MODULAR BIM GUIDELINES

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ABSTRACT

This paper presents a concept for development of modular BIM Building Information Models – guidelines based on a knowledge management perspective. BIM guidelines are at present mainly developed by large companies and organisations for their own needs and processes. Due to the high cost and time consumed in their development, these are often used in projects and processes which they are not optimized for. Turning the development process around allows practitioners to start by specifying relevant information in "information modules". An information module, IM, is a unit of information for a specified purpose, and can be both pre-defined or develop as a part or the design process, and collected into libraries. The IM's can then be dynamically assembled into BIM guidelines. Use of the principles of modular BIM guidelines enables the AEC/FM companies to develop their own guidelines adapted to theirs requirements. Starting with specifying information modules can therefore be an initiative for development of active knowledge managements systems.

Keywords: BIM, Knowledge representation, Knowledge management, IDM, Standardization.

1 THE "I" IN THE BIM

1.1 Introduction – Information modules (IM)

This paper intends to increase the systematic development of BIM –Building Information Modeling – in practical use in projects. We will introduce the concept of BIM guidelines based on composition of reusable information modules, IMs. Other terms used for this is BIM guide, BIM protocol document or Model Coordination Plan. The use of reusable information modules will save cost and time and increase the flexibility over the present methods of development of BIM guidance. It is also expected that this will promote a closer connection between the practitioners and the content of information exchanged by software.

1.2 The Changing paradigm

BIM is a new approach to describing and displaying the information required for the design, construction, and operation of constructed facilities. BIM is rapidly changing the way in which organizations are doing business. This is a worldwide phenomenon, based on anticipated benefits (Lillehagen and Krogstie, 2008). A BIM guideline is in essence a specification on how to use BIM – and by this contribute to increased use of BIM. All definitions regarding BIM include focus on information. Our more active approach will require a change of paradigm towards focussing on building information modelling as a knowledge process.

1.3 BIM - Information Modeling – related to Built environments

Today drawings and text documents is still dominating the way we exchange information. This static and document centric way of transferring information is directly visible on paper, even if transmitted electronically. The use of BIM for transferring information is radically different. BIM can be defined as an information model, which can be represented geometrically as drawings and 3-D visualisations. Most of the information is not directly visible because it is encapsulated as attributes in the information model. Plans, elevations and quantity take-off lists are representations extracted from the model, not the information model itself. Instead of declaring that BIM is either –model or –modeling, we suggest that one be aware of the dualism of BIM and include both in the understanding of BIM.

However, the "I" in BIM has to be developed. The awareness of the "I" is also emphasized by in this statement:

> *"Because we too often think of BIM in terms of geometry, we tend to loose sight of the "I" in the BIM, which is information."* (Smith and Tardif, 2009).

Brad Hardin (2009) expresses that Building Information Modeling (BIM) and formal requests for information (RFI) is somewhat a new science. BIM guidelines are methodology for supporting(?) RFI.

1.4 Road map for development of BIM guidelines

This paper presents a new approach for developing BIM guidelines which gives more dynamic and adaptive by introducing information modules (IM) as re-useable units. The different development tracks are illustrated in figure 1 below:

