Processes and Standards for BIM Closeout Information Deliverables for Owners

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ABSTRACT

Building Information Modeling has been a catalyst for process change in the AEC industry in terms of earlier decision making, and in identifying the need for more precise and accurate information throughout the design and construction process. Due to the use of collaborative project delivery methods, and the owner's participation on the project team, the same catalyst is now forcing owners to provide more precise information regarding required deliverables. Consideration of the desired intent for the utilization of information during the life-cycle of the building is necessary to determine optimal information requirement. From the time of project conception, and throughout all project phases, opportunities exist to collect important information. The industry has responded with the development of consulting services to meet the owner's needs, and to also assist with recommended processes for owners to operationalize the project closeout information. Owner guides and standards are purposely kept generic to suit the needs of all owners and rarely attempt to address the specific data needs at the point of close-out. It is common for some owners to adopt another organization's existing contract deliverable statements but owners should articulate their own meaningful verbiage to achieve the desired closeout requirements. There are an excessive number of decisions required from the owner in determining their specific organizational needs, which present various challenges to the owner, but involve instrumental steps to begin constructing meaningful BIM attribute data. An understanding of the taxonomy and standards for the information will assist owners with operationalizing the handover deliverables. Additionally, defining the taxonomy for owner information will further delineate the LOD500 for future research.

INTRODUCTION

All organizations, regardless of type, size, and purpose, should develop a plan when attempting to implement a new process or technology. Although the concept is not new, Reddy (2012) described the information planning process for owners as the need to know where they currently are with regards to people, processes, and platforms – a gap analysis for owners. The Planning Guide for Facility Owners (2012) recommends a three step planning process to begin using BIM: Assess, Align and Advance. As part of the required assessment, owners must recognize the importance of the need for an internal gap analysis. Computer Integrated Construction (CIC) (2012) in their concluding remarks and lessons learned section stated, “While many organizations implement BIM on a new construction project prior to planning and implementing it internally, it is very difficult to create contract requirements that provide BIM benefits to facility operations without first understanding the internal BIM goals and needs.” There is a large amount of information required throughout the design and construction phases of a project, but it is the large amount of information needed once the project is complete that requires rethinking the process of delivering that information. Anuszewski (2013) has coined the term “big data” to refer to the data associated with the life cycle and its relation to digital organization. He also refers to the shift in the industry thought from “first cost mentality” to now beginning to understand how information can be utilized in the long-term management process for owners. Lewis (2012) included the abundance of data as one of the challenges for facilities management in reaching the full potential of BIM. Clayton et al., (1999) recognized that in addition to the over-whelming amount of information, there was also missing information or irrelevant information included in the closeout documentation. To fully realize the owner’s return on investment (ROI) for their BIM uses for facilities management, owners should consider the information as a capital investment (Keady 2013). Davenport (1997) devised the term, “information ecology” to emphasize an organization’s holistic environment which includes the firm’s values (culture), processes, and pitfalls (politics). Additionally, it includes what “systems” are in place (technology). He also described the important differences in defined terms:

- Data – Simple observations and easily structured
- Information – Data endowed with relevance and purpose
- Knowledge – Includes reflection, synthesis and context

Davenport (1997) cautions that yes, data is easy to collect and store, but the fact that it is data is also what makes it irrelevant. Organizations have a penchant to focus on technology based solutions of without considering how people create, distribute, understand and use the information provided. Although owners may adopt the deliverable needs from another document, a part of the growth for the owner in terms of BIM, is their internal development process in assessing informational uses once closeout documentation has been provided.

