The scope was comprehensive (see contents list), but priority was given to the three key areas of Drawing Management, Visual Identity and Data Structure.

Mott MacDonald Ltd CAD Standards Manual Content List

Mott MacDonald has followed such a content list for the CAD Standards Manual:

1. Introduction

2. Standards – gives background on what standards their document have been based on, and how to amend this document to form a project-specific standard when required

3. Visual identity – lines, colours, symbols, text styles, drawing frames, etc.

4. Good practice – advice on models vs drawings and best practice in 3D modelling

5. Data structure – file names, folder structure, layer codes, etc.

6. Drawing management – responsibilities, revisions, drawing status, checking, approval, etc.

7. Communications – how to issue (and receive) drawings electronically

8. Software – advice on in-house software, statement on which software is our standard platform, etc.

9. Disciplines – sections for more detailed advice on specialist areas, e.g. structural engineering

10. Plotting – advice on everything that happens after a drawing has left the CAD system

11. Learning and development – advice on training, CPD, etc.

12. Appendices – Glossary, Standard Abbreviations, List of Standards, Manual for in-house utilities, copy of AEC (UK) Layer Standard, etc.

A core team was formed from Mott MacDonald's existing CAD Development Working Group, and drafts of the standard were published at intervals on the company Intranet. The key target audience was the firm's own CAD users, and feedback was sought via an Intranet discussion group, and face to face at an annual CAD Forum. It was stressed that the document would always remain a 'work-in-progress' to reflect future changes in the technology.

The document reviewed several existing standards, including the relevant ISOs. Where possible, these have been incorporated into the company standard, but it has often been found that they do not match well with general UK practices or the company's in-house practices. Many of the requirements incorporated in the company CAD standard came instead from the existing drafting manual or from discussion with users.

The CAD standard is published in PDF format, which was seen both to be suitable for online viewing via the Intranet, for downloading, e.g. to laptop users, and to print out as a paper document. The online version contains hyperlinks to other related areas, e.g. the corporate QA system, which is also online. The standard is produced in a two-column format, with requirements in one column and explanations in the other. This is because giving the staff not only what they had to do, but also explain why.

Layer naming standards proved to be one of the most difficult issues. Although there are some very detailed schemes available, these are often resented by users due to their complexity. Mott MacDonald have taken the approach of relying on a very wide-ranging scheme, but only presenting users with immediate access to the more limited sets of layer names that their individual discipline will use on a frequent basis. After an abortive attempt at in-house development of layer codes, the firm decided to adopt the AEC (UK) CAD standard layer names.

One key issue throughout the process was the need to make it easier for users to comply with the standard than to disregard it. This would reduce the need for spot-checks, auditing and compliance monitoring. To this end, an in-house software utility was developed for AutoCAD, which automatically sets correct styles, and allows easy access to standard symbols. It includes toolbars allowing instant access to the online manual and Intranet discussion group. The utility continues to develop, with the most recent enhancement being the addition of a revised layer creation feature allowing easy generation of standards-compliant layer names.

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8. Summary

A typical construction project involves many actors from a variety of disciplines. The parties involved in the construction process need to share graphical information in a quick, easy and efficient manner. For this, a set of standards must be used in CAD environments. These standards help construction parties use the same language in the drawing deliverables. With the increase of sharing documents in an electronic environment, the construction industry is now focusing more attention to CAD standards. Some companies begin to develop CAD standards either in a printed manual or increasingly published via the Internet.

This guide has explained:

- What CAD standards are,
- Why it is necessary for a company to use standards in a CAD environment,
- How to develop CAD standards for a company / project life cycle.

The benefits of implementing standards in the CAD environment will be seen in the reusability of the design data between the project participants. Without the implementation of CAD standards, the sharing of design data can result in errors that are very difficult and time consuming to rectify.

