Exchange of relevant information in BIM-objects defined by the Life cycle Information Model (LIM)

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Abstract

This paper focuses on the importance of exchanging relevant and reliable information in BIM (building information model) based software. The concept "Life cycle Information Model" (LIM) is a framework for information relevant to specified phases of the building's life cycle, and is proposed in this paper. Software model objects / object libraries are proposed as the container for standardized professional information. Model objects with information are suggested to be named "BIM-objects". The AEC-industry should take the initiative for achieving a broad consensus about the selections of information that should be standardized in the BIM-objects. A "BIM-object standard" can be based on the LIM framework. Content defined in BIM-objects can be included in development of IDM's (Information Delivery Manual) within different professional purposes. Correct use of BIM-objects during the building projects life cycle should be supported by BIM manuals. Improved exchange of information in BIM based software will support use of integrated design solutions, (IDS)

Keywords: information exchange, standardization, BIM objects, BIM

1. Introduction - Problems addressed

The exchange of relevant information in the AEC-industry (architects, engineers, contractors, operators and owners) is extensive. Use of IDS (integrated design solution) based building design processes, which normally is based on a team of different actors and disciplines performing together, is increasing the demand for exchange of *relevant* information at the right time.

The development of BIM (Building Information Model) based software for the transfer of information represents a change from the traditional design process. BIM integrates geometrical representation, which is directly visible, and information, which is not directly visible. In this paper focus is set on the information content, or lack of content in the model objects / object libraries, in this paper named BIM-objects. Today we observe that BIM generally contains very little relevant professional information, e.g. thermal transmittance, acoustics rating and/or fire rating. The variation between different software programs is large. The documentation of exported what information is usually absent, even if the software is marketed as BIM software, or profiled IFC-certified. A major challenge is therefore to remove the "black-box" information exchange which depends on the software developers’ priority, and instead move to a transparent information exchange where the user knows exactly what information is exported.

Standardization of professional information will have a positive influence in information exchange in the AEC-industry, and for increased use ICT tools in IDS. The AEC-industry should take initiative to develop a standard which set up the demands of reliable and valid professional information in BIM-objects.

2. Use of information in the AEC-industry

2.1 Tradition for utilization of new information

Because of the increasing complexity of buildings and the design process, the demand for information exchange in the AEC industry is increasing. Information exchange in previous times was based on a very small amount of formal exchange, and was more about the presence of the master-builder and his commands. There has been a development from the self-builder to the master-builder, and then to the period when the architects became a separate profession. The AEC-industry of today is very fragmented, which reflects increased challenges in exchange of information.

Information exchange is today separated and handled by separate systems; drawings, technical documentation, procurement, legal documentation etc. A question is therefore if the ability to deliver information at the right time, in the right place and in the right quantity and quality has followed up. BIM is sometimes presented as the solution to the information flow. It is doubtful if this ICT technology itself will provide the relevant professional information. However, BIM - especially based on the IFC-format (ISO/PAS 16739:2005) is expected to have an impact on technical interoperability.

When we try to utilize information in BIM based systems, we should take into account the challenge of defining the relevant information. It is important that the AEC-industry control this process, not the software developers, even if it may be hard to reach consensus. A main purpose with information is to support the decision made in the design process. The possibility to carry through an interactive design process with multiple revisions is a central aspect of IDS projects. More *relevant* information should enable the possibility to make better decisions in an earlier phase than those made traditionally. In this way improved information exchange can be expected to have a high pay-off.

2.2 Information is a relation

The traditional sequence of: data – information – knowledge – wisdom, gives information a rank, but no definition. Bateson (1979) defines information as "a difference that makes a difference", hence "*information is a relation*". This perspective starts by defining what action you want to perform (method to use) – and then relates this to the information which is demanded. The result is a distillation of the *relevant* information. According to Sowa (2000) the information exchange must be as clear and transparent as possible to avoid struggling with the "Knowledge soup" vagueness, uncertainty, randomness and ignorance.

The common tendency to regard more information as better is well documented in studies by James G. March (1994) who finds that only selective information is used in practice. Managers spend much time in collecting information that is not used in the actual decision. An indication of the support for this view is that if all information is error free, it can be exported from a software application and then imported into another software application; the problems with information exchange are solved. The "quality" of information is therefore context dependent. Some solutions for finding the relevant information are suggested in the next chapter.

