STANDARDISATION IN THE BUILDING INDUSTRY

THE STEP BUILDING CONSTRUCTION CORE MODEL

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ABSTRACT

A brief summary of ISO efforts leading to the buildings-related Standards committees is given, together with the scopes of the main related national and international work. The concept of the Architecture, Engineering & Construction (AEC) Building Core Model (a high level data model dealing with the main entities of relevance across the appropriate sector of industry) will be presented and illustrated by examples drawn from the version which is current at the time of the workshop. A comparison of different approaches adopted by various European Union projects is given and the role of de-facto standards is discussed.

Keywords

STEP, Application Protocol, Building Construction Core Model,

INTRODUCTION

This paper is concerned with the development of standards for the exchange and sharing of information within the building construction industry. Attention is centred on the continuing efforts leading towards the ISO Standard for the Exchange of Product Model Data (STEP).

At present, data exchange within the industry mainly uses the DXF specification and this has the status of a de facto standard. Other efforts to define formal standards within the industry have had little impact. This may be explained partially by the simplicity and ease of use of.DXF However, the world is changing and a new generation of CAD systems is emerging. These will be based on object technology and will offer users a much richer set of features beyond traditional CAD geometry. In order to meet the legitimate information exchange needs of the industry, a more detailed capability is required. STEP has this capability. It is intended to examine how STEP is developing, particularly using the proposed Building Construction Core Model (BCCM) as an example. The use of STEP methodologies as a means of providing interim solutions is also examined.

One of the most important questions is whether de facto standards will emerge for the industry and succeed in place of STEP (much as was the case with DXF and IGES). This is also addressed.

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ISO STEP RELEVANT COMMITTEES AND PARTS

When work on STEP first started in 1984, its objectives were beyond the technology of the time. To a large extent, it had to develop its own ways of doing things which it did through the development of the EXPRESS data definition language and the adoption of graphical methodologies (IDEF0, IDEF1X, NIAM and, later on, EXPRESS-G). It also had to find ways of partitioning the world it was seeking to address into manageable portions. This was achieved by describing four distinct groups:

• Methods	(EXPRESS, File Structure, Database access)
• Generic Resources	(Geometry, Topology, Materials)
• Application Resources	(Draughting, Building Construction Core)
• Application Protocols	(e.g. 2D Draughting, Building Shape, P&ID)

Each of these areas is handled by different Working Groups within the STEP organisation. Most important for industry applications is WG3 (Product Modelling) which deals with Application Protocols and, in particular, Team 12 which deals with AEC industry requirements13. WG3/T12 comprises shipbuilding, process and offshore engineering as well as building construction. Recent STEP meetings have been characterised by AEC delegates representing over 30% of the total attendance. Work in shipbuilding and process engineering has developed from NIDDESC models initially developed in the period 1987-1989.

• AP216 - AP219	(shipbuilding)
• AP221 - AP227	(process engineering)

Work in building construction became focussed with the Building Construction Application Protocol Planning Project (APPP) agreed at the Davos meeting in 1994. There are now four active, and two proposed, developments.

• Part 106	BCCM	(commenced April 1995)
• AP225	Explicit shape	(Draft Standard late 1995)
• AP229	HVAC	(commenced April 1995)
• AP230	Structural Steel Frameworks	(commenced April 1995)
• Space Layout	(draft proposal)	
• Roadbuilding	(draft proposal)	

QUANTIFICATION OF BENEFITS

The recent Latham11 report issued in the UK called for a 30% reduction in costs in building construction and proposed that achievement of this would come largely from the increased use of Information Technology. It is the authors' belief that this is feasible although it will be delivered through technologies such as STEP and CALS rather than via the visualisation and virtual reality methods considered by the report.

Presently, there is little hard evidence of the cost benefit of using STEP technology. Such evidence as exists is in the form of predictions from other industries. Shell[4] consider that the potential benefits in their process engineering environment could range from \$15m - \$150m + per year with reported trial experiences suggesting that reductions of engineering costs in the range of 10% - 30% can be achieved through STEP. PDES Inc. have estimated savings of $100m (around 10%) in the delivery of weapons systems in the US through the use of STEP. Indeed, it is in multiple contractor projects that the major benefits are seen. Whilst these are relatively new to many industries, they have been normal in building construction for a long time.