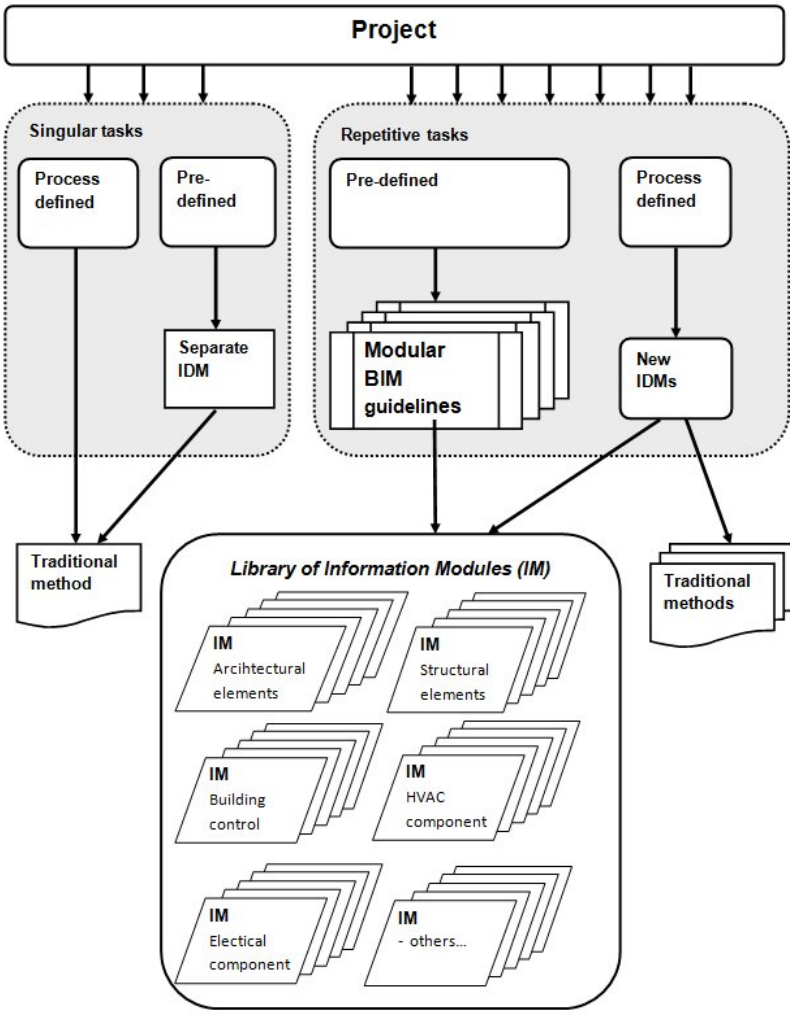

Figure 1: Road-map for development of Modular BIM guidelines and Information Modules (IM).

1.5 Management of relevant information

Enrichment of the model – and then at the end having an As-built-model for FM (facility management) is only successful if the model contains the relevant information what we need. Information about building operation is not the same as accumulated information from the design, procurement and assembling phases. Hjelseth (2010a) present a framework for specifying relevant information in BIM objects defined by the role- and life-cycle. The "RIM/LIM" model (Role Information Model / Life cycle Information Model propose principles for the AEC/FM (architects, engineers, contractors / facility management) request the industry itself to take active part in this

process for defining relevant information to be less dependent of the software industry defining information in the objects.

Although the benefits of Knowledge Management (KM) are apparent, its implementation may not be so straightforward and trouble-free. Very often, it is undermined by main barriers that prevent the full leverage of the benefits (Tan 2011 and Anumba et al. 2007). According to Carrillo et al. (2004), the barriers to KM implementation are; - Lack of standard work processes, - Not enough time, - Not enough money, - Organisational culture, - Employee resistance, - Poor IT infrastructure. BIM guidelines directly establish standard work processes, but will also contribute to reduced time and cost for re-use of information and knowledge. The NIST study (NIST, 2004) concluded that 1-2 % of the industry's costs were related to inadequate interoperability.

2 INFORMATION – ATTENTION

2.1 Attention economics

We see in general that the use of digital tools give an increase in information, apparently at no extra cost. However, information is not free – it demands attention. Attention economics is an approach to the management of information that treats human attention as a scarce commodity, and applies economic theory to solve various information management problems. In this perspective, Davenport and Beck define the concept of attention as*:*

> *"Attention is focused mental engagement on a particular item of information. Items come into our awareness, we attend to a particular item, and then we decide whether to act"*
>
> (Davenport and Beck, 2001).

Herbert Simon (1971) was perhaps the first person to articulate the concept of attention economics when he wrote:

> *"...in an information-rich world, the wealth of information means a dearth of something else: a scarcity of whatever it is that information consumes. What information consumes is rather obvious: it consumes the attention of its recipients. ".* (Simon, 1971).

Simon noted that many designers of information systems incorrectly represented their design problem as information scarcity rather than attention scarcity. As a result they built systems that excelled at providing more and more information to people, when what were really needed were systems that excelled at filtering out unimportant or irrelevant information (Simon, 1996). According to Drucker (1993), we have entered the age of the knowledge economy where knowledge has sidelined both capital and labour to become the 'sole factor of production'. In a knowledge economy, knowledge is regarded as the single most important asset of organisations (Stewart, 1997). The simple matrix in figure 2. illustrates four different approaches whether one know "What" or "How" to do it. We see that when knowing what to do, the project should focus on production.