2.3 Information exchange in IDS

Collaboration and exchange of information using IDS integrating different domains is much more demanding compared to the same within a single domain, such as structural engineering. The iterative process of information exchange to support goal review and decisions on the present information is illustrated in figure 1.

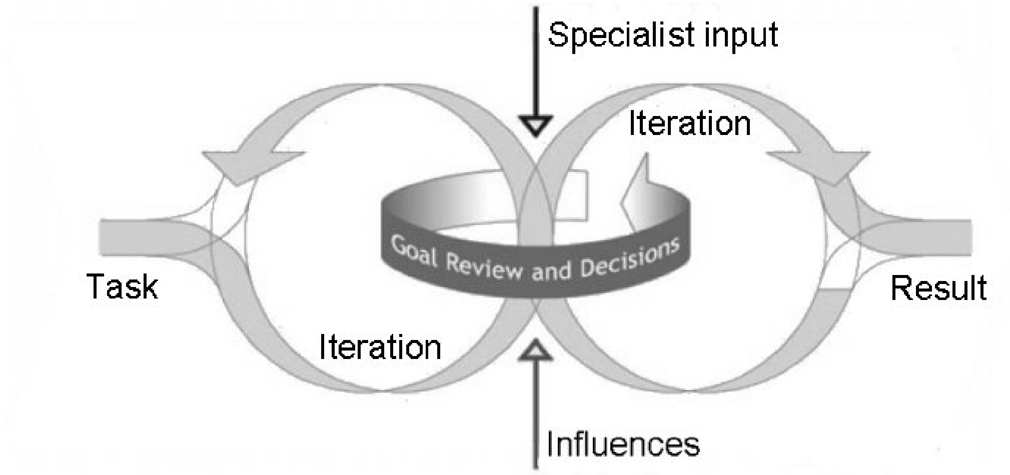

Figure 1. *Iterations as a provider for problem- orientated analyses of design alternatives and optimisation (Löhnert et al. 2003).*

The iterative process should contain relevant information and not only geometry (even if is in 3D and can be realistic visualised) for support understanding and make decisions. Today this is not is general principle possible, and the quality is depended on the software and use of it. Our suggested solution with BIM-objects will improve the information exchange process and as an extension lead to improvement of some parts of integrated design solutions.

2.4 Information Delivery Manual – IDM

The “IDM standard” is publicly available as ISO/DIS 29481. This is a “framework” standard describing a method for developing what information is required to whom and when in which form. It consists of three parts:

- *Process maps* (PM) is a description of the information flow and business processes. Because of the fragmented structure in the AECO-industry, this will itself be very demonstrative. This part is independent of software.

- *Exchange requirement* (ER) is documenting the professional relevant information needed. (it is this part we describe as professional information in this paper). This part is independent of software.

- *Functional parts* is mapping of ER against a technical schema (e.g. IFC 2x4).

The IFC schema (2x3 / 2x4) has achieved broad interest in several actors of the AECOO-industry. Because of some limitation in the IFC schema this part has a cardinal focus. First of all – it is the information that is the major subject, and one must develop ICT systems according to this. One can sometimes get the impression that looking for IFC schema limitations is more important than finding the demand of information exchange among the actors.

Development of IDM's within a defined topic and purpose (calculation method, use of a particular standard etc.) is recommended as a way of getting transparency in the information exchange. The professional information (ER) should be defined by selecting BIM-objects according to the Life cycle Information Model framework (Table 2) rather than being defined as single units. This will probably reduce time in the development of IDM’s, lower the level for participation, motivate for reuse and remodelling of IDM’s ,making them more flexible over time.

2.5 BIM-manuals

BIM-manuals can be used as mandatory guidelines for correct handling of information in a project. The development of BIM-manuals is in rapid progress. At international standardization level has the ISO/TC 59/SC 13 has started the project ISO/TS 12911 Framework for BIM manuals (ISO, 2008). Governmental builders as GSA in USA (GSA, 2008), Senate Properties in Finland (Senate, 2007) and Statsbygg in Norway (Statsbygg, 2009) has developed their own BIM-manuals.

