BIM UNDERSTANDING AND ACTIVITIES

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ABSTRACT

The AECOO (architects, engineers, contractors, operators, owners) industry is moving toward increased digitalization. This unstoppable process requires a clear understanding of the important elements required to reach the defined objectives. The change of process—how we work and interact—is often highlighted as one of the most important objectives for the AECOO industry. BIM; which can stand for building information model, modelling, or management, is one of the enablers and most highlighted initiatives in digitalisation, but there is no joint understanding of BIM. However, our understating of BIM, and especially the M, will directly influence our actions related to implementing BIM with objectives that can be documented. This study is based on a literature review of scientific papers, the buildingSMART Norway newsletter, an overview of BIM-related ISO standards and BIM guidance, and experiences with the digital implementation of BIM guidance. Integrated design and delivery solutions (IDDS) focus on the integration of collaboration between people, integrated processes, and interoperable technology. It has therefore been used as a framework for exploring the dominating understanding of BIM. The findings from this study indicate that BIM primary is understood as the use of software programs. Activities for implementation are related to solving the technical aspect of the development of software as well as the exchange of files. Software skills and the use of software are used as indicators of the degree of BIM implementation. Activities related to the development of skills for information management were hard to identify, except in large projects. The understanding of BIM revealed in this study stands in contradiction to numerous statements claiming BIM as a process for changing the AECOO industry. An increased awareness of our real understanding and how this influences our activities can contribute to more targeted activities for implementing BIM to realize objectives for improving the AECOO industry.

Keywords: BIM, Building Information Model, Building Information Modelling, Building Information Management, BIM Guidance, BIM Manuals, BIM Standards

1 IMPORTANCE OF JOINT UNDERSTANDING OF BIM

BIM is nowadays a widely used term in the AECOO (architects, engineers, contractors, operators, owners) industry. However, "widely used" does not imply "well understood." Understanding a term has a direct influence on one's response to it. This understanding is often considered tacit knowledge, which makes it easy to underestimate the impact of the term. There is general agreement in the AECOO industry that the current level of implementation of BIM is far below what was expected about five or 10 years ago [1, 2, 3, 4, 5]. Could this have some connection to how we understand BIM and the efforts on which we focus when implementing BIM in individual companies or in the industry in general?

This paper explores and critically reviews the use and understanding of BIM in the AECOO industry. In the widely used *BIM-handbook* by Eastman et al. [6] can BIM be treated as a single term, and not necessarily as an abbreviation for building information modelling, building information model, or building information management. An alternative approach is, of course, to state from the beginning that BIM is all three of these or to use all of the words instead of the abbreviation. However, each of these elements/perspectives still needs to be understood in full, not just recognized.

Numerous presentations state clearly that BIM is an abbreviation for building information modelling, and where modelling indicates that BIM is about processes, it is a new way of working and collaborating. These types of presentations have received recognizing nods and applause. "BIM is a process that's enabled by technology. You can't buy it in a box, it's not a software solution, and it's something you can't do in isolation" [7, p. 349]. Also, "Measuring BIM benefits and cost consistently apportioning to who get what's benefit and why is difficult. The reality is that everyone in the supply chain benefits when using BIM in a collaborative way" [7, p. 352].

The BS PAS1192 series of standards for information management from the United Kingdom (UK) is going to be developed as ISO [8] and CEN [9] standards. These standards can have an important impact on the understanding of the BIM-based process in the AEC industry.

This study focuses on whether BIM is understood as a program versus a process. A program includes software tools, training and hardware, things that can be bought as generic product or services. A process includes documented descriptions of procedures for ways of working and collaborating with BIM in projects. The project (or company) specify this in separate documents like BIM guidance (BIM manuals), or documents describing how defined parts in specified standards, BIM guidance from third part (e.g. national or industry BIM guidance) or other normative documents shall be used in the project.

This can be identified by exploring how much efforts is placed on software versus development of soft skills (implementing standards, procedures), versus new ways of collaborating. The research question is aimed at uncovering this by exploring the options of program versus process versus people.

The research question in this study is: *What is the dominating understanding of BIM?*

2 THEORETICAL FRAMEWORK

Integrated design and delivery solutions (IDDS) focus on the integration of collaborating people, integrated processes, and interoperable technology [10] as illustrated in Figure 1. These three aspects are used to structure the findings and discussions in this paper.

