Construction to Operations Exchange: Challenges of Implementing COBie and BIM in a Large Owner Organization

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ABSTRACT

Despite the transition from paper to digital media, hand-off of data and documents from construction to operations and facilities management is still cumbersome and often requires manual entry and duplication of effort. This paper presents initial findings from an ongoing pilot project that began in spring 2011 on a digital information exchange standard called COBie (Construction Operations Building Information Exchange). Through interviews with key participants, we analyze existing practices as well as proposed changes to be made to these practices. Across a large organization, digital information is not trusted—nor is information neutral. Information is connected to particular jurisdictions who currently control the creation and management of their own datasets. We found that despite availability of digital information, people generally prefer to obtain information from colleagues with direct knowledge of the project or from paper documents. Digital information was considered to be either too difficult to access or not viewed as trustworthy since digital data was not consistently maintained. As more digital information is amassed, including information from COBie and building information models, organizational cultures and practices need to be developed around these new datasets.

INTRODUCTION

There is a growing interest in how Building Information Modeling (BIM) can be leveraged to streamline the operations and maintenance of existing buildings. This includes questions about how BIM tools, created for the design, planning and construction phases of a project, can be used for data exchange with owner organizations and for operations and maintenance activities.

While there is much interest in using data that originates within Building Information Modeling for facilities management and operations purposes, in practice there are numerous contractual, technological, procedural and cultural details to be worked out before the average owner organization can do so. For example, the CIC Research Group at Penn State is developing an Owner Execution Planning guide that defines both BIM processes, as well as information exchange and contract requirements (CIC 2011). National and international efforts, such as the buildingSMART (2011) and buildingSMART alliance (2011), are underway to create information exchange standards for building design, construction and operations data to address technical issues of interoperability, as well as establish best practices for the creation, exchange and use of this data. One of the most extensively developed information exchange standards is known as COBie (Construction Operations Building Information Exchange), which facilitates the transfer of digital information from the design and construction process to the facilities management databases (East 2007). These efforts exemplify the AEC industry's growing interest in meeting the challenge set by CURT (Construction Users Round Table) in their 2004 report: "Digital information created by the collaborative team flows throughout the lifecycle of the building project, emanating from the building information model that has virtually constructed the building before construction commences and supports its operation throughout its life."

Our initial findings suggest that implementing BIM and COBie would indeed streamline project activities with the most immediate tangible benefit being improved tracking of warranty information to avoid potentially significant costs associated with unnecessary equipment repair or replacement during the warranty period (Smith and Tardif 2009). We have found that the exchange of the COBie BIM information involves the distribution of COBie BIM data across the owner's distributed information technology (IT) infrastructure, where information is not neutral, and often not trusted, and is connected to particular jurisdictions and requirements. Once transferred, the subsequent use and maintenance of the COBie and BIM data is not a trivial problem.

BACKGROUND

Much of the research on BIM has focused on the processes of design and construction, and research around owner's use of BIM for operations and maintenance activities are much less common. However, in 2004 the National Institute of Standards and Technology (NIST) published a study that estimated an efficiency loss of $15.8 billion in 2002 in the US Capital facilities industry resulting from inadequate interoperability between industry software systems. Of these costs, two-thirds ($10.6 billion) are borne by owners and operators with the majority of that cost ($9.1 billion) occurring during the operations and maintenance phase (Gallaher et al. 2004). As a result, there has been an increasing focus on creating BIMs for owners that can be carried through the lifecycle of the building.

Since then, studies have embarked upon targeting and quantifying specific efficiency losses to ensure managers that implementing a new system will provide a return on their investment (Becerik-Gerber and Rice 2010). Much of the literature is focused on interoperability, specifically transferring building information from the design and construction phase to the operations and maintenance phase. With this focus on COBie and BIM transfer, comes the image of a BIM with COBie data ("COBie BIM") as a "final deliverable." This COBie BIM is exchanged from construction phase to the operations phase and the "model is kept live" for O&M. However, we have found several organizational challenges such as a distributed IT infrastructure, distrust in digital information, and difficulty with digital information retrieval make the roll out of COBie and BIM difficult for owner organizations

The management of digital information is a common theme in recent literature (Javernick-Will and Levitt 2010). Organizations that implement BIM, for example, are encouraged to create a BIM manager or "information steward" position to manage and maintain BIM information (Smith and Tardif 2009). Much of the focus has been on transferring the information from the design and construction phases to operation and maintenance, with the assumption that it would be utilized by owners and O&M personnel if made available (East 2007). However, plans for how facilities operations and maintenance personnel consume, maintain and use information are less clear. While it is reasonable to expect a position, or multiple positions, to be dedicated to maintaining digital information, people at all levels of an organization are generally expected to retrieve and use their own information. Currently maintenance personnel rely on tacit knowledge networks (i.e. colleagues) who are uniquely qualified to provide the right kind of information because they have an understanding of the context (Javernick-Will and Levitt 2010). Furthermore, the majority of O&M personnel are conservative with computing environments – preferring to use people or paper documents to transfer information – and often have difficulty finding information in digital repositories (Lee and Akin 2009; Lee and Akin 2011).