The BIM manuals can be developed to software related manuals, explaining how to set up the software (e.g. object libraries) and where to enter specific information. Use of defined BIM-objects and management of their information through the life cycle can be specified in BIM manuals.

3. Proposed solutions and frameworks

3.1 New – Need – Nice – Noise - Nonsense

The common tendency to regard more information as better can lead to information obesity and more problems in practical use. The information that is needed for one purpose in an early phase can for other purposes and phases is directly misleading. To distinguish between different types of information we use the terms; New, Need, Nice, Noise and Nonsense as illustrated in table 1.

Table 1*: Types of information*

Information	**Demands for use**	**Example**
New	New methods	Use of environmental information in the pre-project phase. Most methods today are developed for detailed analysis in the construction phase.
Need	Defined methods , standards	Can be applied today and indentified with relation to defined methods and standards. Can be too inflexible for changed used due to no "overhead".
Nice	No defined methods (– most are good)	An extension "need" without defined purpose. Can give some flexibility for new combinations, but "nearly fit" can sometimes be hard to discover.
Noise	No defined methods (– all are good)	Undefined methods ("faulty goods") Information can seem to fit. Can be counterproductive.
Nonsense	Nothing defined at all (– but can "fit all")	Difficult to handle the model due to misleading info and large files. Definitely counterproductive.

- *New:* Information that has to be developed / determinate. Use of environmental information in the pre-project phase, stage 0 – 3 in Table 2, is an area that lacks proper information and methods. Use of EPD, environmental product declarations, has information in defined public databases (EPD, 2009). The information value is

determined by ISO standards; ISO14025:2006 and ISO/FDIS 21930 and is primarily used for procurement in the pre-construction phase, stage 6 in Table 2.
- *Need:* This is information that is defined by its relation to specified methods, calculations, algorithms, analysis etc. Can be considered as the "relevant information"
- *Nice:* This result in a larger amount of information than necessary because the methods are not defined, but only assumed. When used on a specific method it can be seen that information is still missing. Another aspect is that this motivates the use of approximate values, resulting in unreliable results.
- *Noise:* Too much irrelevant information in combination with some relevant information makes the analyses uncertain.
-*Nonsense:* Irrelevant information and duplicates, e.g. detailed and extensive information making wrong results and lead to computer slow down or fail.

Information content in both "New" and "Need" can be implemented in standards. This demands involvement from the AEC-industry.

3.2 The Life cycle Information Model - LIM

The proposed framework "Life cycle Information Model" (LIM) is to be used for development of context related BIM-objects. The Life cycle Information Model uses 4 major phases for defining professional content;

- *Pre-project phase* (4 stages)
- *Pre-construction phase* (3 stages)
- *Construction phase* (3 stages)
- *Post-construction phase* (2 stages).

The information focuses on the object – building part or building function – and information is related to the building's life cycle and the decisions relevant for specific stages. The LIM framework can be used as a template for developing standards for specification of professional information which model objects / object libraries must contain to be defined as "BIM-objects". The phases used in LIM correspond to the phases defined in ISO 22263:2008 "Framework for management of project information", see table 2 for example of information. In addition to information about performance and status, can craftsmanship or other properties be included. The recommendation is to keep the list of mandatory properties as small as possible du to development cost and liability of information.

Table 2. *Life cycle Information Model – LIM*

Stage phase	**Stage number**	**Stage name**	**Description of information elements**	**Example /Case "Wall"**
Pre-project phase				
Inception	0	Portfolio requirements	Establish the need for a project to satisfy the clients business requirement	-Superior demands - Total geometry - Thickness of load-bearing core - Door type: single, double, swing - Location: Internal / external - Performance indicators, optional: thermal transmittance, acoustics rating and fire rating
Brief	1	Conception of need	Identify potential solutions to the need and plan for feasibility	
	2	Outline feasibility	Examine the feasibility of options presented in phase 1 and decide which of these should be considered for substantive feasibility	
	3	Substantive feasibility	Gain financial approval	
Pre-Construction phase				
Design	4	Outline conceptual design	Identify major design elements based on the options presented	All layers in wall identified. (can interact with IFD) - Performance indicators, mandatory: thermal transmittance, acoustics rating and fire rating - Status, optional: Suggested / decided / built / replaced
	5	Full conceptual design	Conceptual design and all deliverables ready for detailed planning approval	
	6	Coordinated design (and procurement)	Fix all major design elements to allow the project to proceed. Gain full financial approval for the project	