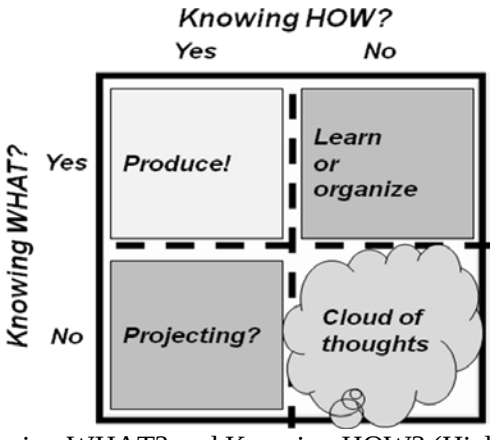

Figure 2: Knowing WHAT? and Knowing HOW? (Hjelseth, 2010c).

Nigel Cross (1986) uses the term "a designerly way of knowing". According to Cross and Lawson (2004 and 2004) does the development of design have their own way of systematics. This distinguishes it from a more stringent construction of systematics, which is characteristic for scientific based knowledge.

2.2 New – Need – Nice – Noise – Nonsense

The quality of information or the impact of it the information is depended on how it satisfy your purpose. Information without purpose has no value; it therefore is purposeless (Hjelseth, 2010b):

"Information is a relation and the value of information depends on the relation to its purpose"

We want to stress the first two parts of the series; New – Need – Nice – Noise – Nonsense. Please note the augmented perspective by introducing "New", indicating support for development of new methods and processes. This perspective is also presented by Lillehagen and Krogstie:

> *Avoid information overload - computational procedures flood the designer with a wealth of information that sometimes is complete nonsense!* (Lillehagen and Krogstie, 2008).

BIM can according to Hjelseth (2010b) be used as an abbreviation for:

Building Information Modeling – *process*
Building Information Model – *product*
Building Information Miss – *too little*
Building Information Mass – *too much*
Building Information Mess – *without purpose or structure*

3 DEVELOPMENT OF GUIDELINES

3.1 BIM deliveries

Currently the development, use and implementation of BIM guidelines is limited and most guidelines are at a general level. It is mainly large organisations or public builders who have developed BIM guidelines or BIM manuals. These guidelines works well for its own defined ways of design process, classification of phases and deliveries. The problem is that these BIM guidelines also become frequently used by other companies with different structure of their projects. This can affect their utilization of BIM based deliveries, and the result can become inefficient, costly and insufficient. Large cost, long time and limited experience can be reasons why companies use others BIM guidelines, rather than develop their own guidelines adapted to their responsibilities, processes and need for deliveries of information.

3.2 Categories and Levels of BIM guideline

The ISO technical committee ISO/ TC 59/SC 13 have developed a technical specification; ISO/ TS 12911:2011 - Framework for Provision of Guideline on Building Information Modeling.

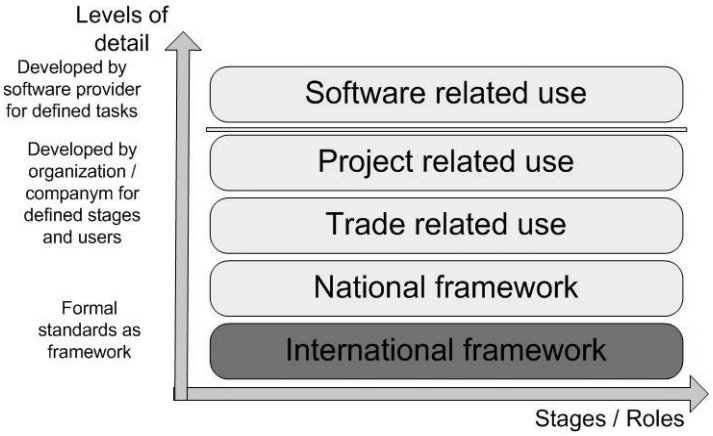

Figure 3: Framework for BIM guideline (ISO/TS 12911:2011).

A modular BIM guideline will normally be best suited for "Project related use" according ISO/TS 12911 in figure 3. The practical software related "BIM-ing" will be the interaction between project and software related BIM guideline. The guideline can be defined to cover everything from for a small section of a stages and one role, to cover the whole design life-cycle. As we will focus on, project related BIM guideline should be composed of individual guidelines that cover a defined task within a stage.