As digital building information grows, the ability to quickly find and retrieve information becomes more crucial (Dossick and Neff 2011). Developing COBie BIM practices requires developing "consistent procedures for file naming, data storage, data indexing, and data archiving so that information can be easily retrieved and validated" (Smith and Tardif 2009, p. 39). Within the construction IT field, techniques such as establishing semantic networks and using intelligent retrieval mechanisms are being developed (Goh and Chua 2009). Another consideration is the "push" method for information retrieval. A standard search for information would be considered pulling information, but a study at University of Salford proposes establishing "profiles" that personalize information needs and thus push specific information to personnel (Rezgui 2006). However, developing a profile or a consistent file naming system may not be enough. A successful archiving and retrieval system for facilities may need to consider moving beyond using words as a storage medium. With the increasing use of GIS and smartphones, images and symbols may become the predominant method of connecting information to storage locations. This is how Google Maps has given 80 million U.S. smartphone users access to data that once was contained only in the yellow pages (Lunden 2011).

METHODS & SETTING

Researchers and practitioners are working together to implement a BIM/COBie Pilot Case Study project at the University of Washington (UW) as part of a joint initiative by the Construction Owners Association of America (COAA) and buildingSMART alliance. For the University of Washington, this pilot project is seen as a part of a larger initiative by Capital Projects (design and construction) and Facilities Services (operations and maintenance) to create better hand-off processes for facilities and O&M information, and the creation of meaningful BIMs for the owner organization.

The University of Washington has over 335 buildings on its main campus and manages approximately 20 million square feet of real estate. The campus buildings and infrastructure have a long complex history and the building records are as varied as the buildings themselves. Any new construction information is consumed by a large distributed organization that manages different operational functions.

For this pilot, the construction team created a COBie BIM for the Foster School of Business Phase II building. Our approach for this project was to understand how the

UW facilities operations and management would utilize and benefit from COBie BIM data, and this in turn would guide the Capital Projects group's development of future COBie BIM deliverable specifications. We interviewed not only consultants and UW personnel associated with the case study itself, but also personnel throughout the university to gain a more complete understanding of typical hand-off procedures, workflow, and information flow. Over the summer of 2011 we completed 27 structured interviews with personnel from University of Washington and two key members of the building project team. See Table 1 for the breakdown of interviewees by department and title. The research team consulted UW organization charts to determine a representative cross-section of university personnel to speak with. A few interviews resulted from snowball sampling from initial interviewees. Each interview lasted 45 to 60 minutes and was recorded and transcribed. Interview notes were also taken. The team collected paper documents and obtained access to web documents, such as a printout of the commissioning tracking table, the Computerized Maintenance Management System (CMMS) asset group list with attributes, a sample work order printout from the CMMS, and Electronic Document Management System (EDMS) websites used for storage of construction documents. From the data collected, we mapped workflow processes and information exchange, and identified several recurring themes.

Table 1. Interviewees

Department	Title	# interviewed
UW Capital Project Office	Construction Manager	2
	Assoc. Const. Manager	3
UW Facilities Services Campus Engineering	Manager (Electrical, Arch, Environmental, Records)	1
	Architect	1
	Electrical Engineer	1
	Mechanical Engineer	1
	Records Program Coordinator	1
	GIS/GPS Specialist	1
UW Facilities Services Maintenance & Alterations	Director	1
	Zone Manager	2
	Zone Coordinator	1
	Electrical Lead	2
	Plumbing Lead	3
	Refrigeration Lead	3
	Metal Trades Lead	1
	Architectural Trades Lead	1
Outside Consultants	Construction Admin Architect	1
	GC Senior Project Engineer	1
	Total Interviews	**27**

FINDINGS

Introducing new datasets and data structures, such as COBie, to a complex distributed organization such as the University of Washington, presents a challenge in that the owner is not a single unit or single database, but a complex organization with distributed functional requirements and jurisdictions. We found that adopting COBie was not just about *what* information was being exchanged, but more importantly the how, when, and where it was being exchanged (Marsters et al. 2011).

