1. INTRODUCTION

At its 1997 meeting on 4 June in London, ISO TC59/SC13 (Building/Organisation of information about construction works) ad opted the following proposal:

Resolution Sydney 1996-7 amended the scope of the work item WD12006 to include the development of a "framework for object-oriented information exchange". Since the Sydney meeting various members of WG2 have participated in dialogues with other interested parties and outcomes include:

A paper presented to ISO TC59/SC13/WG2 titled "An information framework for the construction industry" (STABU Foundation, Kees Woestenenk, 1997).

A report presented to ISO TC184/SC4/WG3/T12/Building and Construction titled "Current building industry classification initiatives" (Richard Wittenoom, 1997).

The first of these proposes a generic framework which could be underpinned by a "list of object types called a taxonomy with defined characteristics using standardized characteristic classes".

While not agreeing that such a framework and taxonomy challenges the validity of the current proposal for a draft classification standard, WG2 regards the development of such a framework as being of fundamental importance to the future organization of information about construction works.

This work is seen as being of value to a number of ISO initiatives including the following:

- *CAD layering*
- *Product modelling*
- *Design life of buildings*
- *Terminology*

However, more dialogue is needed amongst these and other areas of interest and WG2 now proposes that such a dialogue be organized in conjunction with other ISO groups via the Internet with a view to arriving at a clearer definition of the likely outcomes than is now possible.

Accordingly, WG2 proposes:

ISO TC59/SC13/WG2 should commence a project titled "An investigation of the role of objects and object orientation in the organization of information about construction works" and all interested organizations and individuals be encouraged to participate via the Internet and the project leader be Terry Wright (Australia).

This report to ISO TC59/SC13 tries to give an account of the main issues, stakeholders and ideas for further development where the interests of various ISO activities in classification and object modelling[1] meet and/or overlap.

Some of these issues have puzzled, even troubled, the members of ISO TC59/SC13/WG2, the working group currently responsible for classification matters.

The group was working towards an international standard which was to embrace several decades of development of construction information classification when it made its first attempt to grapple with the implication of the emerging (this was the late '80s) object modelling.

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[1] I have preferred to use this term rather than the narrower "product modelling". Booch (see 5 below)) describes the object model thus:

... a sound engineering foundation whose elements we collectively call the object model ... encompases the principle of abstraction, encapsulation, modularity, hierarchy. typing, concurrency and persistence. By themselves, none of these principles are new, What is important is that these elements are brought together in a synergistic way.

Since then international interest in the object modelling of construction information has gathered pace led, in particular, by ISO STEP product modelling standards development and its recent offspring IAI IFC. The participants in these developments, it is reported, have turned from time to time to the established classifications and found them wanting.

The most obvious issue was the idea that construction “objects” needed to be separated conceptually from their “attributes” and “relationships”. The established classification systems, it was said, had tended to mix these things up by selecting views (by function, form, skill etc) of the information thus rendering them of no use for object modelling.

It was also held that apart from their use for specific applications (e.g. conventional cost planning or specifications), the established classification systems had no relevance to today’s information management.

While I must agree that a useful, general purpose, standardised classification system which serves all construction information needs has escaped my attention over thirty or so years of practice as an architect on several sides of the world, this argument may well be throwing the baby out with the bathwater.

For example, the Australian national specification system has classification needs; it has composed its own classification for its information and it is more than happy with it; the Dutch have done the same; so too the British and the Swedes. Each of these serves a particular need; problems with classification systems only seem to emerge when efforts are made to standardise them across boundaries (national or otherwise).

Given that these classifications had been designed for a traditional and very different range of functions to the specific needs of object modelling, it is hardly surprising that they didn’t provide a classification for it. This role could hardly have been on the agenda of the authors of SfB (Europe) or Masterformat (North America) as they were developed before the ideas of “object-orientation”[2] had even been borne.

On the other hand at least one British study clearly identified the need that is articulated in this report. An account of the Building Industry Code, intended for use in conjunction with the whole British education building program, said in 1969:

The most precise attempts of expression occur in mathematics, which is simply a highly specialised language. One of the branches of mathematics is concerned with the theory of sets. Language might be termed as a series of sets; in one set it gathers all the naming words and calls them nouns; in another set verbs and so on. It then has a formula on how one may arrange these words for logical expression and calls it syntax. The greater our vocabulary, that is the more words we store in each set, the greater our range of expression, and the smaller the chance of ambiguity.

In building we have developed a highly technical jargon, which is a debased language, and anyone not associated with the industry would find it unintelligible, and even to those within the industry it is fraught with danger, firstly because it is imprecise and secondly because the industry is made up of vast range of people with varying powers of intellect. This leads to ambiguity, misunderstanding and to the misplacing or loss of information. Or, where attempts are made to describe all information for all to understand, such descriptions tend to be lengthy, and to vary slightly if repeated on different documents and ultimately to be disregarded.

Ideally then communication must mean the transmission of information in a brief and succinct way and in a form which can be understood by the recipient.

[2] “Object-orientation” (OO) turns up in a variety of contexts - *OO Programing, OO Design, OO Analysis.* Booch defines the later as ... *a method of analysis that examines requirements from the perspective of classes and objects found in the vocabulary of the problem domain.*

...To establish then a precise language one must begin with the naming of parts.[3]

The “parts” have still not been named with precision but it is the conclusion of this report that a new **built object terminology** should be developed using a database structure for its development, presentation and maintenance. Whether or not such a project should commence under ISO’s auspices must await responses to the publication of this report and expressions of interest in the form of project proposals; **no such proposals have been received in the course of the preparation of this report**.

