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A PILOT STUDY: TOWARDS BIM INTEGRATION - AN ANALYSIS OF DESIGN INFORMATION EXCHANGE & COORDINATION

Submission No: 36

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ABSTRACT

Construction projects are costing too much and taking too long as a consequence of unnecessary omissions and errors in project documentation and sub-optimal coordination of design information between consultant disciplines. The theory behind BIM provides an exciting integrated solution for project information management, however in this new process further effort is required to define the content of information deliveries and a number of basic who?- what?- when?- how?- questions relating to object and property definitions need to be resolved.

This study investigates and attempts to define the functional requirements for integrated information management through the design stages of a construction project focusing on architectural practice requirements within the residential sector in Sweden. In a pilot study concerning a residential construction project in Sweden the buildingSMART Alliance's new *Building Information Modelling Execution Planning Guide* was applied. The principle BIM planning procedures are applied to the case, tuning requirements to the specific project and localised to support Swedish classification standards. Through the enquiries required to develop and define these processes, a new information exchange protocol emerges, tuned to the Swedish residential sector.

Keywords: BIM, information exchange, design coordination.

1 INTRODUCTION

1.1 Background

In recent years there has been an international explosion of interest in the development of BIM in the construction sector. Actors are gradually developing the skills and personnel to implement BIM and are starting to leverage some of the benefits of working with intelligent 3D objects in a virtual building design environment (Eastman et al 2008).

One reason for an increase in this adoption is that traditionally much project information and development relies substantially on human input and subsequent multiple manual checks and cross-referencing operations which, on complicated projects, inevitably leads to errors or missing information leading to extra cost and waste (Cohen 2010).

Construction projects are becoming increasingly complicated in nature, requiring more specialist discipline input resulting in a much greater volume of technical information which in turn requires to be coordinated and kept up-to-date and relevant through the life cycle of a project. In such contexts conventional project filing systems and information work-flows are becoming un-manageable and there appears to be a need for user friendly practice guidelines to supplement existing standards which if adequately tested, could form a key part of an Information Delivery Manual (IDM) or even a National BIM Standard.

In Scandinavia, where building is generally more expensive than in central and southern regions of Europe (Statistics Sweden, 2009), there is a concern expressed throughout the industry that building productivity must be increased. In conjunction with the new processes implied by BIM for design delivery, construction and facilities management, an industry-informed information exchange protocol should be able to contribute toward providing better value.

BIM, amongst other things, seeks to streamline processes, present construction information in an accessible and common way, minimise the possibility of missing or clashing information and ensure optimised project

coordination. The real value of BIM to any organisation be it a design firm, construction firm or building owner, is in leveraging the structured information contained in a building information model to create value (Jernigan 2008).

To implement BIM and tap into leveraging efficiency benefits an organisation must first consider a critical evaluation of its core competencies and business objectives, followed by strategic deployment of appropriate technology to take the guesswork out of business decisions and shift the organisation's output from traditional routine, low-value-added tasks and services toward high-value-added tasks and services (Smith 2009).

For design firms, this means investing in tools and implementing business processes that are essential to increasing efficiency, productivity, profit, and value. There is a need for a new focus on providing sustained value to clients, eliminating or reducing inefficiencies in the process and eliminating repetitive and mundane tasks.

1.2 Problem statement and research questions

The theory behind BIM provides an exciting integrated solution for project information management, however, in this new process a number of key questions need to be resolved: Who is involved? What models are required and why? When are the models needed? What should the models contain? How are the models exchanged? Who manages the process?

Whilst some of these matters may be obvious in a traditional method or design methodology, new processes with new responsibilities are emerging which need to be defined in order to facilitate optimised design co-ordination and integrate BIM into working practices. The research question investigated in this study is how the new process requirements may be handled in a systematic way.

1.3 Purpose and objectives

This study aims to assist in and promote the adoption of BIM technologies in the Swedish architectural, engineering, construction & facilities management (AEC&FM) industry, and try to avoid the uncertainty and disparate approaches that created inefficiencies with the implementation of 2D CAD over the past three decades (Jernigan 2008).

Many business aspects are affected through full and effective BIM implementation. By viewing the implementation process and the act of exchanging information as a role of information stewardship (Smith 2009), the study aims to test and reveal the results of mechanisms facilitating and constraining BIM integration through an analysis of identified BIM uses, designed implementation processes and developed information exchanges.