From our analysis of a series of work process maps and sociograms, we found that the COBie data structure supports direct digital exchange between the contractor's BIM tool and the owner's information systems. In this case there were several mature IT projects that were ready to interface directly with the COBie BIM data.[1] This information exchange occurred across a network of distributed O&M databases. The COBie BIM is compiled from a variety of construction models and datasets, exchanged as a single file and then divided again into parts as the datasets are consumed by the CMMS (asset data), the Space Layout (architectural BIM), and the EDMS for records archive. The gateway nature of the information collection and exchange is illustrated in Figure 1 which shows a sociogram of information as it is created, exchanged, consumed and used throughout design, construction and operations. Nodes represent the variety of repositories for AECO information ranging from hardcopy documents to database systems such as Innovator (UW's EDMS) and Honeywell (one of UW's building controls systems). In Figure 1, as one moves from left to right, from design to operations, the

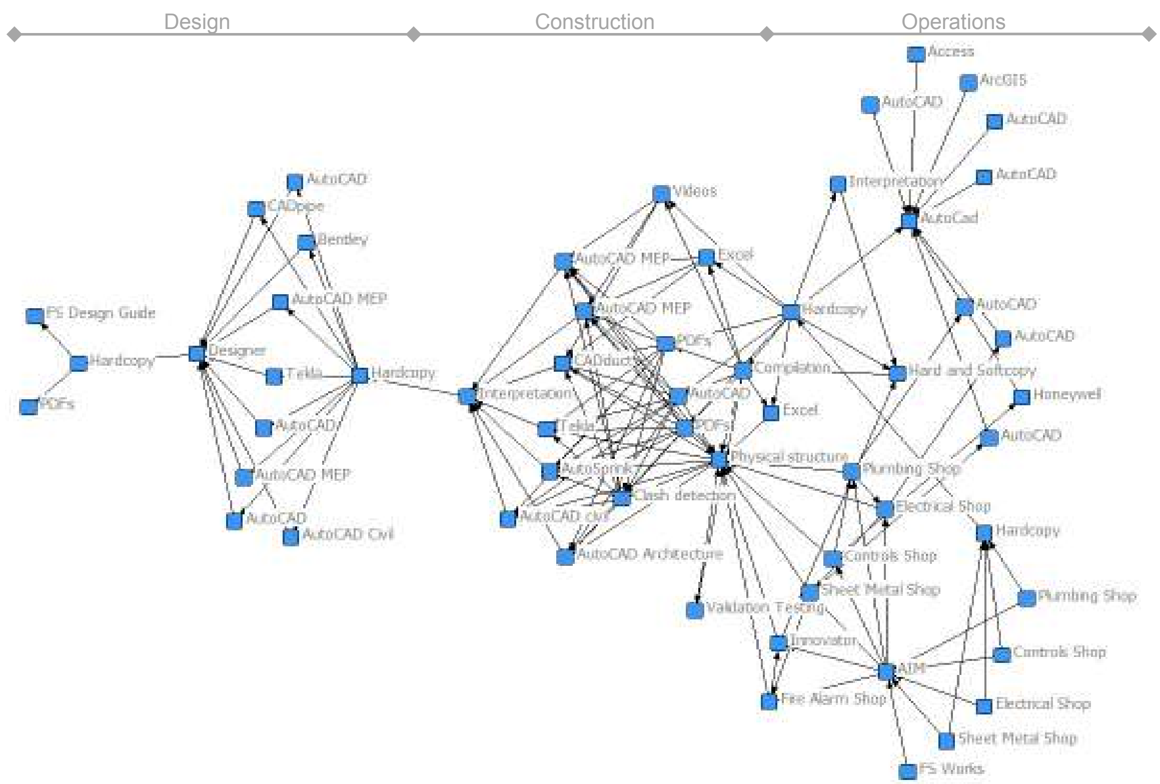

Figure 1. Distribution of COBie/BIM information

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[1] These include the CMMS system AiM by AssetWorks and a homegrown GIS/BIM/CAD tool for space layout.

network of information infrastructure becomes more distributed. In contrast to current BIM theories, where the design and construction models coalesce into one operations BIM, what is striking about the information map shown in Figure 1 is how information from the design and construction process is disaggregated and distributed across the operational functions such as Fire Alarm, Plumbing, and Controls and fans out into a wider spectrum of distributed datasets than either of the previous two phases of design and construction.