3.3 Published BIM guides

We see an increasing number of organizations developing BIM guidelines for national- and trade related use. The list below is not comprehensive for all initiatives, but gives examples of published BIM guidelines:

- GSA (U.S. General Service Administration) USA; Library with a various guidelines. (GSA, 2011)
- Senate Properties (Finish public builder) Finland, a series of BIM 9 guidelines. (Senate, 2007)
- Statsbygg (Norwegian public builder); Now published it's third version. (Statsbygg, 2011)
- NBIMS (National Building Information Modeling Standard), USA. BIM guideline with overview, principles and methodology. (NBIMS, 2007).

3.4 Practical development of information modules (IMs)

Development of IMs (information modules) is supports the development of BIM guidance. This related to the maturity of BIM and requirements for defined information deliveries. So far this has been a top-down process where organisations (NBIMS) or large builders as Statsbygg and Senatee Properties define relevant information. Use of IMs can be a part of their future BIM guidance. They may provide a library of IMs which can be re-used for different tasks. Due to its flexibility, we can anticipate an increased bottom-up approach where IM will also be developed and used by smaller companies as part of project deliveries or as elements in their QA system.

Standards development organizations like buildingSMART can define and develop IM as part of their IDM solutions. IMs can be launched as approved versions. These organisations can also forward the requirement to the software industry, which can implement the specified information attributes into their object libraries. This concept is described by Hjelseth (2010a) in the article "exchange of relevant information in BIM objects defined by the role- and life-cycle information model" in Architectural Engineering and Design Management journal.

Standardisation publication organisations like ISO at international level, CEN at European level, or the national standardisation bodies at national level can adopt IMs at the appropriate level. These "recipes of required information" is de-facto an IM, and can be delivered as Technical specifications for their related standards. The principles in ISO/TS 12911 can also be regarded as framework for development of IMs.

4 SPECIFICTION AND RE-USE INFORMATION IN PROJECTS - IDM

4.1 Information Delivery Manual

The Information, Delivery Manual (IDM), ISO 29481-1:2010. Building Information Modeling – Information Delivery Manual – Part 1: Methodology and Format, is an approach to capturing information over the project lifecycle.

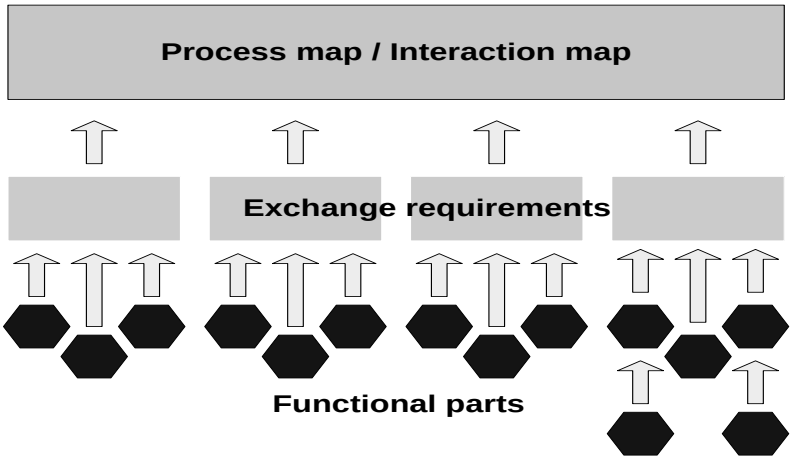

Figure 4: IDM basic framework (ISO 29481-1:2010).

Lillehagen and Krogstie (2008) summarise IDM as a framework that defines process map, exchange requirements and functional parts (see figure 4) IDM aims to identify the discrete processes undertaken within building and construction, the information required for their execution, and the results of that activity. For each of these "information exchange requirements" it will specify the following:

- Where a process fits and why it is relevant
- Who are the actors creating, consuming, and benefiting from the information
- What is the information created and consumed
- How the information should be supported by software solutions.

The ISO standard was first published in 2010, but the IDM concept has been known for some years. Wix (2007) published a guideline for IDM in 2007 and Eastman et al. (2008) mentioned the IDM in the "BIM Handbook". The primary role of IDM has been for specifying IFC Views—specific subsets of the IFC—to be used for specific workflow exchanges. The detailed analysis in IDM has made it less appropriate as a knowledge management tool in practice.