COMMUNICATION THROUGH LOD

The Level of Development (LOD) designation for project milestones has become a means to communicate the modeling process and the extent of the needs throughout the project. Furthermore, the LOD100 through LOD400 is an established standard to describe the expectations of the phased responsibilities for the project team members. The LOD designated by the AIA in their E202 contract (American Institute of Architects 2013), provides contractual assignments of responsibility at project milestones. Regardless of the selection of contract format, the application of the LOD typically occurs in the Object Element Matrix (OEM) or some form of table that describes the expectations of the model. The AGC BIMForum Committee’s Level of Development Specification (2013), facilitates a “level of consistency for the purposes of communicating the state of development of various systems within a

BIM". The specification provides a detailed list, outlined by CSI UniFormat categories with interpretations of detail at each level. The committee has announced that, "While LOD 500 is included in the AIA's LOD definitions, the working group did not feel it was necessary to further define and illustrate the LOD 500 in this Specification because it relates to field verification. Accordingly, the expanded descriptions and graphical illustrations in this Specification are limited to LOD 100-400" (BIMForum 2013). Clayton et al. (1999) states that the as-built or record drawings that are commonly delivered by designers are not adequate as the information base for operating a building. The committee recognized the different end user needs for the LOD500 and one committee member acknowledged the difficultly of equating an as-built model to an FM model (Associated General Contractors BIMForum 2013). As researchers refine the LOD definitions, their adoption and use have become more prevalent as an industry standard, but the LOD500 has yet to be established as an approach for outlining specific facilities maintenance (FM) data needs. The BIMForum (2013) and the Computer Integrated Construction (CIC) Research Program (2012) have added a second level to the LOD500 to indicate levels of as-built conditions. For example, the LOD520 distinction represents as-built conditions, which contain LOD200 facility and geometry data. However, facilities management is a different industry than design and construction, thus there is a different use for the handover documentation. Should the industry continue the LOD100-LOD400 framework for the owner's LOD as well? This paper introduces possible considerations for the purpose of maintaining dialog for the establishment of the LOD500 standard and owner specific solutions.

TAXONOMY CONSIDERATIONS

Yoders (2013) summarizes the benefits of the new LOD Specification, and also contributes a summary of what he describes as "the coming O+M model." There is discussion, but minimal consensus regarding the ways to meet the O+M model goals, especially given that it is possible to meet those needs with a model that has less detail. For example, the specifics of welds, and erection information required for construction is rarely needed for facilities management personnel, but what they do need is more non-geometric information. When considering the end use, the LOD100-LOD400 is intended to satisfy the needs of the contractor, but for the LOD500, the end user needs are for multiple purposes within the owner organization. To contribute to industry dialog regarding solutions for refinement of the LOD500 taxonomy, there are several factors to be considered, which are outlined in Figure 1 and further described in Tables 1 through 4.

LOD 500 Data Taxonomy Considerations			
Data Format (How)	Data Process (Who)	Data Richness (What & How much)	Data Use and Frequency (Why)

Figure 1. Data Taxonomy Considerations

Owners have long been dissatisfied with the traditional closeout documents and as-built plans. Clayton et al. (1999) identified several primary issues including inappropriate format, and a mismatch in terms of structure and content. Collaboration from the A/E firms and contractors has not been an issue, provided the owner defines the needed deliverables (Giel et al. 2012). The purpose of creating the LOD Specification, according to Hamil (2013), is to help owners in specifying what information they want and when, and to help design managers explain those goals. As COBie and the FM Handover Model View Definition (MVD) processes are refined, they provide a structure for the information the owner needs, but they do not support the owner with what to populate them with in order to receive value later in the life-cycle (Love et al. 2013). Love et al. (2013) also noted that the exercise of determining owner information and the taxonomy of content assists with data collection, usage, as well as understanding what may be missing from their internal management systems. When considering "big data" and "information ecology," the taxonomy for the owner's data may include several factors, each of which are further explored in Tables 1-4. The factors also include implications of costs. Considerations for costs to the owner would generally increase between LOD500 and higher LODs, and also imply that there is more value to the owner as the LOD increases.