The COBie BIM from the new pilot project will join datasets that include legacy data from over 300 existing buildings. The UW is currently enacting a LEAN effort to convert existing building records from paper-based to digital. Interviewees spoke about how the process of transitioning to all digital data may allow the organization to be better prepared for implementation of a BIM/COBie initiative. As large institutional owners seek to leverage efficiencies promised by COBie and BIM, there are a number of technical and logistical themes that emerged from our interview data that should be considered. We focus here on challenges to the consumption and utilization of COBie BIM data that will better inform the creation and exchange of COBie BIMs. These issues include: (a) Information overload — the challenge of sifting through large amounts of data, (b) Inconsistent digital storage conventions, and (c) IT usability issues.

Information Overload

One interviewee summed up concerns of several personnel: "Everyone has acknowledged that digital copies are better [than paper]. My question is, how will that work going forward when you have a huge inventory of digitized information?" Operations and Maintenance staff at the UW are aware of the increasing volume of information that must be stored as building systems become more complex: "There's so much more documentation now than there used to be." As a result, each project has a large amount of information which makes searching for specific items more difficult. For example, Phase I of the business school, which was completed just prior to our COBie pilot project site, has 439 documents listed in the UW Records website including manuals, specifications, and drawings. Another interviewee lamented that "the Records site is kind of hard to use. If you type in [a building's name] it has ten pages of every little project that went on in there and I have to sift through and find the original year it was built …."

As part of our study, we have been tasked with determining the specific information each group needs. One interviewee said, "All information is valuable" to which a colleague responded, "You don't want to get saturated, though." A manager summed up our challenge when he stated, "We can't just give a list of things we require because all projects vary. … I'll look at things and think, 'That's not what I want.' It would be nice to pick the things you want to look at. Everybody is looking for something a little different." As COBie BIM technologies, supported by the growing trends of cloud computing, enable larger data infrastuctures, user interface sciences face a growing challenge. Namely with a complex owner organization such as the UW, "Not everybody wants the same information." The distributed organizational structure of UW operational functions necessitates IT that is tailored to divisional requirements. In its current form, the IT infrastructure maps fairly closely to the organizational distribution, and as such creates a tension with the more centralized solution that the COBie BIM suggests.

Inconsistent Name, Storage and Data Type Conventions

We found no consistent procedure for naming or storing information from project to project. During the design and construction phases, some project information is stored on a local drive to which certain personnel have access, while other project information is stored on a web-based EDMS, such as Submittal Exchange or Newforma. Because each project and each group is different, finding information becomes a challenge.

COBie BIM information exchange requires more systematic definitions and standards for naming conventions, storage locations and data types. For this pilot, detailed lists for each asset type were exchanged between the CMMS manager and the contractor to define the specific asset and asset attribute naming conventions. The location of associated files such as manuals, warranties and training videos poses a significant storage convention challenge. One interviewee complained while looking for a document on his computer, "Electronic files could be harder to find than paper files," and reached into his desk drawer for the hard copy. Standards go beyond naming conventions and define also the types of data to be stored. COBie is infinitely flexible. Within the data structure, users can define any number of components and attributes. Gaps will occur when data types are also non-standard in that staff will not expect that to be in the system, as one staff member stated: "Why look this time if the last two jobs didn't have that info?"

IT Usability

One of the lauded benefits of BIM is that it has the potential to increase "wrench time" —time on task for maintenance crews in the field (Forns-Samso et al. 2011). However, we found that a low level of comfort with computers poses a direct challenge to accomplishing successful COBie adoption. As one interviewee was demonstrating the AiM system for us, he apologized for being slow, adding "I was trained in the trade, not in computers." This low level of comfort presented a challenge when converting from the previous CMMS to the current AiM system: "We had a heck of a time getting this CMMS implemented. The biggest issue was getting trades people to be comfortable with a computer." An additional observation from one manager: "It's hard for a lot of these guys to find the information. … There's no easy way to get to this stuff. It needs to be accessible to the average trades guy. If they could look it up [online] rather than spending half a day in [my office looking for it] that would be great." Another staff member explains, "If you can get info without having to know CAD, that would be ideal. Otherwise, it's a waste of everyone's time."

With the vast amount of real estate to operate and maintain with "minimal crews as is," time is a rare commodity among the facilities services personnel. "If [technicians] are interested [in looking up documentation], I'll show them how to do it, but it's time consuming to teach so I try not to do that." This results in the maximum benefit from software systems not being realized. "[AiM] can do a lot, but we don't know how to use it so we're just using the part that we know."

We found personnel often turn to alternate sources before searching for information digitally. An engineer who uses a computer on a regular basis told us, "I find [the CMMS and EDMS programs] a bit cumbersome. They aren't intuitive. When I really need something, I'll call Capital Projects and ask them to send me a pdf." The manager of a maintenance crew stated, "[Technicians] will look for the hard copies before they sit down at a computer." Even though most project information is available digitally, one interviewee stated, "The weekly OAC meeting is the best way to get information." Another told us, "I carpool with some of these guys. That's where my information comes from: van pool." One technician describing "one of the best hand-offs" said, "[The contractor] had a woman right there on site and you could go right to her for information. If she didn't have the info, she'd find it for you."