I make no apology for attempting, via my own limited understanding of the subjects reviewed, to try to explain them in more or less everyday English to readers whose understanding may even more limited than mine.

In this regard two books have been informative, useful and enjoyable and are recommended to anyone venturing into this field.

Grady Booch’s “Object-oriented analysis and design with applications” [4] says, in its blurb, that it is “the essential reference for anyone ... who want to explore this important new paradigm” and I am sure that is correct. It has a chapter on classification and includes Plato's Statesman and Aristotle’s Categories in its recommended reading.

Douglas Schenck and Peter Wilson’s “Information modelling: The Express way” [5] is an essential starting point for anyone wanting to get some idea of one of the core STEP tools. Various seminal[6] papers have been appended to this report; (relevant footnotes are underlined) apologies are extended to anyone whose work is being republished in this way without permission which has been sought wherever possible.

Finally, thanks to Kees Woestenenk, Richard Wittenoom, Robin Drogemuller and David Marchant for providing most of the ideas and trying to explain things to me at various times. They have also been able to provide useful informal links with the IS0 groups responsible for STEP and CAD layering. All of us are involved in the International Alliance for Interoperability activities with Robin Drogemuller being a member of its Specification Task Force. Kees Woestenenk and myself are active in the International Construction Information Society.

Terry Wright
Chied Executive
Construction Information Systems Australia Pty Ltd

twright@ozemail.com.au, twright@natspec.dialix.oz.au

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[3] TCWP Subcommittee on the Building Industry Code Structure, (1969), *BIC Building Industry Code*, ONWARD, and Morris, HC, (1969), *BIC, A supplement to the Handbook.*

[4] Booch, Grady, (1994), Addison Wesley, Menlo Park California.

[5] Schenck, Douglas A and Wilson, Peter R (1994), Oxford University Press, New York.

[6] Just to show that problems with semantics aren’t confined to building, this could mean “highly original and influential” or on the other hand “having possibilities of development” according to Australia’s Macquarie Dictionary!

2. HISTORICAL PERSPECTIVE[7] AND RECENT DEVELOPMENTS

For the best part of 50 years, systems for classifying construction information have been used with the aim of aiding the rational organisation, storage and retrieval of construction information. They were founded on construction information exchange media and practices - drawings, schedules, bills of quantities, specifications, models, catalogues - which have been in place a long time - for centuries, in some instances.

Attempts have been made to use these classification systems in the computer processing of construction information such as bills of quantities but hardly any have seen practical application.

The earliest example of a formal construction classification was that used by the first Swedish national building specification *Bygg - AMA (General material and work specification for building)* which was published in 1950. Called SfB after the name of the responsible committee (*Samarbettskommitten for Byggnadsfr Cgor*), the classification system, including the notation, was also used for product information and cost information in Sweden.

Interest in the classification grew in Europe throughout the ‘fifties and ‘sixties alongside an enthusiasm for systematic approaches to design and construction and early experiments in computer-aided documentation.

Since then, SfB in its various forms and successor systems has continued in use in Europe and some other parts of the world for the classification of product information, cost information, specifications, drawings and library contents. Numerous national versions have been published, most of these based on the international version published by the CIB. Probably the best known English version was published in 1971 under the title CI/SfB Project Manual. A new system, embracing some of the developments of the 1980’s has been published (1997) under the name Uniclass.

In North America, the most popular classification is known as Masterformat. Introduced in 1963, initially for specifications, its pragmatic coverage of an amalgam of products, processes and systems makes it a favourite not only in the United States and Canada but also among some specifiers in Australia and Asia. A parallel classification for elements for cost-planning is published under the title Uniformat.

Other national classification systems have been developed. Czechoslovakia’s was used for a variety of purposes including classification of buildings for legal purposes and continues in use in the Czech Republic. Sweden eventually abandoned SfB and adopted its own variant. In Australia, the classification used for the national specification system was published in its most developed form as late as 1989.

Recently, there have been efforts to arrive at internationally agreed classification tables, but progress has been slow. There is now broad agreement in the International Organization for Standardization (ISO) on a framework for tables which might be developed at a national level. ISO/CD 12006-2 (1997-08-25), the committee draft of an international standard to be called *Organization of information about construction works - Part 2: Framework for classification of information* is the most recent outcome of this work.[8]

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[7] A more detailed historical perspective is “under construction”. See Wright, Terry (1998) **C**lassifying Building Information: a historical perspective, attached as WrightHistory.pdf

[8] The ISO committee concerned is TC59 with responsibility for standardization in the field of building and civil engineering, of:

* general terminology for building and civil engineering;
* organization of information in the processes of design, manufacture and construction;
* general geometric requirements for building, building elements and components including modular coordination and its basic principles;
* general rules for joints, tolerances and fits;
* general rules for other performance requirements for buildings and building elements including the coordination of these with performance

This draft is a direct descendent of the building classification systems of the 1950s and onwards. However, the information technologies currently under development for the construction industry of the future are founded[9] on quite different concepts and include, as their central mission, the development of information-rich virtual models of products and projects and the exchange of information about and between them.

In the construction industry as well as many others, the vision now being realised, if only so far in experimental projects, is of these project models being assembled from libraries of product models and the project model being added to and modified by various participants working concurrently and being able to use the data for a variety of design and documentation tasks**.**

ISO STEP and IAI IFC

The core technology is found under the heading of STEP[10] (STandards for the Exchange of Product model data), which is multi-sector and is represented by the many parts of ISO13030 Product data representation and exchange, a standard for the computer-interpretable representation and exchange of product data. The objective is to provide a mechanism that is capable of describing product data throughout the life-cycle of a product, independent from any particular system. This makes it suitable not only for neutral file exchange, but also as a basis for implementing and sharing product databases and archiving.