This objective is pursued by: 1) a study of a residential construction project with a major architectural practice in Sweden; 2) a series of workshops with design consultant participants involved in the development and use of BIM in connection with the studied project; 3) an analysis of empirical data collected by the application of the buildingSMART Alliance's new Building Information Modelling Execution Planning Guide (hereafter referred to as the BIM guide) (Anumba et al 2009).

One of the first steps in any research process is to assess the potential for improvement in order to tune the study focus towards a defined purpose in which a valuable contribution towards to development in the field can be realized. The purpose of this initial pilot project is amongst others: to measure and evaluate how far BIM has come in practice; to identify issues of information exchange; to record current practice methodologies; to explore possibilities for improved efficiency and error mitigation; to create an example of set-up guidelines for residential projects; and to develop a proposal for an information delivery matrix.

1.4 Focus and delimitations

This project focuses on information delivery through the design phase of residential projects with the aim of moving towards an optimised system of design material delivery for this type of project. It is intended that further studies will facilitate analysis beyond design stage and out-with the residential sector, however this provides a sound starting point.

The instances of information exchange here centre attention on those commonly understood to be those carried out through the design phase.

2.0 METHODOLOGY

As a starting point an extensive literature review was carried out with particular attention drawn to the various BIM Manual / BIM Guideline documents now emerging around the world through organisations such as the buildingSMART Alliance. Information is not lacking, however, practical experience in moving forward with BIM beyond office boundaries in Sweden still is in its infancy.

Following an investigation of existing literature and other published guidelines, the BIM Guide provided a suitable supporting platform to launch a study focused on shaping an overview of the use and benefits of BIM on a typical residential construction project and exercising a method of reaching a common agreement with regards to information exchange and extent of implementation.

2.1 Case study design

The case study is preferred in examining contemporary events and when relevant behaviours cannot be manipulated. Two important sources of evidence are: direct observation and systematic interviewing. The case study's strength is its ability to deal with a full variety of evidence - documents, interviews, and observation - beyond what might be available through other research approaches (Yin 2003).

Through its natural setting, the case study provides an ideal practical real-life context and a suitable grounded platform to consider and test strategic decisions with regard to information exchanges thereby creating an opportunity to introduce a move towards BIM implementation in practice.

A pilot project has been launched, establishing a collaboration between academic experts at Lund University and industry through White Architects. The purpose is to initiate a strategic study centring on the question of BIM implementation in construction, and specifically information exchange, with an aim to solve some of the structural and organisational issues associated with this new working method in Sweden.

Common goals are to establish a documentable and transferable method of overcoming difficulties in implementing BIM focusing on practical solutions to advance information exchange.

The known attributes of this case project fit well with the opportunities to break new ground in BIM implementation. The project's simplicity, reality, and that it is at an early stage of development present an opportunity to make a fresh start and facilitate optimal leverage of results. Its relevance to the generic problems outlined in the problem statement and transformed into research questions are direct and represent real practical issues to be solved. The study provides a basis for a deeper understanding of specific practice-related issues in their natural setting.

Since new build housing represents a significant market within the construction industry - not least in Sweden - this case study project may be deemed typical as an instance to study. The case being typical, it is likely that the findings can be generalised and therefore applied elsewhere.

2.2 Data collection and case description

The collection of empirical material has been assembled to firstly facilitate a deeper understanding of the context in which BIM is being adopted and used and secondly articulate the current status of BIM implementation in the organisation under study.

To meet these objectives a series of workshops were carried out in connecting with the Gyllins Trädgård project together with the project architect and BIM experts within White Architects organisation. The project is live and provides a real-world setting for the study, facilitating a grounded source of valid data collection.

Through the enquiries required to develop and define the BIM implementation processes described in the BIM guide, valuable data has been collected, organised and analysed. The guide's planning procedures forms the basis of the dialog with White and has enabled a pedagogical and thorough approach whereby data has been collected for the purposes of analysis and system optimisation for future projects.

3.0 THEORY

A number of national standards and BIM guideline documents exist around the world. Amongst other things, it is the task of the buildingSMART alliance to harmonise documentation and BIM implementation methods on a national and international level. The US NBIMS was one of the first comprehensive national standards (NBIMS

2007), with Norway, the Netherlands, Denmark and Australia also producing various forms of national guidelines (eg Denmark's 3D Arbejdsmetode).

