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The principles of a classification system for BIM: Uniclass 2015

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Abstract: This paper describes those principles of the new UK construction-sector classification system, Uniclass 2015, which are specifically intended to serve built-environment information modelling (BIM). Though only seven tables have been officially published at the time of writing, others have been published in draft for comment, and others have been drafted. This paper cuts across them all. Basic requirements for the classification system were spelled out in a 'functional specification', which was developed some time after the first ten tables had been published in draft. Uniclass 2015 at that point already met all but one of these requirements, and had developed a number of other principles not identified in the functional specification.

Keywords: Classification; Uniclass 2015.

1. Introduction

If all construction project information is to be held centrally, for access by all along the entire project timeline, as it is in built-environment information modelling (BIM), then this information should be organised using a classification system that supports these needs. Existing classification systems, such as Uniclass 1997 (CPI, 1997) and the North American OmniClass (CSI/CSC, 2006 to 2013), do not fully support them, though they could be bent to this purpose. Critiques on the two have been published (Gelder, 2011 and 2013 respectively).

The framework for such a classification system is described in ISO 12006-2:2015 *Building construction – Organization of information about construction works – Framework for classification*, for which the author was the UK expert. By 2006 the author had begun to devise a classification system that would eventually implement and extend this standard. The author developed this system, now known as Uniclass 2015, with input from colleagues at RIBA Enterprises, and others, in the UK to mid-2014. For an outline of its development, see Table 1 (and Gelder, 2015). Unlike Uniclass 1997 and OmniClass, it is unified, and aligns to the ISO.

At that point the UK government commissioned a competition for the development of a classification system, using a 'functional specification' to brief the work (SBRI/TSB, 2014). The team

proposing to run with Uniclass 2015, led by RIBA Enterprises, for which the author was working at the time, won the competition.

Table 1: The development of Uniclass 2015.

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Development of Uniclass 2015	•	•	•	•	•	•	•	•	•	•	•
Release of first 10 tables for comment							•				
Release of first 7 official tables										•	
Development of ISO 12006-2:2015						•	•	•	•	•	
'Functional specification' published									•		
UK government mandate for BIM level 2											•

This team developed it further, particularly to better deal with transport and utilities infrastructure, and the first official tables were published in 2015 (RIBA Enterprises, 2015). Uniclass 2015 is now the UK Government's official construction sector classification system, and is a part of its BIM Level 2 resource set. It is being used already in a several UK BIM tools, and a number of Australian organisations have expressed an interest in it.

For this paper, which explores some of the principles of Uniclass 2015 relevant to BIM, the author has used mostly published material in the public domain, but brought up-to-date, rather than unpublished documents internal to NBS, as the basis for discussion.

As a classification system, Uniclass 2015 comprises a number of tables, each dealing with a different object class. Seven of those tables have been published for use, but others have been published in draft, and others have been developed to varying degrees. This paper refers to them all, but readers should be aware that some of the published tables are quite different to the published drafts for which the author was primarily responsible. This paper describes the author's own views. Table 2 shows these tables, against those identified in ISO 12006-2, and those in OmniClass. It can be seen that Uniclass 2015 extends both in scope (on Work results, see 9.2).

The largely after-the-fact 'functional specification' had seven main requirements for the classification system, discussed in order:

- Digital, quick to use, and free.
- Unified.
- Cross-sector (e.g. buildings, geography, infrastructure), cross-discipline, cross-role and cross-purpose.
- Full asset lifecycle (e.g. development, use, FM, demolition).

- Consider legacy classification systems.
- Compliant with ISO 12006-2:2014 (now 2015).
- Integration with barcoding.

Table 2: The classification tables in Uniclass 2015.