A development program which is specific to the construction industry and uses a number of STEP standards is the Industry Alliance for Interoperability's Industry Foundation Classes[11] (now at release 1.5) which it describes as a library of software object classes that are commonly useful for defining shared AEC project models. The IFC provides a mechanism for object[12] sharing = interoperability across the boundaries

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* general rules for joints, tolerances and fits;
* requirements of building components to be used in building and civil engineering;
* geometric and performance requirements for components that are not in the scope of separate ISO technical committees.

Excluded are:
  * acoustic requirements (ISO / TC 43);
  * fire tests on building materials, components and structures (ISO / TC 92);
  * bases for design of structures (ISO / TC 98);
  * calculation of thermal properties (ISO / TC 163).

[9] Richard Junge recently set out (IAI presentation in Sydney by Jeff Wix) the following table of the recent history of product modelling:

Period	Focus of development	Example model
1975-85	'Pre-product models'	
1975-80	Basics of building models	GLIDE, BDS
1980-85	Models for expert systems	
1985-	Building product models	
1986-90	Generic product models	GARM, BSYSM
1990-95	Aspect and layered models	COMBI, ATLAS
1993-	STEP APs in AEC area	AP217, AP225, AP230
1995-	'Consolidated models'	BCCM, IFC
1996-	Distributed models	VEGA, "x-IFC"

[10] See "STEP on it - or miss the information revolution," and Building modelling - so what's new" , by Terry Wright, SPEcnews, July 1995, pp 11-13 attached as WrightSTEP.pdf.

[11] See Wix, J and Liebich, T; "Industry Foundation Classes: Architecture and Development Guidelines, Proceedings of the CIB Workshop W78, Cairns, July 9-11, 1997 pp 419-431 attached as WixLieb.pdf

[12] The use of the term "object" seems to need some care. The following warning may be worth noting: *"The idea that there is an obvious and immediate link between real world 'objects' and computer science 'objects' is misleading and dangerous. It is redolent of the extravagant promises made on behalf of 'entities and attributes'; the use of real world terminology deluded people into believing that the technicalities had some direct and authenticated access to reality"*. (O Brien, M J; 7, Integration at the limit: construction systems, The International Journal of Construction Information Technology, Vol 5, No 1, pp 89-98).

Booch says that because the object model derives from so many disparate sources, it has unfortunately been accompanied by a muddle of terminology. He quotes Bhaskar as observing that the phrase object-oriented "has been bandied about with carefree abandon with much the same reverence accorded motherhood". He notes that and object is any of the following:

of software applications, initially through model exchange and later through software interfaces.

ISO P-LIB

In parallel with STEP, standards for the "computer-sensible representation and exchange of part library data" have been developed as ISO 13584 Parts Library also known as P-LIB. Although developed under the auspices of the same subcommittee responsible for STEP (ISO TC184/SC4 Industrial data), the architectures and methodologies used in their development are different and are said[13] to have resulted in considerable problems for users wishing to use P-LIB for libraries of parts and STEP for exchange of information exchange of information.

A number of STEP application protocols contain requirements for reference to information in external sources and while none of these make specific reference to P-LIB it is expected that future editions will include P-LIB referencing capabilities.

Semantic integrity

As these technologies have developed during the 'nineties there has emerged a critical need for what has been called "semantic[14] integrity" - that words used should mean the same to the sender as to the receiver is one way of looking at it.[15] There are various traditional aids to achieving this aim such as dictionaries, glossaries (specialist dictionaries), thesauruses (which classify words according to their sense) ; various attempts to standardise terminology in the construction industry have long existed, of course.[16]

While these various references serve a useful function none of them have been found to be particularly helpful when it comes to establishing some kind of ordering of the common-or-garden parts of a building. Construction terms are often used most casually. A reference to a 'door' may mean a variety of things such as:

- Provision for passing though a wall usually represented by a simple diagram on a plan.
- An opening in a wall into which has been built or fitted a door-set comprising a frame, a leaf, hinges, and opening and locking mechanisms including the painting of the door leaf and fixing of signs.

- *A tangible and/or visible thing*
- *Something that may be apprehended intellectually*
- *Something toward which though or action is directed.*

He then offers a formal definition as follows:

An object has state, behavior and identity; the structure and behavior of similar objects are defined inn their common class; the terms instance and object are interchangeable.

Schenk and Wilson define an object as being a concept or physical thing which may exist in the real world. They note that the object-oriented world has its own terminology although there appears to be no consensus on exactly what it is! The following table is provided with the comment that the modelling terminology they prefer distinguishes between real world things and modelling constructs:

	Real world	Modelling	OO Programming
Generic	Class	Entity	Class
Particular	Object	Instance	Object

[13] PDT Solutions for the Product Data Technology Advisory group, "Cooperative use of ISO 10303 STEP and ISO 13584 PLIB", July 1996 at the Concertation meeting, Darmstadt which can be found at http://www.pdt2.demon.co.uk/epistle/

[14] "*Semantics deals with the relationship between representations and the world. Anything which can said to be a representation--which could be said to stand for, represent, point to, indicate,mean, refer to, or in some way be about something else--has semantic relations to that something else. Semantics is what makes the word Coffee mean that smelly muddy brown hot liquid that people drink"*. (The University of Alberta's Dictionary of Cognitive Science at http://www.onelook.com)

[15] Another way of looking at it is Humpty Dumpty's comment in Alice in Wonderland: "*When I use a word ... it means just what I choose it to mean - neither more nor less.*

[16] For example BS 6100 - Glossary of building and civil engineering terms, ISO 1803:1997 Building construction -- Tolerances Expression of dimensional accuracy -- Principles and terminology, ISO 1804:1972 Doors -- Terminology, ISO 6707-1:1989 Building and civil engineering -- Vocabulary -- Part 1: General terms, ISO 6707-2:1993 Building and civil engineering -- Vocabulary -- Part 2: Contract terms.