In Sweden the principle guidelines are to be found within *Bygghandlingar 90 : byggsektorns rekommendationer för redovisning av byggprojekt. Del. 8: Digitala leveranser för bygg och förvaltning* (SI 2008). This document contains guidance on the administrative aspects of BIM with reference to other Swedish standards, however lacks a strategic standard method of planning and agreeing amongst project team members a process of BIM implementation with a focus on information exchange. Here the buildingSMART alliance's BIM Guide may be able to bridge the gap.

The BIM guide is a product of the BIM Project Execution Planning buildingSMART alliance™ Project and was developed to provide a practical methodology for project teams to design their BIM strategy and develop a BIM Project Execution Plan. The main concepts behind the guide have been developed to complement the long term goals of the buildingSMART alliance in the development of a standard that can be implemented throughout the AEC&FM industry to improve efficiency and the effectiveness of BIM implementation on projects.

4.0 IMPLEMENTATION

4.1 Case Study: Gyllins Trädgård

The pilot study follows a residential project currently on the drawing board within White Architects Malmö office: Gyllins Trädgård.

Designed to assist White integrate BIM into their working practices, this case project was selected based on that, at time of researching, it was at a suitably developed stage and fulfilled the necessary criteria in terms of participant interest and generic simplicity to implement and test the results of a BIM process centred on an effort to standardise and control information exchange.

At Gyllins Trädgård MKB Fastighets AB plans to build 87 residential units for rent within 9 buildings of 2 to 4 storeys. The project will include 2, 3 and 4 room apartments between 62 and 95 m². MKB, have provided the project consultants with a CAD-coordination manual which stipulates the client's expectations with regards to the use of 3D design tools and for some of the design team members it is the first occasion of working with 3D coordinated models.



Figure 1: Gyllins Trädgård - Marketing Images (White Architects)

4.2 The buildingSMART alliance™ BIM Project Execution Planning Guide & Gyllins Trädgård Project

The BIM guide details a method for creating and implementing a structured BIM Project Execution Plan and it is proposed that the principle BIM planning procedures outlined in this document be carried out and applied to the case, tuning requirements to the specific project: Gyllins Trädgård. In doing this, this opens opportunities to push forward the frontier of research in this area and identify what is missing from existing models.

This new BIM protocol allows this pilot project to take off where existing information and guidelines left off and provide a platform to move forward with BIM in earnest in a Swedish context and a sound basis for initial dialog, facilitating a method to responding to a number of information exchange issues. Further local refinement might identify the conditions necessary for success and the barriers which might limit a full implementation and associated leverage of system benefits.

The guide is well aligned with the scope and purpose of this study and focuses on defining the necessary information exchanges through a step-by-step planning procedure:

1. Define project and team value through the identification of BIM goals and uses.
2. Develop a process which includes tasks supported by BIM along with information exchanges.
3. Develop the information content, level of detail and responsible party for each exchange.

4.3 Concepts to be tested in the pilot study

It is proposed that a number of important key concepts relating to project coordination and information exchange are tested in connection with a live residential project in Sweden. These include a formal method of establishing answers to the basic who?- what?- when?- how?- questions outlined in the problem statement as well as testing the principles of developing a BIM implementation plan while seeking to promote the development of consistency within the industry with organisational concepts that are simple and flexible.

4.4 Step 1: Identify BIM goals and uses

One of the most important steps in the BIM planning process is to clearly define the potential value of BIM on the project and for project team members through defining the overall goals for BIM implementation. These goals could be based on project performance and include items such as reducing the schedule duration, achieving higher field productivity, increasing quality through offsite fabrication, or obtaining important operational data for the facility. Goals may also relate to advancing the capabilities of the project team members, for example, the owner may wish to use the project as a pilot project to illustrate information exchanges between design, construction and operations or a design firm may seek to gain experience in the efficient use of digital design applications. Once the team has defined measurable goals, both from a project perspective and company perspective, then the specific BIM uses on the project can be identified (Anumba et al 2009).

A BIM use is a unique task or procedure on a project which can benefit from the integration of BIM into that process. Several examples of BIM uses include design authoring, 4D modelling, cost estimating, space management and record modelling. The team should identify and prioritize the appropriate BIM uses which they have identified as beneficial to the project.