ISO 12006-2:2015	Uniclass 2015	OmniClass 2006-2013
A.2 Construction information	Form of information	Table 36 Information
A.3 Construction products	Products (published)	Table 23 Products
-	-	Table 41 Materials
A.4 Construction agents	Agents	Table 33 Disciplines
	-	Table 34 Organizational roles
A.5 Construction aids	Construction aids	Table 35 Tools
A.6 Management	Project management (draft)	Table 32 Services
A.7 Construction process	Project phases (draft for comment)	Table 31 Phases
-	Regions (draft)	-
-	Districts (draft)	-
A.8 Construction complexes	Complexes (published)	-
A.9 Construction entities	Entities (published)	Table 11 Construction entities by function
	Entities by form (draft for comment)	Table 12 Construction entities by form
-	Activities (published)	-
A.10 Built spaces	Spaces (published)	Table 13 Spaces by function
	-	Table 14 Spaces by form
A.11 Construction elements	Elements (published)	Table 21 Elements (includes Designed elements) (UniFormat)
-	Systems (published)	-
A.12 Work results	-	Table 22 Work results (MasterFormat)
A.13 Construction properties	Properties	Table 49 Properties
-	Modelling (draft for comment)	-

2. Digital

Uniclass 1997 was only available in book form, and had to be paid for. CPI did not consider that it needed to be maintained. OmniClass tables are delivered online in PDF and Excel formats, with irregular updates, and are free, which is an improvement. But neither are delivered in an on line digital format which would allow rapid searching across all the tables simultaneously. Uniclass 2015 has been published in such a format. The format is also designed to support search by synonym, which could be an alternative English-language term for the object in question, or a foreign-language term. This was also a requirement of the functional specification.

The functional specification recognized that a working classification system will never settle. Uniclass 2015 is dynamic. It can only realistically be published, and maintained, in an on line digital format.

3. Unified

Existing classification systems such as Uniclass 1997 and OmniClass are not unified. Many of their tables were developed independently and do not align where they could. This is perhaps acceptable in a pre-BIM environment in which each table has just one main silo user (e.g. quantity surveyors conventionally use Elements, specifiers use Work results, manufacturers use Products). But where use of many tables is

needed by a collaborating user, as it is for BIM, this is problematic. A unified classification system, in which similar principles are used in every table, is preferred.

3.1. Congruence

Uniquely, the Uniclass 2015 tables are congruent. They have similar terminology, sequencing, grouping (bracketing) and coding as far as practicable. This principle is intended to make it as simple as possible to use the classification system along the timeline, i.e. for object classes along the hierarchy. This is essential for the compositional view of modelling, in which parent objects are mapped to smaller 'part-of' objects, in turn mapped to their smaller 'part-of' objects. Once a user has learned the classification mode for one table, the chances are that it will also have been used in other tables of interest.

High-level objects are classified using the same terms and codes for functions. For example, the system has Co-30 for *Industrial complexes*, Ee-30 for *Industrial entities*, and Ac-30 for *Industrial activities*. At the lower level of Systems, we have Ss-40-30 for *Industrial FF&E systems* (i.e. 30 indicates *Industrial*). Other congruences in Uniclass 2015 include the concepts of structure, openings and coverings being applied to both fabric sub-Elements and fabric Products and, on the services side, the concepts of sources, distribution and outlets being likewise shared by sub-Elements and Products. The Project phases table and the Project management table share the concepts of phases (e.g. briefing followed by concept design) and standard activities within each phase (e.g. execution followed by verification). The Modelling framework uses the same performance requirements for high-level object classes, and another set for Entities down to Systems. The services groupings are the same from Regions down to Systems. The Elements and Systems tables align at group level. Temporary work systems align with permanent work systems. And so on.

There are no such congruences in Uniclass 1997 or OmniClass. Every table is a one-off. The critiques already mentioned give examples.

Applying this principle requires some discipline. Because of congruence, if the content of one table is changed, it is likely that the content of others will need to be changed too. This is a good check on whether the proposed change makes sense.

3.2. Coding

All the tables are coded numerically, with each level having two digits, with only the table identifiers being alphabetical (and meaningful, e.g. Ee for Elements). This is better than Uniclass 1997, in which tables are variously alpha-numeric, numeric or alphabetical, and the table identifiers are alphabetical with no meaning (e.g. Table J). It is a small improvement on OmniClass, in which table identifiers are numerical with no meaning (e.g. Table 22).