- A door leaf.

In a conventional classification system this ‘door’ might variously be viewed:

- As a functional element for cost planning purposes.
- As a worksection in a specification for supply and fixing of doorsets, (fixing frames may be seperate work.
- As a product in a catalogue.
- As an asset in a facilities management inventory.

Nowhere at the present time is the meaning of, and the relationship between, say Wall/Door-set/Door-frame/Door-leaf/Door-hinges articulated with “semantic integrity”. Yet commonsense seems to suggest that such an organisation of the common words and their meanings is fundamental to any consistent management of information about buildings in particular.

However a commonsense need becomes an absolute imperative once the ideas of object modelling are embraced. The absence of a precise terminology is regarded as a significant handicap.

ISFAA-97

As part of an internet discussion forum on this topic in 1997[17] numerous contributors commented on this and other issues that are central to this paper.

Charles Eastman commented on the role of semantics in computing[18]

Semantics has a long history in philosophy, and a more recent one in computing. A computer model of a building or building processes must respond to at least two kinds of communication issues.

First, it must be precise enough that a person entering information knows what is required. This applies to many aspects of our description. It applies to the “things” we describe (what is a column), to their attributes (how do you define its diameter), its relations (how do you define the structural load on the column) and its behavior (what computation is used to define its deflection).

It is obvious then that one issue is to define the terms used in this communication, what the knowledge engineers call an “ontology”. The ontology should become the vocabulary by which we communicate with the computer about the external world, for example to describe it, and for the computer to simulate or predict future external worlds, proposed in a design.

...We want to have a library of such objects, but leave open the opportunity to add new attributes for new ways of using entities. There are schemes in the literature creating objects, then classifying them (classification logic) and we can define object instances, and later specialize them, using object oriented techniques.

I take these extensibility issues to be fundamental. No object should be of a fixed class.

Anders Ekholm also commented on the relevance of the separation of construction objects from their attributes: [19]:

In innovative design it is necessary to be able to distinguish between an object and its properties. During the design process we may want to change our object both quantitatively and qualitatively, i.e. we want to add and withdraw attributes from an object that we in spite of its change still think is in some way the same. In the ISFAA-conference there seems to be an agreement that design support is an important

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[17] An internet based workshop organised by the STEP B&C subgroup to examine future information requirements of AEC projects - see http://www.wt.com.au/~ausstep/aec_libraries

[18] ISFAA-97, 9 April 1997

[19] ISFAA-97, 14 May 1997

quality of a product modelling system, and that one of the necessary prerequisites for this is a neutral construction object to which different attributes can be added and removed.

Such neutral construction objects could be provided by spatially determined objects left open for functional and compositional attributes...

It seems important to reach an agreement on what kind of spatial objects that should be used, and how different spatial properties shall be achieved. Having that, it is then necessary to agree on the most important functional and compositional attributes. The spatial attributes have been a major issue within STEP. The functional and compositional issues have been dealt with in different levels of abstraction by domain experts within TC59, ICIS and in national classification agencies.

This seems to be a reasonable division of labour, however to solve the current interoperability issues of OO-CAD a joint international effort is necessary.

Frits Tolman identified what he called "semantic interoperability" [20]

The problem of open information sharing, storing and exchanging in a multi-application and multi-platform environment (required to support Computer Integrated Construction and such) can only be solved if done on the semantical level. What is needed is that our computers learn to communicate with us and with each other is the terminology of the B&C industry itself. Anybody doubting this?

Different participants in the B&C industry use the same semantics, but with (slightly) different meaning and attribute definitions. Some participants are active in other sectors of the AEC industry as well. Some are even active outside AEC, like electrical engineers.

The main questions that we have to answer are: "How can we provide semantical interoperability between the CAxx systems of all those people, if they use different semantics?" And: "How do we maintain the semantical integrity of a project database?".

I think that these questions can only be answered if we cooperate with the Classification people. TC59 and such have been doing some work in this area, though mainly ignoring interoperability aspects, and consequently, but unfortunately with very little success up till now.

STEP, as you all know, is somewhat sloppy with semantics. Once you have developed an AAM and ARM and go through the 'interpretation' process, most understandable meaning is lost, or at least hidden in some dark corner.

I think that ... we should develop a 'neutral' unambiguous set of B&C semantics, including some basic attribute definitions (like coordinate axes). A large model, probably with a few thousand entities (though with few attributes). Probably divided in a number of smaller, or even small models, I don't mind.

Guy Pierra, developed Frits Tolman's and other comments[21]:

*... there exist two broad categories of product. The first category are those products that are more or less build from scratch. A major concern for such product is to define, to exchange and to share their *shapes*. It was the major role of the first generation of CADSsystems. It was also the kind of products on which STEP focused during its first development. As an example, in a lot of STEP documents the only example of property is the "shape".*

For such products there exist a small enough number of properties and of concepts to enable to "hard encode" them in the data model. The STEP IRs enable to specify some (say: less than one hundred) properties and/or concepts that may be described explicitly in an AP and associated with a particular information model.

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[20] ISFAA-97, 4 March 1997

[21] ISFAA-97, 28 March 1997

But there exist another category of products. AEC and B&C products fall in this category, but also piping and engineering, electronic assembly design and large mechanical assembly design. In this category, a product mainly consists of assemblies of pre-existing products (a door, a pump, a capacitor a screw), each one with its own specific "technical properties": maximum_working_temperature, nominal_pressure, theaded_length, ...