The BIM guide provides users with template documents to help record and develop their project-specific BIM implementation plans.

4.5 Data collected (Workshop No. 1)

The initial workshop centred around a line of questioning facilitating population of a *BIM Goals* and *BIM Use Analysis* worksheets in connection with Gyllins Trädgård. The purpose of these worksheets is to assist project team members in the development of BIM Goals and the selection of BIM Uses based on project and team characteristics.

The design team identified a number of key BIM goals, each allocated with a priority rating and a potential BIM use. It is essential to identify the specific goals that will provide incentive for implementing BIM on a project basis, with consideration to potential benefits, team competencies and technical resources.

Table 1: Extract from BIM Goals Worksheet - Gyllins Trädgård

Priority (1-3)	Goal Description	Potential BIM Uses
1- Most Important	Value added objectives	
1	Reduce design failures	3D Design Coordination, Quantity Scheduling
3	Optimise building rational	Phase Planning (4D Modelling), Site Utilization Planning
1	Establish early control of areas / spaces / relationships	Area Scheduling, 3D Design Coordination

High priorities are to reduce field conflicts through well coordinated 3D design and to be able to leverage data to deliver and control design parameters such as the accommodation schedule against client requirements. These goals were readily implemented by the design team through the deployment of 3D parametric design authoring tools and capable staff.

By identifying such goals the design team made a first step in planning for a level of BIM implementation. The definition of project team BIM goals allows individuals to understand each other's contribution and outlines the motivations behind the forthcoming information exchanges.

Next, the identified BIM goals are translated into actual BIM uses. The relationship between BIM goals and uses is interpretive and in which a common understanding and agreement is reached through early collaboration and planning.

With each use that's being considered, at least one responsible party is identified. Building information data should ideally be entered only once during the building or information lifecycle by the most authoritative source. By reviewing and formally agreeing who is responsible for what information, it enables building information to be coordinated by the correct source, allowing that data to maintain optimum value.

Table 2: Extract from BIM Use Analysis - Gyllins Trädgård

BIM Use*	Value to Project	Responsible Party	Value to Resp Party	Capability Rating	Additional Resources / Competencies Required to Implement	Notes	Proceed with Use
	High / Med / Low		High / Med / Low	Scale 1-3 (1 = Low)			YES / NO / MAYBE
				Resources Competency Experience			
3D Design Coordination	High	A	High	3 3 2			Yes
		MEP	High	3 3 2			
		SE	High	1 1 1	Training in Revit required	Revit coordination & 2d dwg	

Through auditing a capability rating against each BIM use, responsible parties make an objective judgement with regards to their resources, competency and experience - in other words their professional ability to carry through the BIM use. Together these parameters lead project teams to decide whether or not to proceed with a proposed BIM use. In the case of Gyllins Trädgård, however, a number of aspirational BIM uses were pursued to test results against traditional methods.

4.6 Appraisal

Through this stage of the planning procedure, value is captured by team members articulating the BIM uses to pursue and developing a common understanding of joint goals. Extracted from the BIM use analysis template the plan includes, the following strategic choices can be evaluated as follows:

- *3D Design Coordination:* Here, utilizing collision control tools together with an iterative process of design refinement a significant step forward in the preparation and delivery of a coordinated design information has been realised (see Figure 2). By mitigating potential field conflicts more effectively in 3D, greater cost certainty can be achieved.
- *Design Authoring:* By using BIM tools to generate a composition of parametric objects, the model creating process ensures proper alignment and facilitates a degree of automatic correction - such as adjusting a wall and window schedule in the event of a window deletion - thus reducing the need to manually manage design changes.
- *Design Reviews:* Regular design team meetings with the model as review platform allowed on-the-spot group design decisions to be made, driving an iterative design process, using data to support solutions.
- *Cost Estimation:* Although not completely BIM automated, cost estimates were carried out at incremental stages with increasing level of detail. Quantities were manually extracted but then checked against the models automatically generated quantity schedules. Confidence is still lacking in the accuracy of BIM quantity and cost data amongst some industry professionals however, efforts to test and compare results should in time address this concern.
- *Digital Fabrication:* Here information for the off-site manufacture of timber trusses was released. Whilst not entirely BIM automated, geometric information was extracted from the BIM and augmented with information that was necessary for the CNC machines to interpret and implement the appropriate manufacturing operations. Early enquiries to ascertain exactly what information the prefabricator needs for his machines could further streamline this area and mitigate re-work.