To be continued

Table 2. *Life cycle Information Model – LIM (continued)*

Stage phase	**Stage number**	**Stage name**	**Description of information elements**	**Example /Case "Wall"**
Construction phase				
Production	7	Production Information	Finalize all major deliverables and proceed to construction.	- Status, mandatory: Suggested / decided / built / replaced - Reference to detail drawings and assembling descriptions
	8	Construction	Produce a product that satisfies all client requirements. Handover the building as planned.	
Post-construction phase				
Maintenance	9	Operation and maintenance	Operate and maintain the product effectively and efficiently.	- "As-built model" - Maintenance demand and interval: Last maintenance Next maintenance -Need for special actions: e.g. toxic components
Demolition	10	Disposal	Decommission, dismantle and dispose of the components of the project and the project itself according to environmental and health/safety rules	

In contradiction to the "enrichment of the model" where more information is synonymous with better - leading to information obesity, the LIM focuses on the relevance of information relation to purpose.

The LIM framework defines the mandatory information for a defined type of object for a defined stage in the building process according to Table 2. Case: Wall is used as object type and pre-construction as phase, stage 4-6 in Table 2, stage, this BIM-object should contain information about: total thickness, core thickness, and performance related information; thermal transmittance, acoustics rating and fire rating. This fundamental construction information is not present in most of available BIM software today. For post-construction, stage 9 - 10 in Table 2, the same BIM-object should have information about maintenance interval and other FM related information. The BIM-object can contain information for one or more stages.

Status - In design processes, and especially in IDS, it is important to know the formal status of the object. The design process is a decision process and knowing the status for all objects would be useful. The proposed status system has four categories:

1) *Proposed:* component, element, building part etc. This will be the native BIM-object status.
2) *Decided;* and should not be changed, e.g. placement of columns (but exact material, reinforcement does not need to).
3) *Built* indicates that the "object" has been assembled on the construction site.
4) *Replaced*, shows especially "historic" information, and will be useful in maintaining "as-built" models.

The LIM framework for BIM-object information should be developed by a standardization organization (as for instance ISO) or by a professional alliance. It is also possible to integrate LIM and IFD (International Framework for Dictionaries, ISO 12006-3:2007) in development of IDM's or IDM modules. We consider LIM as a supplement to, and not as a replacement of, these standards.

3.3 Information in BIM-objects

The content of information should be defined by use of the LIM framework. By explicitly defining the content of information into each type of BIM-objects (such as such as walls, windows, doors, zones, electrical equipment, HVAC equipment, interior equipment, etc.) which can be used in all kinds of BIM based software. It does not demand connection to databases and use of other external systems. At present, there is no common definition of professional content in objects, even if they are supplied in BIM or IFC certified software. The main focus is on geometrical representation and visualizations.

Standard - The information in BIM-objects / object libraries should be defined in ISO or national standards. These standards should contain lists of both mandatory and optional information according to the LIM framework (table 2). For ensuring that the information is as relevant as possible, the standardisation work should be performed by experts from the AEC-industry, and with minor dominance from software industry. The BIM-object standard could be provided as a series of parts for covering all the different kinds of building objects and disciplines.
- *Development* – Development of the BIM-objects can still be performed by the same actors who provide model objects today. The only difference is that the providers now include professional information according to the BIM-object standard. They still maintain their visualization features and profiling of own products. The software developers could facilitate this by including a "BIM-content" tab to the object property features. I addition to the generic models included in software, manufacturers of construction elements offer a wide range of objects for free use. It can be expect that manufactures that offer "BIM certified objects" will be preferred, and this will gain a swift implementation of the

information elements into their existing product objects.
- *Certification* – For some types of BIM-objects such as wall, window, doors etc. there is a close relation between properties such as thermal transmittance, acoustics rating and fire rating. A certification system can be established to ensure logical relevance and validity of information values.