Here the number of involved concepts, components and properties change its order of magnitude. For instance, SIEMENS use several thousand of such technical properties to describe, to model and to exchange its elector-technical components.

For this kind of product, the remark from Bill Burkett applies:

*"Our objective is to enable all the agents involved in CIC to communicate unambiguously via shared data access and exchange. In order to do this, Frits predicts (conservatively, I believe) a model with a few thousand entities. The problem that I feel we will face is that it is impossible for any one person or group of persons to understand a data model of this size. And a comprehensive understanding such as this will be necessary to ensure the *unambiguous* exchange of data. I have heard it estimated (I unfortunately cannot remember the source) that a practical upper limit for the understandability of a data model is 200 entities."*

This means that a completely different approach shall be used to model this huge number of concept and properties.

The solution is outlined by David Marchant using the natural language metaphor:

"The various postings regarding a language for communication and my postings regarding a generalised model, I think anyway, are both aimed among other things at just this point. By modelling an unambiguous grammar which is then populated by defined terms, we have a viable alternative to a profusion of data models.

"For example, we are now communicating in the English language, obeying its rules of grammar (hopefully) and using words which are defined in an English dictionary, or if not we need to define our terms on-the-fly. Most of us have command of several thousand terms, and where we do not know one we could look it up in the dictionary. Therefore we are operating in a kind of meta environment in which the terms can be seen as the data being instantiated as we communicate. I concede that the English language is not always unambiguous - but this only reinforces the point of tightly defining a grammar.

In fact, what we need in product modelling, is a two level modelling architecture:

At the product data model level we use symbols (the "terms" from David) that represent either a particular kind of product (e.g., a door, a pump) or a particular property (e.g., its working-pressure). These symbols are used to define the semantics of a particular component or to define the particular value of a particular property for particular component (e.g. working-pressure = 20.0).

These particular symbols are defined in a computer-sensible and human-readable dictionary that may be exchanged together or separately form the product model.

As pointed out by David, such a dictionary shall be slightly different from the English Oxford dictionary.

It shall be un-ambiguous: this means that it shall be based on a strong, formal and knowledge-oriented information model.

It shall be both human-readable and computer usable (and exchangeable).

It shall define an un-ambiguous "symbol" this means a data structure, to reference a dictionary entry from product model data (in PLib, such a symbol is called a Basic Semantic Unit or BSU).

The information model of such a dictionary is usually called a meta-model, and the data that describe each entry are called meta-data: with respect to a product data model, they are the data that describe the data that appear in this model (e.g., maximal-

pressure = 10). The necessity of such meta-models and meta-data is largely recognized for electronic business. There was a workshop organized by ISO JTC1 in Bellevue last September that gathered all the standardization Committees working in this area, and a new workshop will take place in Stanford next July. ISO TC184/SC4/WG2 is an active participant of this effort.

Other views

At its October 1997 Florence meetings STEP/WG3/T12/AEC/Building construction sub group stated[22]

One of the items being carried out by TC59/SC13/WG2 is the development of an object based classification framework. This model will be populated from data from a dictionary which is being developed as part of the work by Kees Woestenenk (with the support of ICIS). The AP221 and POSC/CAESAR project teams have also spent some time developing STEP-LIB data dictionaries which are similar in character to the dictionary produced within TC59.

The BC subgroup of WG3/AEC have expressed the view that it might be appropriate to use this work as the basis of a glossary of agreed terms for use throughout the AEC (and, possibly, the wider STEP) community. Under current arrangements, AP developers produce their own lists of terms and definitions - for AAMs, scope statements, data models and other sections of their documents - on an ad hoc basis and it could be of considerable value to AP developers if they were able to select terms and definitions from a shared Semantic repository.

Dutch BAS project - Construction Industry Protocol

A Dutch group has commenced[23] the development of Common Objects which are types of concepts which could be shared by the (construction) industry as a whole, independent of a particular use of, or view on these concepts. Common Objects are identified by names which are part of the ‘industry language’. Common Objects are defined by Descriptors (used in the meaning of ‘descriptive data of a Part’), which should also be common, in order to be interpretable in different environments and applications.

Though Common Objects are not dependent on view or use, they live by nature within a limited environment. For example a ‘Floor’ is a typical part (component) of a building, but not a typical part of a bridge. A ‘Deck’, on the other hand, would be a typical part of a bridge, and not a typical part of a building, whereas a ‘Parapet’ could be a typical part of both a building and a bridge. Thus, there are limits to the ‘commonness’ of a Common Part, and, similarly, there will also be limits to the ‘commonness’ of Common Descriptors.

Work has commenced on the following tasks, under the auspices of the Dutch BAS (translates as “Construction Information Protocol) Association,

- To develop a meta-model for Common Objects and their Descriptors.
- To define Common Descriptors (data types), irrespective of the described Part, which could be used for the description (definition) of Common Objects as well as for the description of user defined Objects. Such a set of Descriptors should be compatible (as far as possible) with already defined data types in standards and regulations.
- To populate a library, or a set of libraries, with populations of Common Objects in certain environments, predefined with Common Descriptors, to provide for interoperability between applications and between different domains in the construction industry. Such libraries should be harmonised with Class Libraries and Component Libraries currently under development.

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[22] Several requests have been made to this sub-group to provide an explanatory and exploratory paper a contribution to this report but there has been no response.