4.1.1 Process map – PM

"The purpose of a process map is to describe the flow of activities within the boundary of a particular topic, the roles played by the actors involved together with the information required, consumed and produced". (ISO 29481-1:2010). It is important to separate role and actor. A defined role can be performed by one or more actors. The roles must be defined by the task to be solved. Each Role will be a swim-lane in the BPMN (Business Process Modeling Notation) based Process Maps at operational level. It is less urgent do define which actor is responsible for which role but this can also be used as a way to illustrate changed design processes where actors get new roles.

4.1.2 Exchange Requirement – (ER)

An exchange requirement is a set of information that needs to be exchanged to support a particular business requirement at a particular stage of a project. It is intended to provide a description of the information in non technical terms. An exchange requirement represents the connection between process and data, see figure 4. (ISO 29481-1:2010). Exchange requirements can operate within the OWL-based process ontology. (Lillehagen and Krogstie, 2008).

4.1.3 Functional Part – FP

A functional part is a unit of information, or a single information idea, used by solution providers to support an exchange requirement. Each functional part provides a detailed specification of the information that should be exchanged as a result of the action. Therefore, functional parts are designed to be reusable within many exchange requirements. (ISO 29481-1:2010). The ISO IDM standard is not

written for a specific technology or data format for information transfer but IFC is used as one example. The representation of IDM as computable artefacts in ifcXML is described by Nisbet (2008).

4.2 Information Modules

> ***"Make it as small as possible, but not smaller"***
> Re-formulation for Einstein's famous quote about simplification.

An information module is defined as the specification of information for a single task. The "product" after using the IDM standard is "IDM's", or specification of information module. The IDM can be designed as "modules", and not as complete systems for a large process like energy analysis. We prefer to call the modules for IM's, Information Modules. IM is defined as a specification of information for performing of one single independent task or objective. An IM can be a "property set" (Pset), combination of attributes from Psets, or collection of Psets. However, there is a significant different approach and methodology for specifying the content of relevant information for a defined task. IM is related to Exchange Requirements and not Functional Parts inn the IDM standard (ISO 29481-1:2010). The structure for re-use and combines of IM is illustrated in figure 5. below.

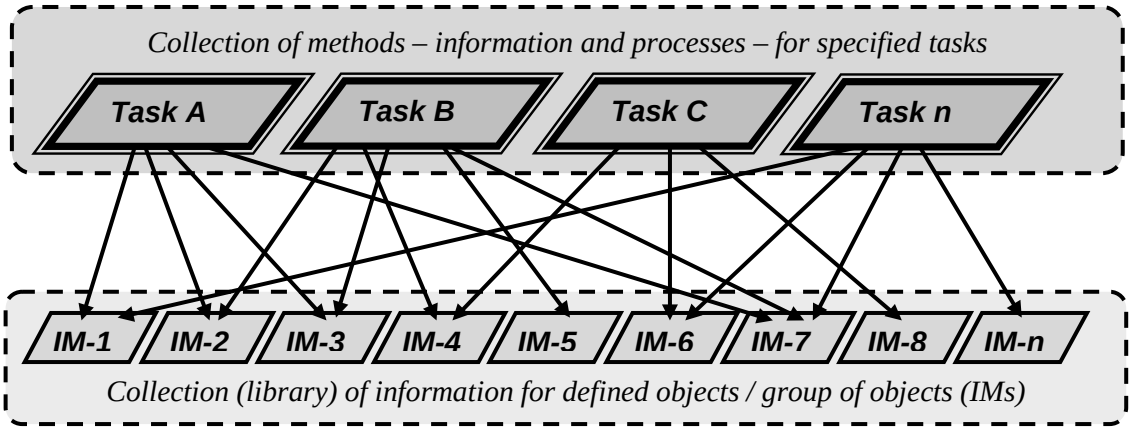

Figure 5: Principle for modularisation – relation between IM (information module) and Task.

4.3 Information transfer - Push – Pull

Information has to be transferred from a promoter to a recipient to be used (re-used). The central part is whether this initiative is done after as a "Push" from the promoter or as "Pull" from the recipient, giving him the control. Even if IDM focus on deliveries, this must not be interpreted as a push process. It is the relevance of the information to its purpose which gives it value (pull). The arrows in figure 5. are therefore directed from the task to the relevant information module.