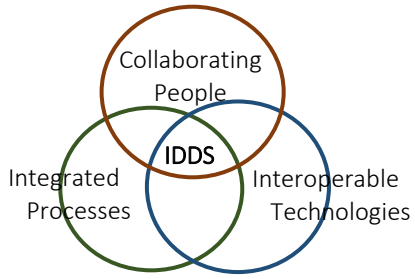

Figure 1. The three aspects of IDDS [10]

BIM can be regarded as an integrated deliverable. The aspects of IDDS can be embedded into BIM in the following ways:

1) Integrated Processes –> use of BIM guidance and BIM-related standards for specification or exchange of information
2) Collaborative People –> collaboration between stakeholders in the BIM project
3) Interoperable Technology –> use of BIM-based software with IFC export/import

IDDS was developed in 2009 as a special theme by the International Council for Research and Innovation in Building and Construction (CIB) [11]. IDDS can also be regarded as a simplification of the sociotechnical theory that Bostrom and Heinen [12] adapted to the AECOO industry.

3 METHODS AND MATERIALS

This study used a qualitative approach based on a literature review of multiple sources to obtain an overview of the situation in the AECOO industry. By using multiple sources, this study identifies sources that could be applicable to further studies, either qualitative or quantitative ones. Where numbers are compared, the precision of the numbers helps to illustrate a situation and trend, not a short time comparison. The multiple sources used come from around the world to provide a general impression either program of process is given priority. This study therefore does not include national queries. National differences can be expected, and more in-depth studies including queries could be used to explore and compare situations, but this is not the scope of this study. IDDS is used as the framework for the classification of findings.

This study includes (1) the classification of papers from *AutoCON* from 2013 to 2017 to explore the focus on the research and to determine where the development in the industry has taken place. To explore which themes are in focus in the industry, an (almost) bi-monthly newsletter (2) from buildingSMART Norway [-] has been used. An overview of ISO standards (3) and BIM guidance (4), as well as when they were developed, is included to illustrate that support for BIM as a process has been available for long time. BIM guidance is made for the manual validation of content in BIM files. A survey (5) about the automatic validation processing of BIM requirements is included to illustrate that processes can be supported by programs such as BIM-based model checkers. Each (#) above refers to a subchapter of Section 4 below.

4 FINDINGS

4.1 Research perspectives in AutoCON papers

Table 1 is a classification of 274 papers from AutoCON from 2013 to 2017 [13], which was done to explore the focus of the research. The findings indicate a massive focus on technology compared to research studies on collaboration and processes.

Table 1. Research perspectives toward AutoCON papers from 2013 to 2017 [13]

Year		**Interoperable Technology**	**Collaborating People**	**Integrated Processes**	**Total**
	#	202	25	47	274
	%	74	9	17	100
2017					
	#	20	0	2	22
	%	91	0	9	100
2016					
	#	54	4	9	67
	%	81	6	13	100
2015					
	#	45	9	13	67
	%	67	13	19	100
2014					
	#	43	6	7	56
	%	77	11	13	100
2013					
	#	40	6	16	62
	%	65	10	26	100

4.2 buildingSMART Norway's Newsletter

Table 2 provides a general impression of the focus of different articles in the buildingSMART Norway Newsletters from February 2014 to December 2017 [14]. Reports from projects without profiles that can be classified by the IDDS framework [10] are not included.

Table 2. buildingSMART Norway Newsletters from February 2014 to December 2017 [14]

Year/Month	Interoperable Technology	Collaborating People	Integrated Processes	Comments
2016				
- December	******		*	Standard mentioned
- June	*****		*	Paperless construction site
- Mars	******	**	*	Change management
2015				
- December	****	**	*	Article where Statsbygg (#) proposes model to be valid if disagreement happens
- October	****	*		---
- June	*****	**	*	BIM execution plan
- April	*****	**	*	buildingSMART Norway BIM guidance launched
- February	*****	**		---
2014				
- December	****	**		---
- October			*	Architecture company get all staff BSN certified (%)
- August	*****	**	*	New Norwegian BIM standard NS8360 launched
- June	*****		*	New committee for BIM standardization of carbon footprint
- April	****	**	**	Info about Connect & Construct New tyes of contracts
- February	******	**		

*) Illustrate number of news about each group of theme
#) Statsbygg – The Public building and property agency in Norway

4.3 Overview of BIM-related standards developed by ISO

The overview in Table 3 of BIM-related standards developed by ISO illustrates that some of them have been available for many years, but there was a significant increase in the development of new standards and in the revision of old standards starting in 2001. Most of these standards set requirements for processes – how the work is organized or managed. This listing illustrates that processes have focus, but it does not say anything about how they are implemented, how widely they are used in different countries, or if they are used as a foundation for the further development of solutions.