[23] This is a digest of an email from Kees Woestenenk. See his discussion paper (April 1998) IASI Built Objects Library attached as Woestenenk.pdf

The Construction Information Protocol (CIP) differs from existing classification systems in the following ways:

- CIP makes a rigorous distinction between Objects and their Descriptors, whereas existing classification systems are mostly a mixture of both.
- Existing classification systems are Aspect oriented, by *grouping* Objects by Aspect, whereas CIP is Type oriented by *identifying* Part types by their set of defining properties. Aspect orientation implies how Objects behave in their environment (what roles they play), Common Objects, on the other hand, are defined by (intrinsic) properties, resulting in potential behaviour (extrinsic properties) and potential involvement. By definition, an Aspect orientation provides a single view, whereas Type orientation allows for multiple views associated with the same Part.

France - PIPPIN[24]

The BAS project has arisen directly from the needs identified by the Dutch national building specification STABU. In a quite different domain - of process plant product modelling - work on 'meta-data' for technical objects was initiated five years ago as a joint effort of ISO TC184/SC4/WG2 and IEC SC3D

The information model for a dictionary of properties and of component has been published twice (for administrative reasons!), both as IEC FDIS 1360-2 and ISO 13584-42 (P-LIB).

Several Committees are already developing dictionaries compliant with this information model:

- A dictionary for electronic components and properties (that define several thousand of technical properties) has just been published as an IS (IEC 1360-4). It will be, in particular, referenced by AP[25] 212 (Electrotechnical design and installation) and AP 210 (Electronic assembly, interconnect and packaging design).
- A dictionary for component and properties involved in AP 221 (Plant functional data and their schematic representation) has been developed and proposed. It is intended to be part of AP 221. Its current version contains hundreds of properties.

Several product standardization committees are developing P-LIB-compliant dictionaries (e.g., ISO TC29/WG34 for machining tools)

The capability to reference such dictionaries from STEP AP has been worked out by WG10 using as test case AP 212 and AP 221. It is now possible for any AP to make reference to a P-LIB-compliant dictionary .

This dictionary structure (defined by ISO FDIS 13584-42) is compatible with a catalogue structure (defined by ISO CD 13584-24), this means that it is also possible to exchange not only definitions of concepts (e.g., a "pump", called in P-LIB a dictionary definition) but also (implicitly) the particular instances of this concept in a particular catalogue (called, in P-LIB, library specification).[26]

Australia - Lexis

In Australia CSIRO-BCE reports it is developing "Lexis" which is intended to provide a foundation of a language that will support the storage, access, exchange and understanding of application specific information.

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[24] Pilot Implimentation of Process Plant .....? A definition classification for AP221 Objects edited by D Langlois has recently been published. This specifies within two dictionaries:

- *The definitions of properties for components and materials used in process plant.*
- *The definitions of the component classes with associated classification scheme.*

[25] AP=STEP Application Protocol; the numbers are the parts of the STEP standard ISO 10303

[26] This is a digest of information provided by Guy Pierra as part of the ISFAA 1997 forum (email 27 March 1997). See his paper "Industry requirements for intelligent electronic catalogues" attached as Pierra.pdf. He commented *"This dictionary structure being an abstraction of the common requirements of both the mechanical/engineering community (the ISO side) and the electronic community (the IEC side), I think (hope) that this structure should meet the requirements of AEC and B&C."*

At this point, says its author Howard Leslie, Lexis has evolved into two distinct but closely related components.

- Lexis Core - is a data dictionary in which the objects (not all physical) are reduced to simple indivisible concepts. The concept 'wall' is defined in the core. So too is 'width', 'acoustic transmission', 'capital cost', 'is_composed_of'. The 'internal wall' and 'external wall', compound concepts, are not. They would be found in one or more Views.
- Lexis View(s) - are application specific classifications built out of the 'kit of parts' provided in the Core. Views, which might include capital cost, recurring cost, structural frame, external closure (thermal envelope), emergency egress, are to be developed and maintained by the relevant interest group.

The wall, a simple concept in the core, becomes a compound one in a view. For example the wall, qualified by its location (external), dimensions and capital cost, would be part of 'external fabric' in a Capital Cost View. Alternately, the same wall, qualified by, its location (external), dimensions, and thermal performance, would be part of 'external closure' in a Thermal View.

A 'flow' View was developed to manage concepts as they evolve over the project life-cycle. For example, a project brief might identify two activities (lxsSettings) - one noise generating and the other noise sensitive. The need to avoid conflict will introduce lxsSeparator, a notional object that identifies a required acoustic performance. During design, if operational requirements demand, they might be adjacent to one another and a wall - with the required acoustic performance - introduced. Later this generic wall will become a specific one (eg. 110mm solid brick) with the relevant specifications, construction details, materials list and position in the construction schedule.

The Views, built using common concepts from Core, provide the project decision-maker with domain specific filters with which to isolate and relate the systems and components (operational, shell and service) relevant to a particular set of decisions or actions.

The draft document Lexis Cost, developed jointly by the Australian Institute of Quantity Surveyors and CSIRO-BCE, is the first view. Others are said to be planned.

Lexis, along with the information framework, is intended to be developed and maintained by the building and construction industry. Its purpose is to provide an industry agreed library of objects that support clear, concise communication between the project stakeholders.[27]

[27] By email from Howard Leslie, CSIRO-BCE, Sydney. See also Information management in the construction industry attached as Leslie.pdf

3.0 TOWARDS A CONCLUSION

This paper started with an acknowledgement by ISO TC59/SC13 of a need for it to chart a path through the developing technology of object modelling generally and building product modelling more specifically. It has identified a number of streams of activity, some closely related, some even overlapping within the international standards community.