THE POTENTIAL AND IMPLICATIONS OF STEP

Poyet[12] considers two categories of STEP users whom he describes as orthodox and pragmatic. Orthodox users come to STEP, develop APs, have these integrated and see them through to becoming a standard. Pragmatic users are interested in the use of STEP technology, develop ARMs for a particular purpose and implement them. These ARMs may later contribute to the development of a formal standard in the orthodox manner. Pragmatism can be seen as relatively quick (and economic); orthodoxy takes longer. An example of this is development of the proposed AP230; Structural Steel Frameworks. Emanating from work on the EU funded (Eureka programme) CIMSTEEL project, the development to a standard will require 2-3 years of effort, even allowing for the fact that a model already exists based on the methodology.

Demonstrations of the capability of the CIMSTEEL models to industry caused the participants to agree on the need for a pragmatic solution. Since participants include major software houses active in structural engineering, what they decide may significantly enhance data exchange within the application. Their efforts are known as the CIMSTEEL Integration Standards (CIS) which are expected to be completed mid 1995.

STEP AND CURRENT TECHNOLOGY

Technology has caught up with STEP and progressed beyond it in certain areas. The growth of object oriented developments is one example; the ability to encapsulate behaviour is beyond the current descriptive capability of the EXPRESS language. Is STEP therefore an anachronism?

STEP is moving more towards the status of a conventional standard in the sense that is now attempting to standardise a technology which exists rather than one which does not. It should also be remembered that the emphasis of STEP is on data which it regards as publicly available. This contrasts with the typical O-O view which considers behaviours (generally) to be public whilst data are private. Consequently, STEP can provide a transport mechanism between O-O systems.

A Comparison of Approaches

As Product Modelling methods are adopted for use within R & D projects in building construction, it is becoming increasingly evident that usage experiences are pointing in the same overall direction. This is towards a single, coherent model which brings together common aspects of information across all disciplines within the industry. Within various projects, this coherent or 'canonical' model is named differently, including:

- Reference Model (GARM, IRMA)
- Canonical Model (ICON)
- Project Type Model or BPtM (ATLAS EU7280)
- Integrated Data Model (COMBINE).

Application Requirements

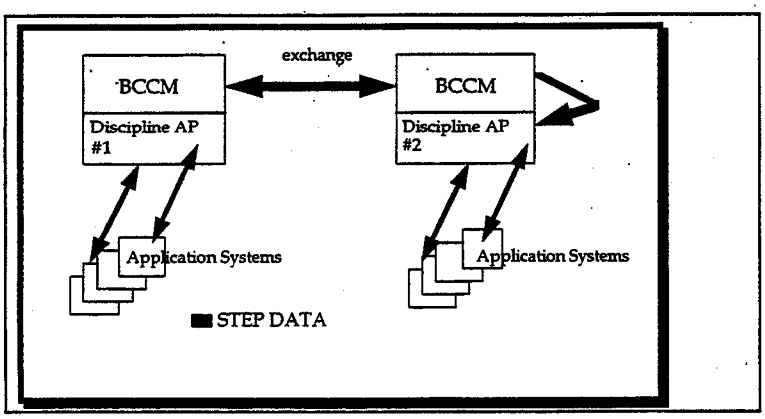
As with a 'canonical' model, there is consensus between R&D and Standards on the need to develop logically separate product models to take into account particular discipline needs. Again, there is a range of nomenclature including Perspectives (ICON), Aspect Models (COMBINE), View Type Models or VtM's (ATLAS). The CIMSTEEL project takes this further by describing a 'Logical Product Model' and then defining a series of Exchange Protocols to enable the sharing and/or exchange of information relating to a given set of activities within structural steel design. All of these are broadly equivalent to the 'Application Protocol' (AP) within STEP where an AP seeks to define the information requirements of a given domain in an unambiguous way.