Within each table the object of interest (the System or the Product, for example) is always at the bottom level. This is not the case in either Uniclass 1997 (except for Tables J and K) or OmniClass. The number of levels in the various tables in Uniclass 2015 is also fairly consistent (most have 3 or 4), again unlike its predecessors: OmniClass ranges from 2 to 8, Uniclass 1997 from 2 to 7.

The code 00 is not used at all – the coding stops at the level being studied (e.g. Pr-45 rather than Pr-45-00-00-00) to indicate a collection of objects, i.e. that the user is not at the lowest level in a table's hierarchy. This is unambiguous, unlike OmniClass where the 00 code could be a collection or an object.

3.3. One object class and one classification mode per table

Uniclass 2015 has one object class, and one classification mode, per table. Uniclass 1997 and OmniClass do not always do this. For example, in OmniClass the Spaces (by function) table also includes classification by planning type. The Spaces (by form) table includes a legal and geopolitical classification. Similarly, Uniclass 1997 Table E Construction entities offers alternative approaches to classification for buildings and bridges. Table D Facilities describes three object classes (Complexes, Entities, Spaces), but none of them completely.

4. Cross sector

A key requirement of the functional specification was that the classification system serve all sectors and so be sector-neutral. Work towards this objective had been underway since 2006, starting with a proposal for mergers of the separate building and civil tables for Elements and for Work sections in Uniclass 1997. This idea has been extended so that all tables must serve buildings and landscape, transport and utilities infrastructure, and process engineering. The first ten tables published in draft for comment had reasonable content for building and landscape, reflecting the author's expertise, but left room for objects serving other sectors. Transport infrastructure has since been added to the seven tables that are now officially published – Complexes, Entities, Activities, Spaces, Elements, Systems and Products.

The tables in Uniclass 1997 and in OmniClass do not serve all sectors evenly (Gelder, 2011; 2013). OmniClass, for example, is skewed in the Spaces (by function) and Products tables towards healthcare. Uniclass 2015 aims to be more balanced.

A good example of sector-neutrality is the way that Products have been classified. They are not classified by sector: there are no tables, or parts of tables, for landscape products, or transport infrastructure products, for example. Nor are they classified by the Systems they serve: there are no tables for Air-conditioning products, or Walling products. Rather, Products are classified pragmatically by their function (e.g. *Metal* primers), material (e.g. *Clay* bricks), form (e.g. *Centrifugal* fans), or a mix of the three – generally whatever seems to make sense to manufacturers, suppliers and specifiers.

The classification system also had to serve all disciplines, roles and purposes, and so be discipline-, role- and purpose-neutral. For example, the Project phases and Project management tables recognise that procurement is not just about the construction phase, but occurs in all phases of the project. Uniclass 2015 is not an object library, a plan of work, a method of measurement, a manufacturer catalogue, or a specification. But it has to be able to be used equally easily for all these applications, and others besides.

5. Full asset lifecycle

The functional specification required the classification system to serve the entire project life cycle. This requirement has been met in a number of ways.

5.1. Object hierarchy

Uniclass 2015 sets out a continuous hierarchy of mutually-exclusive physical object classes, from Regions down to Products. This aligns roughly to the timeline: when designing, a designer starts with high level objects, such as Complexes, and ends with low-level objects, such as Products. When

constructing, one works the other way round. Builders start with Products, assemble them into Systems, which assemble into Elements, and so on.

This hierarchy is very similar to the hierarchy in ISO 12006-2:2015, and so will be found in many classification systems around the world (eventually). However it includes Regions, Districts, Complexes, Activities and Systems, unlike Uniclass 1997 and OmniClass – they do not have complete continuous mutually-exclusive hierarchies. See Table 2.

5.2. Project phases and Project management tables

The Project phases and Project management tables embody the entire project timeline, from before inception to after deconstruction, and give all phases equal status. The construction phase does not rule the classification system.