3.4 BIM-library manager

BIM based design is primary assembling of a large numbers of different BIM-objects, as doors, windows, walls, electrical, HVAC components. The number of BIM-objects with variants will therefore be very large. Practical use of relevant BIM-objects can be supported by use of a BIM-library manager for collecting, organizing, presenting and selecting the right BIM-objects. This feature is available today for handling model objects, and is built on a simple "drag and drop" interface. Figure 3 illustrate a simpler way than table 2 to select BIM-object with necessary information. This can be used for both manufacturer and generic BIM-objects. A BIM-object can cover one or more indexes (stages).

Table 3. *BIM-object Ordering System*

Index	**Purpose**	**Description, relation to Table 2, the LIM-table**
A	- Demand BIM	Information for stage 0 in LIM-table (table 2) All defined predefined information. No values is predefined, but can be entered or "enriched" in later stages. The values will be project depended.
B	- Draft model	Information from stage 1 to stage 3 in LIM-table (2).
C	- Detail model	Information from stage 4 to stage 6 in LIM-table (2).
D	- As-built model	Information from stage 7 to stage 8 in LIM-table (2).
E	- Facility management	Information from stage 9 to stage 10 in LIM-table (2).

From a technical point of view, adding the program lines in the BIM-objects for relevant content of professional information is expected to consideration marginal extra cost. It should be expected that development and distribution of BIM-objects for different software will maintain the same pattern as for model objects / object libraries today. This indicates that the change for using objects without professional information to use BIM-objects should be possible to be implemented.

3.5 The "BIM-tab"

In present BIM-based software one can double-click on an object and a dialogue box appear. We suggest supplementing this dialogue box with a "BIM-tab" for explicit viewing of professional information. For a BIM-object of a wall, the BIM-tab will in contain information according to the BIM standard. It will be possible to relate this to future IFD integration. From a software point of view this will only be presenting the content in the object attributes. The implementation of this feature is not expected to be difficult or expensive.

4. Discussions

This paper started with focusing on the basic of information exchange, and ended up with a practical solution on something one should believe was solved a long time ago. BIM is after alt about exchange of information. It can therefore appear strange that there are so few options for entering professional information in BIM based software: "Where is the I in BIM?"
One explanation can be that for the software user it seams like information is present and is being exchanged from the architecture software to the software for energy of fire-safety analysis. But the architectural software (and exported file) does no contain information about the thermal or fire index properties. These properties are processed in the analysis software on basis of the wall geometry (structure) - and for most walls is the 200 mm space in middle of the wall interpreted as insulation – with related properties and values. This gives a proprietary "black box" solution. The impression of information BIM results leads of course to low demand for real BIM-objects because one are not aware of the missing professional content.

The lack of I in the BIM can explained by constraint that the benefit of implementing professional information in BIM object require consensus about what information should be implemented. Lack of standards can be a consequence of this. Limited use of IDS with its demand for information exchange can be another reason. A common interest to develop a BIM-object standard could be the first step. If, or when, the AEC-industry can put forward a defined demand for "BIM-objects" – expressed in a "BIM-object standard – it is likely that the software developers will invest the marginal effort to implement these features. However, if no consensus in the AEC industry, it is likely that a lot of proprietary ad-hoc solutions will emerge, and the priority of a formal standardized solution will suffer.

5. Conclusions

The lack of defined information in model objects in BIM based software limits the utilization of information in the design process in general and IDS in special. The limitation in software model objects has a connection to the absence of consensus about what type of information should be exchanged. The AEC-industry should take initiative to improve this situation and start a standardization process for defining relevant information to be exchanged.

The proposed "Life cycle Information Model" (LIM) should be used as a framework for defining the relevant information in BIM-objects according to its use in the life cycle. The "BIM-object standards" should be developed in series for covering the variation professional disciplines. The BIM standards should contain definitions over mandatory and optional information related to the different categories of model objects. These standards can be used for both development and for use of BIM-objects.

There are to day a lot of software developers and manufactures that offer model objects (often for free). The ICT technical effort to extend the model objects to BIM-objects is regarded as minor. With a standard on place and demand from the marked, is can be assumed that the transition to BIM-objects will be implemented.

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