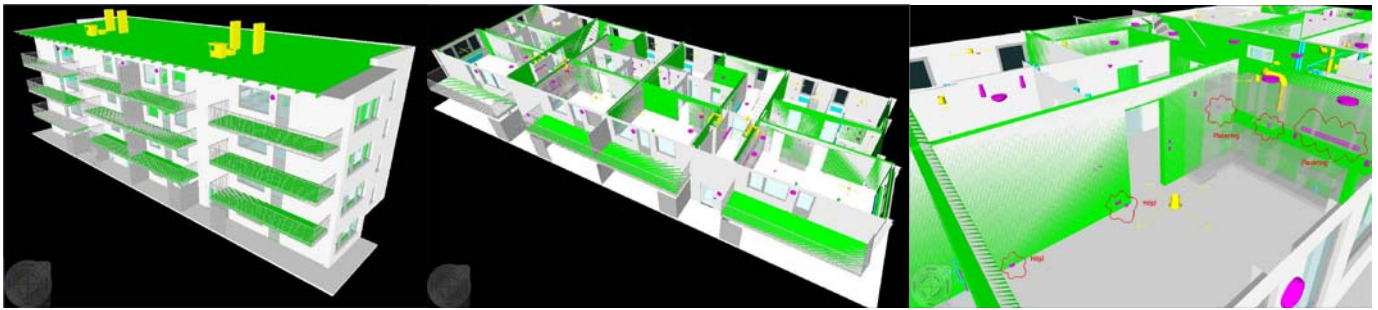


Figure 2: Gyllins Trädgård - Coordination Model (White Architects)

4.7 Step 2: Design BIM project execution process

Once the team has identified the BIM Uses, a process mapping procedure for planning the BIM implementation can be performed. Initially, a high level map showing the sequencing and interaction between the primary BIM Uses on the project is developed. This allows all team members to clearly understand how their work processes interact with the processes performed by other team members. First the high level (Level 1) map is developed (see Figure 3), then more detailed process maps can be added by the team members responsible for each detailed BIM use. The high level map shows how the BIM authoring, energy modelling, and cost estimating, are sequenced and interrelated. The secondary detailed maps records the detailed processes that will be performed by an organization or in some cases several organizations, such as the energy modelling.

Engaging the design team in this process goes some way to determining the 'who' and 'when' questions previously cited.

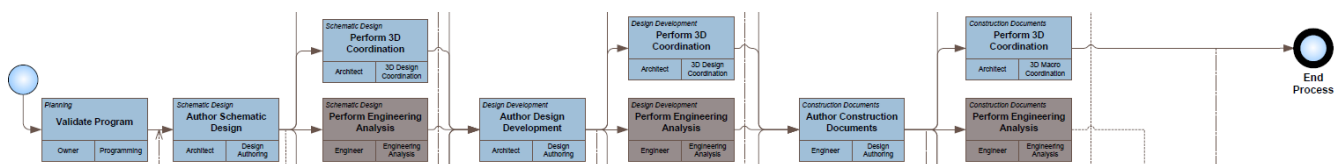
4.8 Data collected (Workshop No.2)

A second workshop was scheduled to record relevant information to facilitate the design of BIM *Execution Process Maps* for Gyllins Trädgård. The overview map below (see Figure 3) shows the relationship of BIM uses which will be employed on the project. This Level 1 process map also contains the high level information exchanges that occur throughout the project. Fundamentally the BIM use work packages or processes develop in information maturity as the task passes from *schematic design* through to *construction documents*.

The BIM uses are arranged according to project sequence, helping to communicate the phasing of each BIM use and define implementation sequence. Responsible parties for defining the information required to implement the process as well as the information produced by the process are identified and graphically notated.

Detailed BIM Use Process Maps are created for each identified BIM Use to clearly define the sequence of various processes to be performed. These maps also identify the responsible parties for each process, reference information content, and the information exchanges which will be created and shared with other processes. Here, beyond BIM process sequencing, dependencies between the processes are defined by considering the connections between processes. Gateways provide opportunity to represent decisions, design iterations or quality control checks.