5.3. Specification

A key insight in the development of Uniclass 2015 was that the specification serves the entire time line (Gelder, 2014a). And so, the brief is a type of specification, as can be seen in ISO 9699 and its predecessor (O'Reilly, 1987). At the other end of the timeline, the operation and maintenance (O&M) manual might be better viewed as an O&M specification.

The written description for a project is not just of Systems and Products (the conventional construction specification), but also of all other object classes relevant to the project. It evolves along the timeline, with new information being added, about lower object classes, and older information, about higher object classes, becoming redundant. In traditional IT this redundant information is discarded, but in BIM it is retained in the model for future reference and back-checking.

This insight suggests that introducing a standard structure to specifications all through the timeline, based on Uniclass 2015, would be very beneficial in a BIM environment. Currently briefs, construction specifications and O&M manuals have quite different structures, creating time silos, but for no good reason. The Modeling framework provides this structure.

6. Legacy considered

The functional specification required the classification system to draw upon precursor classification systems where relevant. Uniclass 2015 drew upon ideas and concepts in a number of existing classification systems, including Uniclass 1997 and OmniClass.

The idea that the object of interest should always be at the lowest level was borrowed from Uniclass 1997 Table J, as were the groupings for services (e.g. 70 Electrical), used from Regions down to Systems. The idea of two digits per level was borrowed from OmniClass. Uniclass 1997 Table D Facilities was used as the basis for the Regions, Districts, Complexes, Entities, Activities and Spaces tables, and for FF&E Systems, in Uniclass 2015. This was key for the development of congruence.

The concepts implemented for fabric Elements were borrowed from Uniclass 1997 Table G, which has a simple set of technically-neutral fabric elements (e.g. External walls), all made up of standard technically-neutral sub-elements, e.g. Core fabric and External finishes. These ideas were extended to Elements of other kinds.

7. Compliance with ISO 12006-2:2015

Compliance with ISO 12006-2:2015 (not actually published at the time) was a key requirement of the functional specification. The advantage of compliance is that a complying classification system from one jurisdiction should be able to have its various tables relatively easily mapped to those of another. Both will have implemented Elements, for example, using the same definition for this object class.

This standard sets out an internationally-accepted framework for classification. The author was the UK expert on the working group for the 2015 edition. This work began in 2011, before the functional specification was published. Compliance with the standard (and vice versa), which is based on the 2001 edition, was always the intention in the development of Uniclass 2015.

Uniclass 2015 was one of the first classification systems to work to the new ISO definitions. These differ from the old. For example, an Element was defined in the 2001 edition as a 'construction entity part which, in itself or in combination with other such parts, fulfils a predominating function of the construction entity', but is now defined as a 'constituent of a construction entity with a characteristic function, form, or position' – the function of an Element is no longer the only way it can be classified. OmniClass is geared to the definitions in the 2001 edition. Uniclass 1997 is aligned to older definitions, given in a precursor document to the 2001 edition.

8. Integration with bar coding

This requirement in the functional specification was wrong-headed. Bar codes are developed by manufacturers on an ad hoc basis, apart from the first few digits which represent the country in which the coding was applied. No universal classification system is used. Some individual manufacturers might have their own, but these will only be used by them. There is nothing for the Uniclass 2015 codes to map to, in other words – this would have to be done for every individual product. Furthermore, barcodes must be scanned visually by the reader. Most objects in a building or other entity are hidden, remote, or both. Barcodes cannot be overwritten, or updated, along the timeline.

However, it is possible for the classification to integrate with radio-frequency identification (RFID) tags, quite easily. This does not need mapping between Uniclass 2015 and whatever classification is used in the RFID tag. Depending on the type of tags, they can be written with data from the BIM, using the open-BIM IFC file format if desired. The Uniclass 2015 code can be held directly in the RFID tag. Furthermore, RFID tags don't have to be visible to be accessed, and can be accessed remotely, depending on the size of the tag (or aerial). They are much better suited to ID labelling of objects in a building than barcodes. They can also be overwritten, or updated, along the timeline. At deconstruction it is therefore possible for the RFID tag to hold a potted history of that object. This idea has been demonstrated live (Swift *et al*., 2015).