4.4 Specifying relevant information

4.4.1 Dynamics in development of information

We propose a two aspect concept for development of information models. The first concept is based on specification or relevant information (input) that can be pre-defined as information modules related to specified tasks. In the second concept is the relevant information is specified by awareness on capture of information through the design process (see figure 1. for an overview) and saved an information module library for re-use in other projects. Table 1. gives examples of pre-defined and process defined information modules (IMs).

Table 1. Examples of pre-defined and process defined information modules.

Task	**Information modules**	**BIM used as reference is delivered from**
Visualization, sale	Process defined	Architect
Visualization, production	Pre–defined	Consulting engineers, all disciplines
Clash detection	Pre–defined	Architect and consulting engineers
Quantity take off	Pre–defined	Architect and consulting engineers
Space program	Pre–defined	Architect
Production planning	Process defined	Merged model from all – Input form contractor
Quality Assurance on site	Process defined	Merged model from all – Input form contractor
Energy analysis	Pre–defined	Consulting engineers – Building technology
Fire analysis	Pre–defined	Architect

4.4.2 Pre-defined –> Need

This concept is placed in upper left corner of figure 2. – "Produce!". The benefit in based on re-use and the possibility to build systems – software – that support this method. The traditional view of IDM supports this methodology.

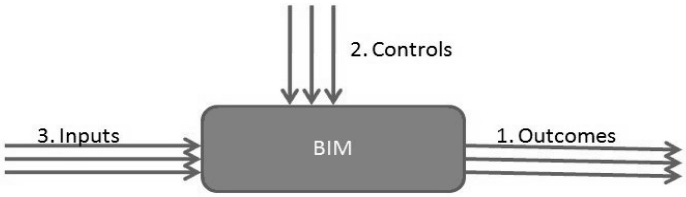

Figure 6: Principles in the framework for BIM guideline in ISO/TS 12911:2011.

Figure 6. is captured from ISO/NP TS 12911:2011 – Framework for Provision of Guidance on Building Information Modeling, and illustrates three BIM principles. The first and the third can be interpreted as focus on reliability and validity, which is discussed from different perspectives in this paper. A control mechanism is important to avoid this transfer to be a "Black-box" solution. The transferred information can be according to the paper "Overview of concepts for model checking" by Hjelseth and Nisbet (2010) be verify by use information model content based checking system.

4.4.3 Process defined –> New

This concept is placed in upper right corner of figure 2. – "Learn or organize". We experience that that much of the relevant information is either not available, or documented (tacit knowledge / experience based reference values), or implemented in the BIM software solution is not distributed to all involved in the design process. Instead of trying to standardise this as some kind of "unverified" pre-defined information, we focus on the process, and how parts of this can be standardised to create new relevant information. The proposed method is deliberate use of Process Maps from the IDM framework. The captured information can be prepared as information modules (IMs) and organised in a library for re-use in other project. This way of define relevant information can also support new composition of team or design processes.

5 CONCLUSIONS

This paper presents use of IMs (Information Modules) as a way of thinking for development of BIM guidelines. Development of modular BIM guidelines based on assembling of information modules is documented as feasible. Information modules can be collected in library's for re-use. Using module based BIM-guidelines is an incremental process, supporting both control of information utilization in projects and development of knowledge management systems in the organisation. This synergy is illustrated in figure 7. below.

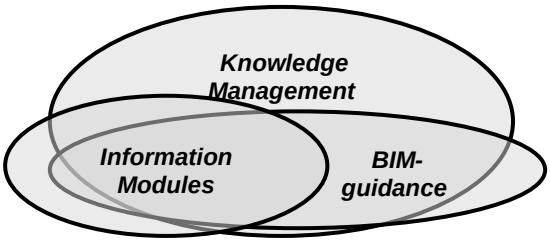

Figure 7: The synergy between BIM-guideline and Information Modules in Knowledge management.

The use of BIM regarded as information modelling is generally at a introduction level in most AEC/FM organisations. The AEC/FM industry is not known for it systematic and long time implementation of knowledge systems, or ICT use in general. The proposed approach in this paper, require awareness of information in the organisation and in the project. This can be a cultural change that can make difficulties of capturing and re-use of an information model library. However, starting small with hands-on information (Information Modules) can reduce the gap for to developing knowledge systems in the AEC/FM organisations.

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