The ideal situation would be for everyone in the construction industry to use the same standards. In this case, every party would speak the same language, thereby reducing most of the communication related problems. However, the fact remains that there are many CAD standards available in the market by respectful organisations such as British Standards Institution (BSI), International Organisation for Standardisation (ISO), etc. This guide suggests that companies may select these published standards as guidelines or develop their own standards and apply them to the project environments. In order to gain maximum benefit from CAD standards, the participants in a project life cycle should also accept the agreed guidelines and work with them. Although the selected standard should be consistent for the whole project life cycle, they should be open to change for other projects. For example, you may adopt British Standards when you are doing business in the UK but you should be flexible and open to change when you are doing business with a US company.

9. Further information

This section lists some of the organisations and their publications on CAD standards:

● The International Organisation for Standardisation (ISO) - www.iso.ch/:

The International Organisation for Standardisation (ISO) is a network of national standards institutes from 140 countries working in partnership with international organisations, governments, industry, business and consumer representatives. ISO has published several documents about CAD and standards:

Document Number: ISO 128-21:1997
Title: Technical drawings -- General principles of presentation -- Part 21: Preparation of lines by CAD systems

Document Number: ISO 3098-5:1997
Title: Technical product documentation -- Lettering -- Part 5: CAD lettering of the Latin alphabet, numerals and marks

Document Number: ISO/TR 10127:1990
Title: Computer-Aided Design (CAD) Technique -- Use of computers for the preparation of construction drawings

Document Number: ISO 13567-1:1998
Title: Technical product documentation -- Organisation and naming of layers for CAD -- Part 1: Overview and principles

Document Number: ISO 13567-2:1998
Title: "Technical product documentation -- Organisation and naming of layers for CAD -- Part 2: Concepts, format and codes used in construction documentation"

Document Number: ISO/TR 13567-3:1999
Title: Technical product documentation -- Organisation and naming of layers for CAD -- Part 3: Application of ISO 13567-1 and ISO 13567-2

● British Standards Institution (BSI) - www.bsi-global.com

Document Number: BS 1192-5:1998
Title: Construction drawing practice. Guide for structuring and exchange of CAD data

Document Number: BS ISO 128-21:1997
Title: Technical drawings. General principles of presentation. Preparation of lines by CAD systems

Document Number: BS EN ISO 3098-5:1998
Title: Technical product documentation. Lettering. CAD lettering of the Latin alphabet, numerals and marks

Document Number: 96/102394 DC
Title: ISO 13567. Technical product documentation. Organisation and naming of layers for CAD. Part 1. Overview and principles

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Document Number: 96/102395 DC
Title: ISO 13567. Technical product documentation. Organisation and naming of layers for CAD. Part 2. Concepts, format and codes used in construction documentatio

Document Number: 96/715802 DC
Title: Technical product documentation. Handling of computer-based information. Part 7. Structuring CAD files from an administrative point of view (ISO/CD 11442-7)

● U.S. National CAD Standards (2001). Published by National Institute of Building Sciences (NIBS) - www.nibs.org

A standard for the U.S. building design and construction industry. Incorporates:

- American Institute of Architects (AIA) CAD Layer Guidelines

- Uniform Drawing System, Modules 1-8, published by the Construction Specifications Institute

- Plotting Guidelines Developed by the U.S. Department of Defence Tri-Service CADD/GIS Technology Centre

● Construction Production Information Committee (CPIC) - http://www.productioninformation.org/

CPIC has published a document entitled “Production Information: A Code of Practice for the Construction Industry” which provides guidance to practitioners on using CAD systems to improve production information.

● AEC (UK) CAD Standards - www.bentleyuser.org/

AEC (UK) CAD Standard published by the UK Microstation Community (but intended for cross-platform use). The AEC (UK) CAD Standard has been developed from previously existing CAD standards documentation (BS1192 part 5, Autodesk User Group’s CAD Layering in The Construction Industry, and the committee’s own internal and project-based CAD standards) in order to provide an update of those documents to allow for more up-to-date CAD usage. This is supported by a number of leading AEC firms including BDP, Foster & Partners, Halcrow, Mott MacDonald etc.

● BAA CAD Standards - http://www.baa.com/amanet

● Uniclass – Unified Classification for the Construction Industry

Building Project Information Committee. Available from: Royal Institute of British Architects.

● CI / Sfb Construction Indexing Manual,

RIBA Publications, Royal Institute of British Architects.

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