Table 3. Overview of BIM-related standards developed by ISO

ISO Standard	Title
ISO 15686-4:2014	Building construction. Service life planning. Service life planning using building information modelling [15]
ISO 16354:2013	Guidelines for knowledge libraries and object libraries [16]
ISO 29481-2:2012	Building information models. Information delivery manual. Interaction framework [17]
ISO/TS 12911:2012	Framework for building information modelling guidance [18]
ISO 29481-1:2010 Revised in 2016	Building information modelling. Information delivery manual. Methodology and format [19]
ISO 22263:2008	Organization of information about construction works. Framework for management of project information [20]
ISO 12006-3:2007	Building construction. Organization of information about construction work. Framework for object-oriented information [21]
ISO 16739:2005 Revised in 2013	Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries [22]
ISO 12006-2:2001 Revised in 2015	Building construction. Organization of information about construction work. Framework for classification of information [23]

4.4 Overview of BIM guidance

The intention of BIM guides is to support how BIM should be used and which information has to be exchanged. These specifications can be given on different levels, as the technical specification ISO/TS 12911:2011 – Framework for BIM guidance [18] in Figure 2 illustrates. Without the use of an established BIM guide, all requirements have to be negotiated by the stakeholders in the project.

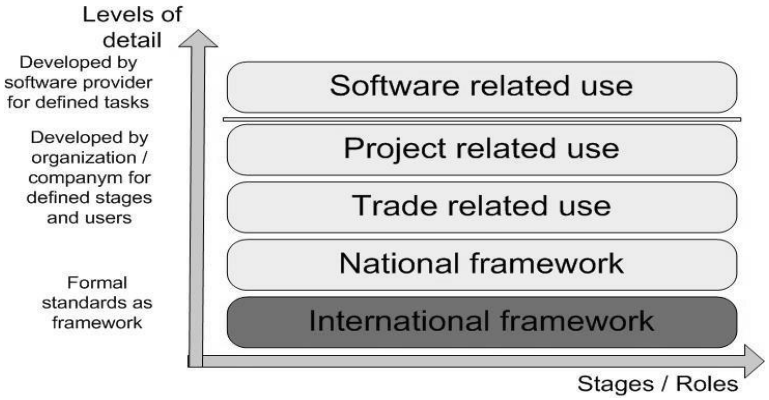

Figure 2. The ISO/TS 12911:2011 framework for BIM guidance [18]

A large number of BIM guides have been developed for different purposes. Table 4 provides an overview of BIM guidance, when and in which country they are developed. This list is not comprehensive but illustrates both a long history and that some countries have more guidelines for different purposes. Guidelines also have to be updated due to various experiences and to keep up with the users' development or maturity, as well as the increasing complexity of the projects.

Table 4. Overview of BIM guidance, when and in which country they are developed

Year	Country	BIM Standards / Guidelines
2017	Norway	Statsbygg – Norwegian Property Agency, v2.0 [24] Under Development, will be a Requirement Database with Digital Functions for Validation of BIM file in IFC 4.0 Format
2015	USA	GSA – BIM Guide Series 06 v1.0
2015	USA	GSA – BIM Guide Series 07 v1.0
2015	USA	GSA – BIM Guide Series v1.0
2015	USA	NIBS – NBIMS v3.0
2014	German	German BIM Guide
2013	UK	AEC – UK BIM Protocol
2013	USA	AIA – Document E201 – 2013 Project Digital Data Protocol
2013	USA	AIA – Document E203 – 2013 BIM and Digital Data Exhibit
2013	USA	AIA – Document G302, Project Digital Data Protocol
2013	USA	AIA – Guide; Instructions and Commentary
2013	Norway	BoligBIM – Norwegian Home Builder Association
2013	USA	PSU – The Use of BIM
2012	USA	PSU – EBM Planning Guide for Facility Owners v1.02
2012	Finland	Senate – Finland Common BIM Requirement COBIM
2012	Singapore	Singapore BIM Guide
2012	Norway	Statsbygg – Norwegian Property Agency, v1.2
2011	USA	Georgia Tech BIM Req. & Guidelines for Arch., Engineers and
2011	USA	GSA – BIM Guide Series 08 v1.0
2011	USA	GSA – BIM Guide the OE v1.0
2011	Australia	NATSPEC National BIM Guide, Australia, v1.0
2011	USA	PSU – BIM PEP Guide v2.1
2010	USA	PSU – BIM Execution Planning Guide v.2.0
2010	USA	PSU – BIM PEP Guide v2.0
2009	USA	GSA – BIM Guide Series 03 v1.0
2009	USA	GSA – BIM Guide Series 04 v1.0
2009	USA	GSA – BIM Guide Series 05 v1.0
2009	USA	PSU – Penn State Uni. BIM PEP Guide 1.0
2009	Norway	Statsbygg – Norwegian Property Agency, v1.1
2008	USA	AGC – The Contractors Guide to BIM
2008	USA	AIA – Document E.202-2008 BIM protocol exhibit
2008	Norway	Statsbygg – Norwegian Property Agency, v1.0
2007	USA	AIA – Document E201 – 2007 Data Protocol Exhibit
2007	USA	GSA – BIM Guide Series 01 v1.0
2007	USA	GSA – BIM Guide Series 02 v1.0
2007	USA	NIBS – NBIMS v1.0
2007	USA	NIST – General Buildings Information Handover Guide
2007	Finland	Senate – Finland BIM Requirements