Figure 3: Extract from BIM Execution Process Map - Gyllins Trädgård - Level 1: BIM Execution Planning Process



4.9 Appraisal

This process aims to determine which party is the best authoritative source for a particular piece of information, and what pieces of information each source or design participant needs to provide to others to enable those third parties to perform their tasks. The Level 1 process map allows team members to map what it does, what information it handles, and whether it is the optimum responsible party for that information.

By mapping BIM uses, processes and ultimately information exchanges in this way, it enables the design participants to:

- Appreciate new types of information a team member may be able to share that might be useful to others;
- Which information, provided by others, could help a team member perform its function better;
- How information is used in each team member's business processes and how it flows through their business systems;
- Focus on delivery of real services thus reducing or eliminating low-value data entry tasks;
- Opportunities to eliminate overlaps, redundancies or abortive work;
- Identify information exchanges that accelerate iterative workflow cycles.

The process of simply entering into dialogue and mapping BIM uses and associated work flow can help an organisation discover an ability to exchange information internally among different software applications that it previously didn't know, or that information created for previous projects may now be exploited more effectively for future projects.

The fundamental advantage of agreeing and recording such procedures is that it enables the team members to understand each other's tasks and work towards common goals that are often interdependent on information supplied by each other.

4.10 Step 3: Define Information Exchange Requirements

Once the appropriate process maps have been developed, the information exchanges which occur between the project participants can be identified. It is important for the team members, in particular the author and receiver for each information exchange transaction, to understand the information content.

This information content for the exchange is defined in the Information Exchange table. Here, consultants develop a chart mapping information exchange content, level of detail and responsible party for each exchange. This procedure identifies the vital information required to implement each BIM Use as defined previously.

The purpose here is to document the information that must be passed from one organization (responsible for a BIM use) to enable another to progress with their business process. When information is delivered in the form and quality expected, an efficient workflow is achieved.

In order for meaningful and enabling information to flow, a number of key factors need to be considered:

- The format of the information (type);
- A description of the concepts used / information to be exchange (what) and when;
- A common understanding of each design team member's information needs.

Once defined, an information exchange matrix can form the basis for parties' data interchange, allowing the information to be treated as an asset enabling efficient BIM processes and regulating information sharing between design team participants.

4.11 Data Collected (Workshop No.3)

A third workshop enabled collection of data to complete the BIM plan's Information Exchange Worksheet. This worksheet was developed to aid the project team to define the information required to implement each BIM Use with maximum efficiency. The mission here is to record information delivery expectations against a model element breakdown (the intention is that this should concur with the local classification system) through the scheme design, design development and construction documents stages for each BIM use.

Parties can share a strategic insight into the content, format, responsibility and timing of information exchange enabling optimised efficiency in data exchange through the design period.

Table 3: Extract from Information Exchange Worksheet - Gyllins Trädgård

BIM Use Title	Design Authoring (Schematic Design)			Cost Estimation			3D Coordination			Design Reviews			Energy Analysis			Design Authoring (Design Development)				
Project Phase	Design			Design			Design			Design Reviews			Design			Design				
Time of Exchange (SD, DD, CD, Construction)	SD			SD			SD			SD			SD			DD				
Responsible Party (Information Receiver)	A, SE, MEP			Cost Consultant			A, SE, MEP			A, SE, MEP			Energy Consultant			A, SE, MEP				
Receiver File Format	Revit *.rvt Acad *.dwg						Navisworks *.nwd			Navisworks *.nwd			Acad *.dwg			Revit *.rvt Acad *.dwg				
Application & Version	Revit V.10, Acad, MagiCad						Navisworks V.10			Navisworks, PowerP			VIP +			Revit V.10, Acad, MagiCad				
Model Element Breakdown																				
	Info	Resp Party	Additional Information	Info	Resp Party	Notes	Info	Resp Party	Notes	Info	Resp Party	Notes	Info	Resp Party	Additional Information	Info	Resp Party	Additional Information		
A	SUBSTRUCTURE																			
	Foundations																			
		A	A/SE		A	A/SE		A	A/SE		A	A/SE		A	A/SE			B	A/SE	
		A	A/SE		A	A/SE		A	A/SE		A	A/SE		A	A/SE				B	A/SE
		A	A/SE		A	A/SE		A	A/SE		A	A/SE		A	A/SE				B	A/SE

4.12 Information Levels

Key to aligning data exchange expectations within project teams is a system for describing information content. In Denmark (bips 2006) and Australia (CRC 2009) similar systems suggesting a hierarchy of information development levels have been articulated. Both systems suggest 7 development information levels ranging from brief to post construction. Representing a simple form of information maturity, an abbreviated information levels code can identify information maturity expectations.