9. Other principles

At this point the paper examines some minor requirements of the functional specification, and looks at some other principles developed for Uniclass 2105 (Gelder, 2014b).

9.1. Procurement neutrality

Uniclass 2015 takes the view that a clay brick is a clay brick. It does not have separate classifications for the various routes by which a clay brick (or a classroom, or any other object) might be procured. This

means that concepts such as imported, locally-sourced, second-hand, off-the-shelf, factory fabricated, hand-made and site-made are treated as properties of the object (along with colour, density and so on).

Likewise the Project phases table is neutral in terms of whether the project is of the traditional construct-only kind, design-and-construct, construct-and-Soft-Landings (BSRIA, 2014), design-construct-operate-transfer, or any other permutation of procurement. The table accommodates them all. This applies also to the Modelling framework, and the Project management table.

Uniclass 2015 is also scale-neutral. Products can be tiny (a staple) or huge (a tree), as can Entities (a garden shed, or The Pentagon). A rigid approach to granularity is not driving the classification system.

9.2. Work results and Modelling

Uniclass 2015 is perhaps unique among construction-sector classification systems in that it does not have a Work results table. This traditionally describes the work of the building trades, by describing Systems and their Component products in the one section, and so is a basic component in construction specifications. It is replaced in Uniclass 2015 by the separate tables for Systems and Products, where Systems are typically executed by trades. Because all the object classes are mapped formally, and digitally, to their children, using the Modelling framework, the traditional Work sections table, which combines Systems and Products in an informal way, is redundant.

However, NBS Create (a BIM-ready specification library produced by RIBA Enterprises), which implements the Modelling framework, allows the specifier the choice of views: separate Systems and Products sections (with no repetition of Products common to several Systems), or combined Systems and Products sections, the traditional 'work sections' view, with repetition of Products common to several Systems. These are simply alternative views of the same BIM-ready database.

The ISO recognizes that 'work' is much broader than the business of the construction trades. For a given project, it includes pre-design work, design work and maintenance work too. Design work starts with Regions, in principle, and drills down the object class hierarchy, as has been noted. Construction work doesn't stop with trades (Systems and their component Products). After all, the combined trades efforts result in Entities such as buildings and bridges, and built collections of these, with all the interstitial landscape, aggregate to Complexes, and so on all the way up to Regions. So specification sections for all these object classes, along with associated geometry, describe 'work'. The ISO recognizes this. The traditional trades view of a project – Work results (as implemented in the 2001 edition of the ISO, in OmniClass, and in Uniclass 1997) – doesn't cut it for BIM.

The Modelling framework deals with part-of relationships (children are 'part of' their parents) so, strictly speaking, is not a classification table, classification being about type-of relationships, as the ISO makes clear. The framework is, properly, outside the scope of the ISO. However, the concept of a Modelling framework is not an unusual idea. For specifications it equates to the widespread idea of a standard section structure for construction specifications, seen in implementations of the North American SectionFormat (not a part of OmniClass – CSI/CSC, 2009), in NBS Create (this standard section structure is embedded in the Modelling framework), and in other specification libraries such as NATSPEC in Australia.

9.3. Migration and mapping

The functional specification required legacy classification systems complying with the ISO to be mapped, and in due course migrated, to Uniclass 2015. Facetiously one could argue that none of the legacy

systems comply with the ISO, but this is unhelpful. However, mapping between even compliant classifications is not easy. Many-to-many correspondences (e.g. one system has classifies adhesives by function, another by materials) are inevitable, and render such mappings near to useless in terms of exchange of information.

The nub of this is that, sooner or later, tools in the UK such as plans of work, manufacturer catalogues, solid object modelling software, specifications, and methods of measurement must be reclassified to Uniclass 2015. Accordingly RIBA Enterprises has begun this work for NBS Create, the NBS National BIM Library, the IHS Construction Information Service, and RIBA Product Selector.