Core Models

Separately to R&D work (although with the availability of expertise from a number of these projects), the Building Construction Application Protocol Planning Project within STEP described a need for the BCCM with the following primary objectives:-

- To provide a conceptual model of the **common** information requirements amongst disciplines within the Building Construction industry and so to provide a means for the sharing and/or exchange of information to a degree commensurate with need.
- To provide a set of consistent model constructs for areas of information use which can be used and specialised by more specific discipline models so as to ease and improve the integration of the discipline models.

There is a consensus between R&D and the Standards world about the need for a 'canonical' model and that the proper place for it's development is within a formal Standards environment as the only place where the necessary agreement on its constitution can be achieved. Therefore, the 'canonical' model for the Building Construction industry must be the BCCM within STEP since this will be the only model to gain International Standards recognitions (ISO 10303 part 106).



Whilst the BCCM can set out a framework for the development of other parts within a Standard using a top down approach, it must also have a bottom up viewpoint so that it can assimilate contributions from other projects, many of which are pushing at intellectual barriers beyond the scope (or time scale) of a formal Standard. For it to have an impact, commercial vendors must be aware of, contribute to and migrate their de facto approaches towards it. This is already happening in a number of instances including Autodesk (through the UK 'CEIC' project managed by BRE), Intergraph, Bentley Systems, IEZ, Nemetschek and others. The recent UK Technology Foresight report on IT concluded that it is important for Industry to contribute to the development of Standards, not just to await their arrival.

USAGE SCENARIO

The Usage Scenario describes a sequence of tasks to be completed and a flow of information between the primary disciplines (architecture[7], building services[8] and structural engineering[9]) through to realization of a building. It is an important part of the Core Model since it seeks to explain the overall purpose of the BCCM and to describe when and how it may be used in practice.

The Client's Need

At the outset, the client determines a requirement for building construction in order to satisfy a need. This need may be additional office or sales space, production capability, warehousing etc and will be characterised as a building which is classified according to some local convention.

Requirements Stage

At inception, the need is set out in terms of what the client wishes to achieve. Initial requirements will include such matters as site location, space requirements, conditions in which activities are to be undertaken. Sometimes, requirements will be formalised through a mechanism such as 'Room Data Sheets'. In other circumstances, requirements are not available and it is necessary to carry out a feasibility study to ensure that the need can be met within the constraints which apply. It is therefore necessary that the principal advisers to the client are appointed. Each discipline will need to know what is required of them according to the requirements and will need to know of any constraints which may be placed on the achievement of their objectives by other disciplines. In particular, cost and time constraints are important. Known site location and/or building details may also determine constraints.

As a design begins to take shape through feasibility and the presentation of preliminary proposals, each discipline will need to communicate with external bodies to ensure that:

- proposals meet planning requirements
- services facilities required are available, required access can be provided, preliminary works can be ascertained

Any effects on the proposals of other disciplines which are identified by such communications must be notified to others. At this stage, it is probable that any effect would impact on the work of all disciplines.

The Requirements stage is considered to include the provision of an outline space layout, preliminary structural layout and preliminary layout of primary services routes. Engineers will carry out an outline analysis to obtain an idea of the loads they will be required to meet. The cost engineer will be required to determine an approximate cost from architectural and engineering information and reconcile this with any indicative cost allowance initially provided by the client.

The Requirements stage of a project can be seen as the period when an initial need expressed by a client is taken by professional advisers and progressively coalesced into a set of technical requirements which are perceived to fulfil that need. Work is not carried out in detail but only to such a degree as to enable:

- 'proof of concept'
- feasibility, in that the potential solutions offered by the client's advisers can coexist without undue conflict.

Geometry requirements can often be satisfied at this point by an 'arc-node' reference geometry. Shape information may be applicable in certain cases. Preliminary management information concerned with cost and duration will be needed. Information concerning the site will be required and the effects of location, access, public rights, adjacent structures (both above and below ground), topographic detail, servicing etc. will need to be assessed and communicated.

No part of the work of any discipline within this stage can be divorced from the work of others; every design decision has an impact on all others and therefore needs to be communicated. The BCCM is perceived to provide appropriate mechanisms for this.

Design Stage

The Design Stage splits into two parts, namely Scheme (or Outline) Design and Detail Design.