4.13 Appraisal

In a scenario of a heavily laden information model being present, defining information exchanges becomes a critical operation to enable one to distinguish the wood from the trees and avoid laborious and time-wasting filtering exercises. A common frustration in practice occurs when information supplied by another is not what was expected or is of insufficient quantity or quality to carry out the immediate task without additional or subtractive operations. Every element of a project does not need to be present to be valuable therefore, it is important to only define the model contents that are necessary to implement for each BIM use.

If a receiver of information wants to be sure he or she can utilise the information received, the sender and receiver need to agree on which information to exchange. For example, an architect needs to be sure that he receives information from the structural engineer as regards which walls and columns are structurally load-bearing. Similarly, the structural engineer needs to know the use characteristic of the enclosures in order to calculate the correct design loads.

For BIM to be implemented successfully, it is critical that team members consider the future use of the information that they are developing - when the architect adds a wall to the BIM, that wall may carry information regarding the material quantities, structural and thermal properties. The architect needs to know in what way this information will be used in the future. The future use of this data can impact the methods used to develop the model content, or identify quality control issues related to the data accuracy for subsequent tasks relying on the information.

5.0 CONCLUDING DISCUSSION

The buildingSMART Alliance's BIM guide presents a valuable method of determining important prerequisites for effective BIM implementation. Together the BIM plan's planning procedures enable team members to gain a strategic insight into the who?- what?- when?- how?- questions relating to information exchange. The process facilitates a rational of continuous improvement by enabling teams to identify areas where processes are suboptimal and offers meaningful and flexible direction to achieving BIM integration and scope to identify opportunities for standardisation.

It can be observed that some technologies are not being used to their full advantage but enthusiasm amongst design consultants has pushed teams to experiment in parallel with traditional methods in a hunt for confirmation of usefulness.

However, what is problematic is that often project teams have varying levels of competence and willingness to partake in an iterative design process where fees are spent before they're earned. With new processes comes new relationships and organisations, firms cannot afford to view their contribution in isolation. At times it can be a struggle to obtain a consistent information level across all disciplines in a similar time frame but parallel processes are enabling a higher quality of design service to emerge which more and more clients are demanding.

One thing is clear, however, and that is that the participants all recognise the benefit of working in close collaboration from the early stages through design development. The possibility to make early and informed decisions through the use of technology to leverage a high level of quality information at the right time in the process has enormous potential to improve the state of the construction industry by injecting greater certainty.

It was noted that the drive behind BIM on this project has come from the client who has supplied a CAD-Manual detailing a base contractual requirement to produce 3D coordinated models for delivery to the contractor. There is the suggestion that many design consultants in Sweden are committed to implementing BIM since it is being demanded by more powerful actors. They see BIM as the means of addressing design challenges with which they are now faced. They believe that if they do not accept this challenge now, they will be overtaken by their competitors.

White Architects face a transition period between old practices and new while still meeting day to day programme requirements and deadlines. There is an inherent element of risk in changing practice working methods, however, such pioneers are beginning to realize efficiency gains. Although the extent of BIM usage here was somewhat immature, the focus is on perfecting the areas where BIM implementation is successful and where results are trusted. Secondary BIM possibilities are being investigated in parallel, and with experience on the rise, confidence should follow and enable extended uses and greater efficiencies to be leveraged.

As more industry professionals gain a greater understanding of the value of building information created not just through the design phase but through the whole building life-cycle, and learn to manage their own information accordingly, more will be able and willing to engage in value-added information exchange.

This process of attempting to define information exchanges for each relevant BIM use is closely tied to the development of the Information Delivery Manual (IDM) and Model View Definition (MVD) in which exactly which information is to be exchanged in each exchange scenario is specified (buildingSmart 2010). If developed into MVDs the exchange requirements should be assembled into re-useable concepts mapped to specific objects, properties and relationships present.

The conclusion of this preliminary study naturally leads to the development of a more extensive study of information deliveries and standardisation needs using BIM to enable findings to be generalisable and conclusive.

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