9.4. Unambiguous classification

The functional specification required that there be no ambiguity in Uniclass 2015. A good example is that of windows. They cannot simultaneously be an Element, a System and a Product (as estimators, specifiers and manufacturers would conventionally have). Objects can only be of one class – there can be no inbuilt silos. In Uniclass 2015, windows are classed as a System. Their components (frames, glass, sealant, handles) are Products. They correspond to the technically-neutral sub-Element, *External wall operable openings*, in turn a part of a technically-neutral Element, an *External wall*.

An example of ambiguity in Uniclass 1997 is the Element 'external lighting' which is found in two tables (G and H) at least five times. It occurs just once in Uniclass 2015 (in the June 2013 draft – the published version does not include services)

Uniclass 2015 avoids the use of 'other' or 'miscellaneous' or 'mixed-use'. These are useful for filing perhaps, but not for classifying (Borges, 1952; Banks, 2007). Uniclass 2015 also only classifies an object in one way in a given table. For example, it has PVA adhesives (classified by material), but not also Tiling adhesives (classified by application or parent System). Compare this with glass sheets in Uniclass 1997, for example – classified by manufacture (e.g. toughened), function (e.g. safety) and finish (e.g. coloured) in Table L.

9.5. Human and machine readable

This was a requirement of the functional specification. Annotations in Uniclass 2015 use both words (human-readable) and codes (machine readable), both standardized. Both are needed. Typos in the code wouldn't otherwise be detected or corrected, and the codes by themselves convey no information to human readers. On the other hand, the words alone wouldn't tell users where to find the object in the classification system, and hence in the model – codes are needed for this.

The codes can be extended to deal with types and instances (project-specific, and beyond the role of Uniclass 2015), as well as classes.

9.6. Numbering

Numbering in Uniclass 2015 is not consecutive – gaps are left to allow for some future additions to the classification. Each level in a table can have up to 99 members, though in practice around 20 members is considered 'full'. At the bottom levels in each table, objects are set out in alphabetical sequence (rather than random, or first-in-first-listed, or 'technical logic'). This means that Brass widgets are followed by Steel widgets (under B and S), rather than Widgets, brass being followed by Widgets, steel (under W).

The numbering takes account of letter usage in English as far as possible, e.g. more room is left for words beginning with 'S' than for words beginning with 'Z'.

9.7. Schema

There are many other principles, but the Uniclass 2015 schema seems a good one to end on. It maps to the schema in ISO 12006-2:2015, and is fairly simple. The most complicated idea is that an Entity can have three classes of children – Activities (client view), Spaces (designer view) and Elements (constructor view). Space data sheets are used to model Spaces to their component Activities and Systems.

A final note is that it is possible in the schema for an object of one class to have just one child object in another. A good example is a dry stone wall. It is an Element (External free-standing wall), with just one sub-Element (External free-standing wall structure) comprising just one system (Dry stone walling system), executed by a specialist trade using just one Product (Site-found stones)!

10. Conclusion

Uniclass 2015 has been developed as a classification system for building information modelling. Existing classification systems, such as Uniclass 1997 and OmniClass, were not suitable. In order to serve this sophisticated need, the classification system has been kept as simple as possible. The principles described in this paper indicate how this has been achieved.

Uniclass 2015 came out of its public beta stage on 9 October 2015 and, with the rest of the NBS BIM Toolkit, 'is ready for full project use'. It will continue to develop as the UK's official classification system for the construction industry, with the expectation that it will find its way overseas, e.g. through international adaptions of NBS (and other) tools using Uniclass 2015, such as the NBS BIM Object Standard (NBS, 2015), or though projects carried out by British organizations overseas, using the various UK BIM standards such as PAS 1192-2:2013 *Specification for information management for the capital/delivery phase of construction projects using building information modelling*, the Toolkit and Uniclass 2015.

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