DISCUSSION

The existing information infrastructure at University of Washington appears to be one of the greatest challenges to implementing COBie/BIM. Facilities operation and management is divided into geographic zones to better serve the university, and over the years many of the trades within each of the zones have developed and maintained their own system for collecting and managing data. The systems, which at one time would have been all paper documents, have developed into a hybrid of paper and digital information, rather firmly established within each group. It is generally agreed upon that a single, central BIM as a single source of truth is an "ideological pitfall" that, being unwieldy, will remain unrealized. The emerging BIM paradigm is a distributed model (Smith and Tardif 2009, p. 30). This means for COBie to transfer information to the software distributed among the university without continual effort and input from each group, a significant amount of work to establish the exact individual information needs must occur. One of the goals of this case study is to determine, for the Foster School of Business Phase II, exactly what that entails. Through our interviews, we have determined that warranty information, for example, is a universal need among the facilities shops. It is possible that having access to that information alone would be worth implementing COBie BIM at UW. Substantial completion for the case study building is scheduled for February 2012. Afterward, when all pertinent data has been collected, we can provide a measured assessment regarding the viability of implementation throughout the organization.

Once the information is made available through COBie, the operations and maintenance crews will be able to access the information the same way they do now. That is one of the advantages of COBie – it transfers information to the software systems (e.g. AiM) that people are already using. The problem is, as discussed in our findings, many of the personnel are having difficulty using their current software systems. Therefore, another hurdle before adopting COBie will be to determine if current software systems will remain in place and, if so, will crews need additional training? Is there another way to make information in existing systems more easily accessible?

And, finally, the move to provide all information in a digital format may need to be reconsidered in favor of a hybrid method of information retrieval. Prior to implementing a CMMS at the UW, facilities staff relied on colleagues and paper documents to retrieve building information. As a case in point, while replacing a hot water heater, a plumber turned off the water to a building, without knowing that it serviced an adjacent building as well. "I've only been here four years and didn't know the hot water was connected between the two buildings." He explains that "guys who have been here a long time know these things; it would be worthwhile to sit down with some of these guys that are almost 60 years old and just talk about it."

At the University of Washington, by digitizing all information, maintenance personnel will need to change their information retrieval method from a primarily tacit knowledge network to one that is explicitly contained in a digital infrastructure. While information science addresses issues of information retrieval, we must consider that retrieval is not a "one size fits all" method. For maintenance and alterations crews, whose traditional method of job training involves apprenticeship, people are central to the flow of tacit knowledge – not information technology (Javernick-Will and Levitt 2010). In a transition from a tacit knowledge network to a digital database users don't *know* what they don't know. In a social exchange, people often do know the gaps in our knowledge and are able to anticipate our information needs. In thinking through COBie BIM adoption, we need to address technical details such as file structures as well as ease of use and how the digital infrastructure interfaces with the very powerful tacit knowledge network. Is it possible to create a social-technological system that leverages both the strengths of information databases and exchanges represented by BIM and COBie as well as the contextual power of tacit knowledge networks? Are these sites of intersection places of conversation? (Dossick and Neff 2011).

CONCLUSION

The main goal with digitizing building information is to make the information more accessible and prevent missteps. In our case, we found that there is still quite a bit of work that needs to be done to integrate organizations to use data in this way. One of the advantages of COBie is that it will allow asset information such as warranties and manuals to be exchanged among multiple programs and personnel who are already using and accessing this information. In theory, information could be transferred seamlessly between the COBie BIM used during design and construction and the CMMS used during the facility lifecycle. Consequently, the technician who uses the CMMS will have the building data at the time the building is turned over and this dataset should be more complete and accurate having been automatically populated from the installation process.

However, if BIM and COBie are adopted, we need to not only streamline the flow of information between programs, we need to address the interface for facility services crews so they can leverage these new datasets. The experience and comfort level of operations and maintenance personnel lies not with computers, but in assembling, assessing, operating, and repairing physical systems. Time spent training with new technologies and grappling with complicated interfaces means less time on the physical systems that need their attention. Our interviews confirm there is a frustration with continual software updates. Resistance to new technology adoption is reasonable, considering they believe it will burden them with more administrative tasks. Questions remain, then, as to how to develop information retrieval systems for construction that efficiently provide information to non-technological staff whose primary job is not computer-oriented.

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