How do these relate to the established interests, indeed formal terms of reference, of TC59/SC13 in terminology and classification? Is there a role for it in the object modelling environment?

Under the possibly apposite sub-heading of "Bringing Order to Chaos", Booch[28] suggests:

When designing a software system, it is essential to decompose it into smaller and smaller parts .. in this manner we satisfy the very real constraint that exists upon the channel capacity of human cognition: to understand any given level of system, we need only comprehend a few parts (rather than all the parts) at once.

One approach to this, the "top-down approach" is one we are all familiar with, he says. He describes this as algorithmic decomposition and illustrates it with the following structure chart.

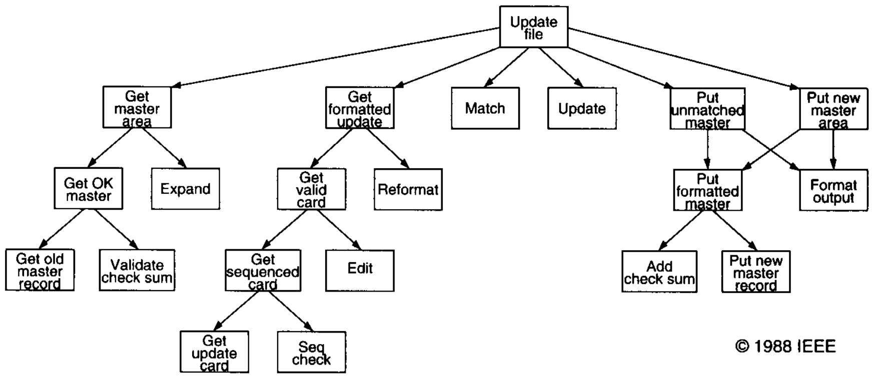

Figure 1: Algorithmic decomposition - the top-down approach.

An alternative, the object-oriented approach, is suggested in which the system has been decomposed according to the key abstractions in the problem domain:

[28] (1994), op cit.

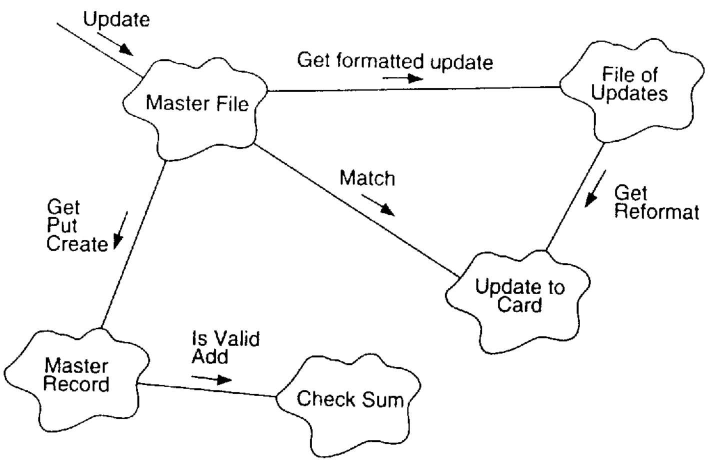

Figure 2: Object-oriented decomposition

Rather than decomposing the problem into steps such as “Get formatted update”, objects have been identified which derive directly from the “vocabulary of the problem domain”.

There is no “right” approach says Booch because both views are important: the algorithmic view highlights the ordering or events and the object-oriented view emphasises the agents that either cause action or are the subjects upon which these operations act. This duality of views, he says, has been studied since ancient times.[29]

The duality can perhaps be expressed another way as in Figure 3 by David Marchant.

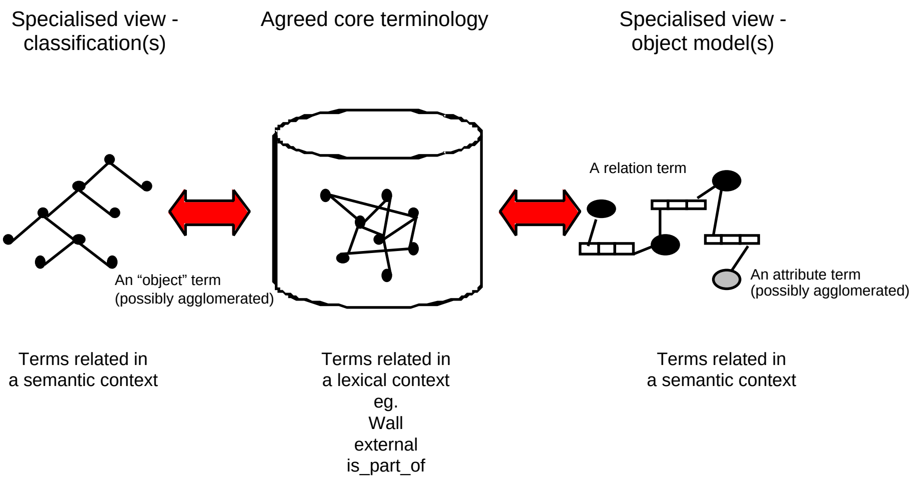

Figure 3: Overlapping interests in core terminology

]Here Marchant suggests that the seperate views of the world (which Booch describes as “orthogonal”) of traditional classification and object modelling have, in fact, a common interest in what he labels a “core terminology”.

It would seem to be this “core terminology” that the commentators cited earlier are seeking; object modelling developments in the construction area are clearly handicapped by its absence. The expectation seems to have been that it could have

29 A passive view was proposed by Democritus who held that the world was composed of matter called atoms thus placing things at the centre of focus; a more active view was taken by Heraclitus who emphasised the notion of process.

been found in the established glossaries, thesauruses or classification systems but this has not been so.