Data Format. Yoders (2013), quotes Jan Reinhardt, Co-chair of the BIMForum LOD Committee, and clarifies that the LOD Specification document exists as an established communication standard, and not as an approach to the progression of the project documentation. Including data format considerations in the LOD taxonomy would communicate the need for the type of transfer methodology. Owners struggle not only with the amount of data but also with the requirement of numerous formats provided at closeout. An additional statement from the LOD Committee confirmed that LOD500 is more about the non-geometric information versus graphical representations (Yoders 2013). Therefore, format should become a portion of what the owner specifies (as shown in Table 1), because the ability to use the information post-construction is often dependent upon the ability to retrieve the information (Keady 2013). In many cases, the format will require minimal additional effort by the consultants because they are already in a preferred format (Clayton 1999). Although the equipment may be provided in a geometric form in the model, which designates the location, maintenance does not need exact representation but instead will need equipment lists and associated warranties and operation instructions (East 2009). The advantage of BIM resides in the attribute and the relational database format. Most CMMS systems are also database driven and the benefits are realized after mapping the two platforms to establish data transfer. Clayton (1999) describes the owner's degree of structure requested by consultants as an "open question" and a "moving target." Until further interoperability issues are resolved, the owner should identify through gap analysis, the format that best suits the internal needs of the organization and include those format needs in the model element matrix.

Table 1. Data Format Description

Description	LOD5XX	to	LOD5XX
CD, hard copy, BIM, COBie or template file	LOD 5X0 to include CD or hard copy		LOD 5X5 to include highest level of transfer capability (IFC, COBie) up-load to owner FM systems

Data Process. Jizba and Wilkinson (2013) describe the use of the Model Development Specification (MDS) for the Mayo Clinic as the primary platform for communication for the model components. The owner in this case has continuous involvement throughout all phases of the project. Similar to design, the planning process for facilities information can occur simultaneously in phases and in conjunction with the project phases. The data process, unlike other considerations for LOD, is a factor requiring owner accountability. An appropriate analogy for a request for deliverables is the purchase of a computer. For example, it is possible to select all computer options and peripheral items when making a technology purchase, but often those selections add up to unrealistic total cost. Most owners are simply unaware of the costs when including all information desired (as opposed to what is truly needed). Unfortunately, since most public owners are not fully aware of total costs, it rarely seems impractical to an owner to request more than what is needed. An overload of information causes a lack of purpose, and therefore what could be information, is simply unused data (Hjelseth 2010).

Table 2. Data Process Description

Description	LOD5XX to	LOD5XX
Deliverables outlined with no collaboration vs. utilization of MDS	LOD 5X0 to include no collaboration for the collection of data	LOD 5X5 to include collaboration and inclusion of MDS with identification of responsible party

Data Mandate (Richness). Data Richness is defined as the degree of information embedded within the model (NIBS 2012). The mandatory provision of data richness will depend primarily on the maturity of the building owner. A study conducted by Sattenini e.al. (2012) concluded that there are concerns with implementation and the ability to mandate model deliverables. Their research primarily focused on adoption and implementation issues, as opposed to the data and deliverable requirements but ultimately, the maturity level of the owner will be a driving factor in their capabilities to designate specific product needs as well as what information associated with each product must be provided. The National Institute of Building Sciences (2012) implemented a minimum BIM in the 2007 version of the BIM Standard, which assisted owners with a starting platform for model mandates. There are a total of 7 areas of interest, several of which address the non-geometric information requirements. Along with the minimums for business, information accuracy, interoperability and others, Data Richness is included and described as a model providing a worthwhile source of data. Although the minimum BIM requirements provides a methodology for strategic BIM improvements, it has a primary focus on the model itself, as opposed to the ultimate use of the data from the model (NIBS 2012).

OmniClass has become the object-oriented standard for BIM data, particularly in terms of the data exchange methods such as the Construction Operations Building Information Exchange (COBie). It has yet to be determined what amount of information is optimal to include directly in the model, but Keady (2013) noted that a vast majority of the equipment information may be linked so that a single BIM object may access an entire facility equipment record. Progress has been made in recent years to standardize object based codes through the use of the OmniClass. Table 23 has 6,906 product items, and other OmniClass Tables are just as extensive; therefore, it is unrealistic to specify information for an all-inclusive requirement of Table 23. The data richness mandate can technically overlap what is known as the Level of Detail (LoD). Although standards provide methods to organize for facilities, there is still the need for the owner to establish relevance. Most facility managers have different opinions of what equipment inventories should be, and what types of inventories exist. Regardless of the apparent need, a portion of the difficulty for the owner is the misconception of the importance of the data format, which is one of the reasons for errors in FM programs and operations (Keady 2013).