Outline Design develops the explicit nature of the design, providing for all aspects of the project to be sized and tested against each other in terms of their precise spatial allocation. Changes may be made to positioning of elements and routing of services and these need to be communicated. Communication may be by means of an implicit or an explicit geometry.

Development of the Outline Design will determine the coordination of the various. External bodies will need to be consulted to obtain their approvals to the actual design (as opposed to the proposals). In particular, information concerning fire prevention and security will need to be aggregated into a consistent whole for approval by the fire authorities.

Cost and duration have continuing significance but become firmer as detail hardens.

Detail Design is considered to be the stage at which the design is developed to a working form including the provision of sufficient information to enable production information (including specifications, Bills of Materials etc.) to be completed. It is at this stage that individual APs become significant. Whilst work at the Requirements stage is interactive between disciplines, it commences to become insular during Design although the overall impact in the development of detail from spatial, aesthetic and other viewpoints needs to be captured at the BCCM level.

Planning Stage

There are two elements to this stage, namely the collection of tenders to carry out the work and the detailed planning of how the work is to be carried out. Tendering is usually carried out in parcels of work. However there is a need to aggregate tender information to enable a total cost to be determined for the project (and compared with anticipated costs). Planning is typically undertaken by contractors and is the stage at which resources are assigned. There is a need to aggregate planning information so as to enable an overall project plan to be deduced. This does not mean that the whole plan for a parcel of work needs to be communicated; only sufficient to assure that an overall plan can be deduced and that areas of conflict can be identified and reconciled

Realization Stage

Realization includes all operations on site up to completion and handover. Designers and contractors are involved in realization and there are generally a number of specific designer/contractor relationships within which communication occurs according to disciplinary APs. The BCCM continues to play a role in a number of areas:

- changes to the planned schedule of work
- variations in cost
- adherence to quality as set down in specification
- provision of financial information
- delivery of testing and commissioning information

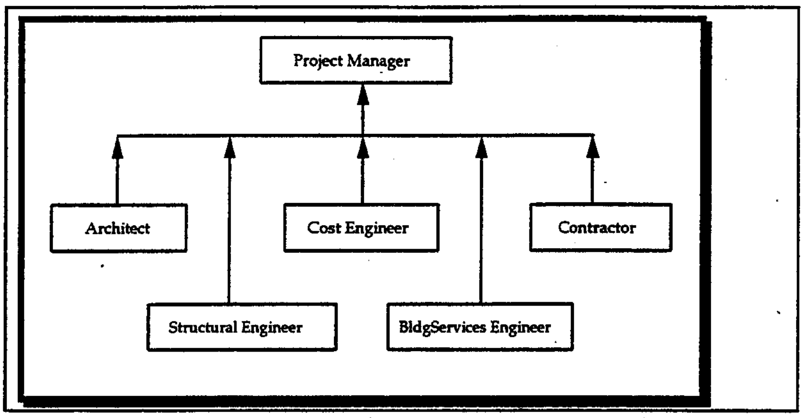
On completion of the project, there needs to be an aggregation of operating and maintenance information (much of which can be derived from descriptions and specifications). Typically this information should conform to standards requirements and consequently, can be developed according to BCCM.

Operation Stage

The use and operation of the project subsequent to Realization is the domain of a facilities and maintenance management (FM) model which is beyond the scope of the BCCM at this stage.

PROJECT ORGANISATION

There are many ways in which a project organisation may be brought together. Organisation may vary according to a number of factors e.g. contract arrangements, location (country) etc. However, for present purposes, a hierarchical arrangement is proposed which should not conflict greatly with any form of organisation. The hierarchy identifies a client's representative acting in the role of project manager (irrespective of particular discipline). All other parties in the hierarchy are responsible to the project manager, and all exist at the same hierarchical level. Broadly this is equivalent to the type of organisation which occurs in any conventional contract where one party is given a management and co-ordination responsibility whilst others carry out tasks which are bound by their domain of technical expertise.



The diagram also demonstrates that there is only one available route by which information can be propagated (or guarantee to be propagated) to all other interested and relevant parties. This is the route which goes via the project manager.

There are certain technical matters which have to be propagated through the project manager, but others which do not. For instance, some issues at Detail Design stage can be resolved (say) by direct contact between the structural engineer and the building services engineer.