Marchant has suggested that the development of a new and precise “core terminology” could use a database structure and provide the flexibility needed for initial and continuing review. He has suggested the datamodel in Figure 4 as a possible approach. The term “lexeme” has been used for the core item (*“LEXEME: term used in some linguistics to identify the fundamental reference which underlies and thus unifies the varying inflections of a word (compare agglutinating, inflecting, isolating). e.g., "run, runs, running, ran" are variants of the lexeme "run.").*

The aim would be to reduce lexical concepts to absolute “atoms” so that the combinations can be assembled to suite different viewpoints without each imposing an a priori view on another. The trick would be to capture definitions which are as context neural as possible. A database used for development would initially provide a medium for a rigorous review of all mismatches in the core terminology and could, for example, address key variables such as

- Definition
- Type (noun, adjective etc)
- Relation and RelationType
- Context and ContextDescription
- Actor and ActorDescription

Eventually, the database would be the form in which the terminology was published, and, of course, maintained. Multilingual versions would be an inevitable development.

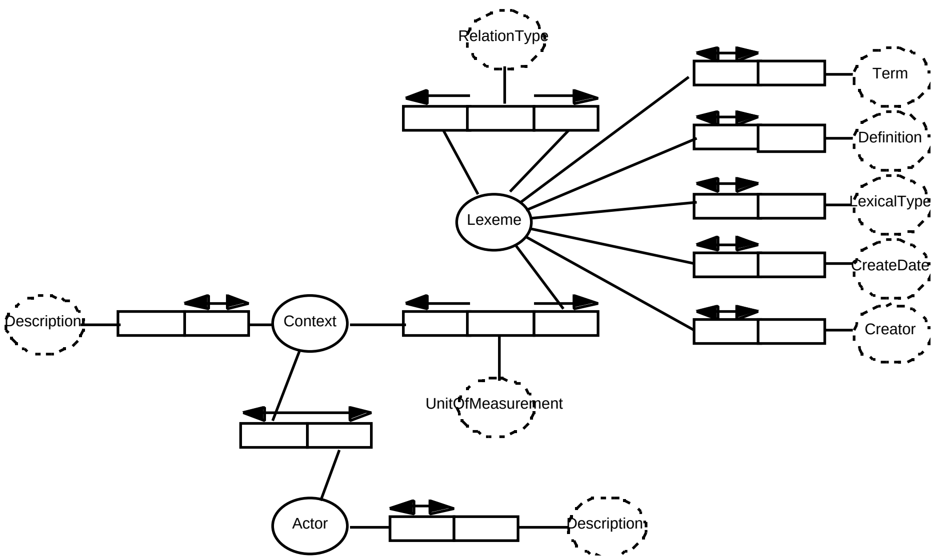

Figure 4: preliminary data model for a core terminology database (draft)

A prototype database has also been developed by Kees Woestenenk to demonstrate his own ideas and he has recently given a lexical emphasis to the Dutch BAS project with this abstract which has been submitted for a forthcoming conference on product modelling

The objective of this research is to identify and define a formal vocabulary for the storage and exchange of information in the construction industry. Such a vocabulary *could be helpful for the integration of models and literature, and hence for the interoperability between models.*

Traditional tools in this area are classification, thesauri and glossaries, as well as standards in which terms have been defined. Of these, standards and glossaries contain real definitions of the meaning of a term, whereas classification and thesauri only group terms by view or use. The problem with terms defined in standards and glossaries is that the definition is of limited scope and often not computer interpretable. Global scope and computer interpretability are prerequisites for terms used in and between models.

The proposed solution is to identify 'Built Objects', which are the results, or intended results, of construction activities. Built Objects are defined by a set of Characteristics, can be identified by an Identification and pass through several States during their lifetime. On the other hand, Built Objects are associated with other Built Objects, or with the 'Environment', with Association Types such as Location, Composition and Involvement. This together forms the framework for the vocabulary.

A framework of this type is under construction in the Dutch BAS project, and will also be brought to the international platform for discussion, and, possibly, population.

Both Marchant (“core terminology”) and Woestenenk (“formal vocabulary”) have articulated in different ways the main thrust of this report which is that a new

vocabulary	)				
terminology	)				
lexicon	)				
lexis	)				
glossary	)				
dictionary	)				
classification	)				
ontology	)	of common	(*built objects*		
taxonomy	)	terms for	(*building parts*		
hierarchy	)		(*construction objects*	and	(*properties*
					(*attributes*
					(*roles*
					(*relations*

is needed for the object modelling of construction information and should be the subject of international effort.

It is proposed that such an effort be directed a “**built object terminology**” whcih should be so-called because

- the domain is what may, will be, is being or has been ‘built’ - “constructed” is too broad a term in this context,
- expression must be given to the concept of “objects” as understood in this context
- “terminology” *(1.the system of words used in a particular subject 2.thscience of the proper use of terms*) is the most precise term available for what it is that needs to be produced).[30]

The international effort might be directed as follows:

- An appropriate sponsoring organisation with a broad interest in construction information management should assume responsibility for the effort. At an

[30] Some candidates such as “ontology” or “taxonomy” may be too broad. “Dictionary” and “glossary” generally refer to books which explain meaning often giving a choice.

international level CIB (Council for Building Research Studies and Documentation), ICIS (International Construction Information Society) and IAI (International Alliance for Interoperability) have appropriate credentials.

- National members of these bodies might also have the capacity to assume responsibility for this work.

- Specific development tasks might be the subject of research grants and/or be delegated to appropriate research instituitions.

- The outcomes of this development process could then be brought forward for further development as an international standard.