Please note that BIM guidance is presented as reports in pdf-format. The work has to be done manually to validate whether or not specified requirements are fulfilled. This is a time-consuming process that requires a high level of competence with BIM. Statsbygg, the Norwegian property agency, is in its final phase of developing its new generation of BIM guidance. This guidance will be a requirement database with digital functions for the validation of BIM files in IFC 4.0 format [24]. This is a significant step toward enabling digital-supported working processes.

4.5 Automatic processing of Statsbygg's BIM requirements

This study focuses on the degree of the automatic processing of digital rulesets and is based on the 1.2 version of BIM guidance from Statsbygg [25], the Norwegian public construction and property management agency. Statsbygg has developed BIM guidelines since 2008, and the current version, 1.2, from 2012 is its third. It is available in both Norwegian and English versions [26]. This BIM guidance is used as a mandatory requirement for all projects above € 5. mill. The BIM-guidance document contains 131 requirements for the specification of information in the IFC file. These requirements were implemented as a separate ruleset by Solibri Model Checker and are included in version 7 and newer [28]. At first glance in Solibri Model Checker, it can be easy to believe that all requirements in the BIM manual version 1.2 from Norwegian Statsbygg are implemented and can be checked automatically. Figure 3 presents the results from the assessment of the digitalization of the implemented requirements in the Solibri Model Checker ruleset.

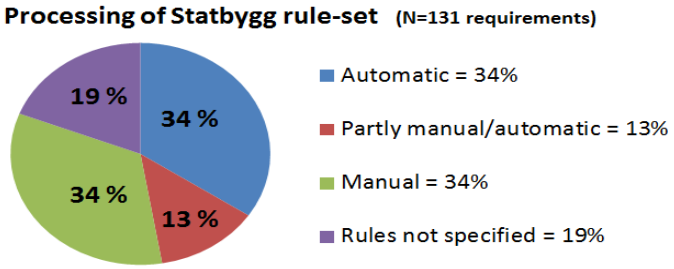

Figure 3. Distribution of processing of BIM requirements in Norwegian Statsbygg BIM guidance version 1.2 [25].

The outcome identified that 34% of requirements could be automatically checked, 13% partly checked automatically/manually, and 34% checked manually, whereas 13% of the requirements were not implemented as digital rules at all. This indicates that approximately half of the requirements can be checked automatically and verified, whereas the other half of the requirements have to be checked manually. It is therefore important to be aware that only parts of the requirements can be checked automatically [25]. This type of model checking can be regarded as an example of "content checking of BIM-file" [28].

5 DISCUSSIONS

This study has a qualitative approach and is exploring a soft and interconnected target. The findings indicate that the focus on processes and people is very limited compared to the focus on programs (technology). This dominating focus on technology stands in contrast to the numerous presentations where changes of processes and new competency are highlighted. The situation in the AECOO industry may be best be described by using a line from the music of Coldplay: "If you get what you want, but not what you need" [29].

Even if BIM guidance is a comprehensive document, all of the documents build on simple modules connecting information to a task [30]. This can be further developed by connecting exchanged or relevant information to both the role and life cycle in the project [31].

According to studies by Arayicia [32], construction companies are facing barriers and challenges with BIM adoption. There is no clear guidance or best practice study from which they can learn and build up their capacity for BIM use to increase productivity, efficiency,

and quality; to attain competitive advantages in the global market; and to achieve their targets in environmental sustainability [32].