Now, from the above, it is possible to develop the idea of the BCCM to deal with information which needs to be propagated widely and thus it can be said to be owned by the Project Manager. This is not to say that there are no areas of the Project Manager's role which may be perceived as exclusively within a project management domain and therefore subject to the development of a specific management protocol. As with the technical domains, scope exists for the development of such a protocol and its ownership will be vested in the discipline which it serves.

CORE MODEL ELEMENTS

Michie[10] has defined the terms integration and coordination to mean the following:-

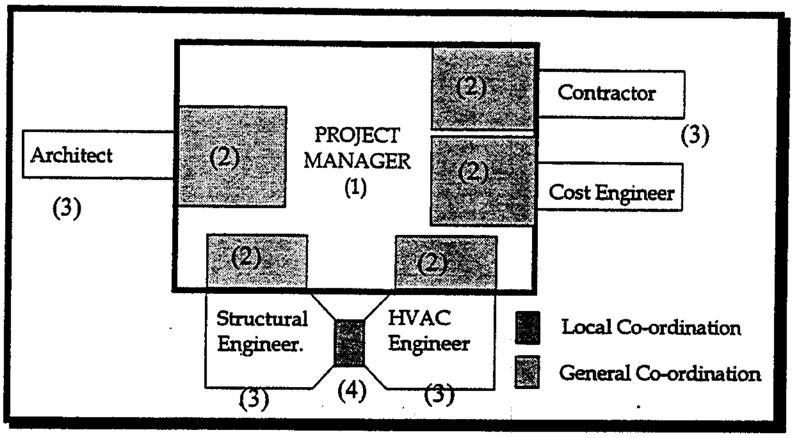
- Integration — Bringing parts together into a whole
- Co-ordination — Bringing parts into proper relationship

APs fulfil an integration role since they endeavour to ensure the technical correctness of the 'parts' within their scope. The BCCM fulfils a co-ordination role in that it endeavours to ensure that 'parts' are brought into proper relationship.

The diagram below shows the BCCM and AP's with four zones of interest.

1. BCCM unique zone which defines the 'canonical' model.
2. The zone of an AP which is conjoint with the BCCM.
3. The zone of an AP which is disjoint with the BCCM.
4. The zone of an AP which overlaps with another AP.

The unique zone defines the systematic way of proceeding with the development of a model and describes APs which should be developed.



The conjoint zone remains within the 'canonical' precept but develops to a more pragmatic level of detail in both management and technical areas. In particular, it takes the areas of common interest and models them in a form which is commonly useful. The model concepts of this zone may appear simultaneously in both the BCCM and the AP. The critical factor is that where they can be the same, they should be the same. The level of detail of information required in common may be less than that required by an AP which would therefore specialize it. The existence of common model constructs allows for:

- More rapid prototyping and development of APs.
- A guaranteed area of AP interoperability.
- Easier integration with other parts of STEP through use of predefined, pre-integrated resources.
- Mapping of AP entities to BCCM entities.

The disjoint zone allows for the specialization of common constructs together with the development of application-specific constructs, which are of no interest to the BCCM but which may be developed using the entity framework of the canonical model. Thus we can broadly define the BCCM and APs as follows:-

- BCCM = Unique + Conjoint
- AP = Conjoint + Disjoint

The overlap zone describes a domain which is of mutual interest to at least two applications and where communication can occur at the same level. Such communication will occur most extensively at the Detail Design Stage and during the Realization Stage when it occurs on an informative basis and does not have contractual significance. Such communication has been referred to as an 'Interacting' Transfer[5]. The important thing about such communication is that it may not be justified for inclusion in a domain-specific AP since it refers to an interface with another domain rather than to something within the current domain. The current example of such a model is AP225[14] which provides a classified geometry of explicit shapes for, amongst other purposes, clash detection. Other examples may exist and remain to be defined.

STATUS OF BCCM

At present, development of the BCCM has been accepted within STEP as the proposed part 106. This means it is considered to be a resource rather than an AP. Strictly, this means that it develops resources specific to an industry requirement which are not otherwise contained witin the STEP Generic Resources (40 series parts). However, the scope of the BCCM also identifies its use as a high level interdisciplinary exchange capability. In this sense, it resembles a conventional AP. This duality is an issue which requires resolution over time since STEP does not currently have the administrative mechanisms to handle it.