Authors have approached ideas for taxonomy of information, and levels of data richness, a concept summarized in Table 3. Becerik-Gerber et al. (2012) identified three types of captured assets, which include the equipment and systems, attributes and data, and portfolios and documents. Wang et al. (2013) further refined this idea and presented a helpful graphic for the BIM database concept which segments the attributes and data in the model from the portfolio and document information and assists owners in the determination of what information should be generated in the model versus provided in a portfolio or separate database deliverable. Several authors (Yu et al. 2000; Becerik-Gerber et al. 2012; and Shen et al. 2012) have addressed ontology concepts for facilities information. Becerik-Gerber et al. (2012) provided a data structure specific to non-geometric data requirements in a pyramid classification from the basic identification down to the operation and maintenance data, where the volume from top to bottom increases. Yu et al. (2000) addressed the human resources and uses of the data, which ties to Data Uses and Frequency, Table 4. Shen et al. (2012) began to address the ontology and mapping, and proposed a system architecture which includes categories of end users and services (similar to Yu (2000)) and systems and basic services (similar to (Becerik-Gerber 2012)).

Table 3. Data Richness Description

Description	LOD5XX to	LOD5XX
Degree of data embedded or linked in the BIM model. (Hierarchy ranging from metadata to OmniClass Level 4)	LOD 5X0 to include only metadata, space, & generic component information	LOD 5X5 to include attribute data through the last level of OmniClass hierarchy. For example: to include very specific template such as a list of products (Table 23)

Data Use and Frequency. The view of data pertaining to use and frequency in Table 4, also ties to the work of Yu (2000) addressing the operations and human resource needs of the data. To capitalize on the database element, considerations for an LOD taxonomy should include a thorough review of asset management practices, and what information provides value for the owner. Information should have a specific purpose for managing facilities. A subset task of FM is asset management, which includes the coordinated activity of an organization and the value of assets. This is especially important as changes to the FM industry include an increased demand for service and expectations, but a decreasing funding source (Institution of Civil Engineers 2013). The Federal Energy Management Program (FEMP), and Teicholz (2001), outlined specific categories of operations and maintenance (O&M)

programs which includes reactive maintenance, preventative maintenance and predictive maintenance – all of which have different levels of frequency of need in terms of data retrieval.

Table 4. Data Use and Frequency Description

Description	**LOD5XX to**	**LOD550**
Use based on frequency. Space information is easily provided and used often vs. maintenance procedures for equipment	LOD 5X0 to include everyday use such as room numbers and space and daily work order needs	LOD5X5 more specific information regarding procedures, manufacturer's recommended stds, contact, warranty, and PM scheduling

Hunt (2013) addressed the layout, content, development and organizational process for an O&M manual. It delineates a system level, technical content, and also addresses task performance. Up to 48% of the data for O&M is available at the 100% design phase, so when clear deliverable requirements exist, it is possible to collect information early in the project and with specific purpose.

CONCLUSION

Each of the proposed areas for consideration includes a literature review that owners must consider in the establishment of meaningful deliverables. The considerations for an LOD hierarchy address not only the needs of the owner, but also the effort required for the project team. Similar to the established LOD Standards, the costs associated with the effort must also be addressed in the hierarchy. The LOD500 will serve the owner’s purpose and therefore a different intent than that of the LOD100-LOD400 and therefore must take into consideration more than the amount of information at each level. Since owners in some cases prefer less information than what may be provided at the LOD400, there may be a divergent path during the LOD300 to address the owner’s desired closeout model. The proposed considerations provide areas for future research, and the establishment of considerations for the framework of an owner’s LOD500, as well as an approach to solutions from the owner’s perspective in the establishment of a gap analysis process.

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