There is also a limited focus on development of business models compared to solving the technical aspects of BIM. Business models are fundamental to realizing the latent value of new ideas or technologies. Magretta [33] described business models as "the story about how an enterprise works," defining who the target customers are, how the business makes money, and what the customer values. More recent definitions include a componential perspective, for example, the canvas model by Osterwalder [34]. An article in *Harvard Business School* illustrates the importance of the development of new business models by stating: "A new model is often needed, however, to leverage a new technology is generally required when the opportunity addresses an entirely new group of customers; and is surely in order when an established company needs to fend off a successful disruptor" [35]. The development of information models should therefore be supported by the development of business models.

There is a need for monitoring the implementation of processes. The increased use of maturity assessment criteria will in this respect be very useful. Works by Bilal Succar [36, 37, 38] and other can be used as foundations. If further studies on real implementation do not indicate real improvements, the implementation strategy for the AECOO industry should be challenged. Skills and plans for implementation of processes are what are missing.

Learning for other project-oriented industries, such as oil and gas, is highlighted as an approach for the increased implementation of BIM [39]. A general experience is that technology is just an enabler, whereas new business models or opportunities, public regulations and standards, and a shift in market trends and the customer's preference (e.g., sustainability/green buildings) act as the real drivers of change.

Industry 4.0 will have a significant impact on the engineering and construction industry in the next five years [40], challenging both technology and business models.

In this respect, the use of IDDS framework may prove invaluable [10]. IDDS is focused on addressing complex and transformative development challenges through integrated solutions that incorporate technology and innovation, the cross-practice delivery of solutions, and the global sharing of knowledge and good practices.

There is a need for addressing implementation up to national or international strategies. In this respect can the new BIM-related CEN standards under development by technical committee TC442 – Building Information Modelling (BIM) [8] have a significant impact in Europe. Likewise will the implementation of the BIM-related standards from ISO/TC59/SC13 – Organization of information about construction works [9] have an international impact.

The AECOO industry has an "engineering" culture with a focus on quantitative factors that can be calculated. When it comes to qualitative factors, the industry has reduced its awareness. Even if some people agrees about importance of soft skills there is generally less awareness about it compared to hard skills in use and development of BIM.

A joint understanding and the use of indicators for BIM processes are necessary to make measurable deliverables similar to other project-related deliverables. This will transform the process from having soft targets to having hard, measurable ones.

6 SUMMARY

BIM is a widely used term and abbreviation. There exists no joint understanding of BIM in the AECOO industry. The use of a term and the understanding of the term can be two different things. This study indicates that BIM is mainly understood as the use of software programs. This is independent of the use of descriptions such as building information model, building information modelling, or building information management. The dominating focus on technology stands in contrast to the numerous presentations where changes of processes and new competency are highlighted. A focus on the development of software and the exchange of files dominates procedures related to the use of BIM guidance and standards. Formal requirements for attaining competency have not been observed as elements in implementing BIM in projects or organizations. Figure 4 illustrates the priority of the program-process-person perspectives. BIM is in general understood as the use of software programs, where advanced use of BIM require advanced software skills.

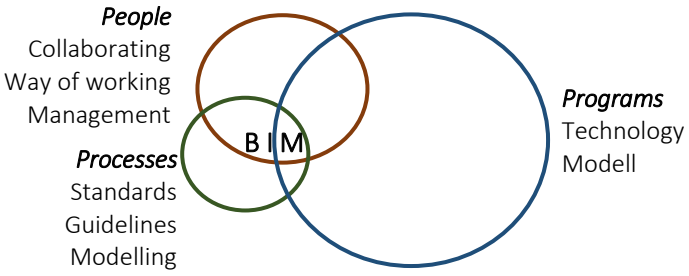

Figure 4. The priority of the program-process-person perspectives

Our understanding of BIM will directly influence our activities related to the use of BIM. The impact of a limited understanding of processes is that a large number of BIM standards and BIM manuals are developed but not implemented in a way that supports the joint exchange of relevant information. Information is related for file-based exchange, not to support processes via improved and fact-based information management.

An understanding of BIM should be expressed by documenting one's (organization's) practice and not by one's presentations on Adobe PowerPoint. A change in understanding influences one's activities and in this way contributes to transforming the AECOO industry by use of BIM as a catalyst for efficient information management—and through this the changes of processes.

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