Development is occurring within the UK and Netherlands with input from other national and international efforts. Strawman versions have been presented to meetings in Sydney (March 1995) and Washington (June 1995).

The model is benefitting from significant industry input within the UK through 'Computerised Exchange of Data' Industry/Research/Government project managed by the Buiding Research Establishment (BRE) and from vendor support from Autodesk who are aiming to ensure that their recently announced Industry Foundation Classes will be able to communicate at a STEP level.

FUTURE WORK AND INPUT

The development programme for the BCCM is anticipated as 2 years from commencement which was early 1995. Therefore, a formal Application Reference Model with interpretation according to ISO 10303 requirements is anticipated at end 1996/early 1997. In practice, the development of the model using common industry terms has already started and will continue in a pragmatic context. It is likely that early implementation tests of the ARM will be starting in early 1996. This is an important element of the work since it helps to ensure that the model does meet the objectives of industry operating in the real world..

Input from other people and organizations in the industry is welcomed, particularly from those with modelling knowledge and/or existing models which can contribute to BCCM development.

CONCLUSIONS

1. Parts of STEP have already become an ISO standard with others to follow. The first part aimed at building construction is being ballotted from July 1995 and is expected to become a draft standard at end 1995.
2. The STEP methodology can be used as a pragmatic solution to data exchange/sharing problems in advance of the formal standards being available. Projects such as CIMSteel and COMBINE are delivering viable solutions to industry in this way.
3. Industry can expect to gain productivity benefits directly from the use of STEP technology. However, the greatest benefits will come from re-engineering business processes to maximise the advantages of a product model exchange and sharing world.
4. In addition to the direct bottom line benefits, industry can expect to improve product quality through the use of STEP technology.
5. However, in order to release these benefits, coherent industry models must be developed to include both single discipline and inter-disciplinary needs and which are flexible enough to take account of differing national and contractual practices. To maintain this coherence, the Building Construction Core Model is designed as a co-ordination mechanism.
6. A draft version of the Building Construction Core Model exists with major software vendors observing its development.
7. Projects exist within the UK and the Netherlands to facilitate building the necessary consensus for the Building Construction Core Model between software vendors and the building construction industry.

REFERENCES

1. Aouad G. et al . ICON Methodology. Integrated Databases for the Design, Procurement and Management of Construction. University of Salford, (July 1994)
2. Parand F. Building Research Establishment Environment for Design. Building Research Establishment UK, (May 1995)
3. West M. STEP: The Future of Engineering Information. (Draft). Shell International Petroleum Co. Ltd., UK. (December 1994)
4. Potential Benefits of STEP - Case Studies and Examples, Shell International Petroleum Co. Ltd., London. Report IC94-101. 1994
5. Cornick T. and Wix J. Information Transfer in Building. NEDO/Business Round Table. UK (1991)
6. ISO 10303 part 225. Building Elements Using Shape Representation. Committee Draft for Comment. June 1995
7. RIBA Plan of Work for Design Team Operation. 1973 edition.
8. Wix J. Information Flow in Building Services. BSRIA TN9/86, Building Services Research and Information Association, UK 1986
9. CI - PM Activity Model. University of Leeds. 1994
10. Michie A. Co-ordination of Building Services. BSRIA AG1/82, Building Services Research and Information Association, UK (1982)
11. Latham M. Constructing the Team (July 1994)
12. Poyet P. Electronic Mail discussion on STEP AEC Exploder. (March 1995)
13. ISO 10303 part 1 Overview and Fundamental Principles (1994)
14. ISO CD 10303 Part 225. Building Elements Using Explicit Shape Representation. Washington Draft. (June 1995)

GLOSSARY

AAM	Application Activity Model
AIM	Application Interpreted Model
AP	Application Protocol
APPP	Application Protocol Planning Project
ARM	Application Reference Model
CIS	CIMSteel Integration Standards
NIDDESC	Navy Industries Digital Data Exchange
STEP	STandard for the Exchange of Product Model Data