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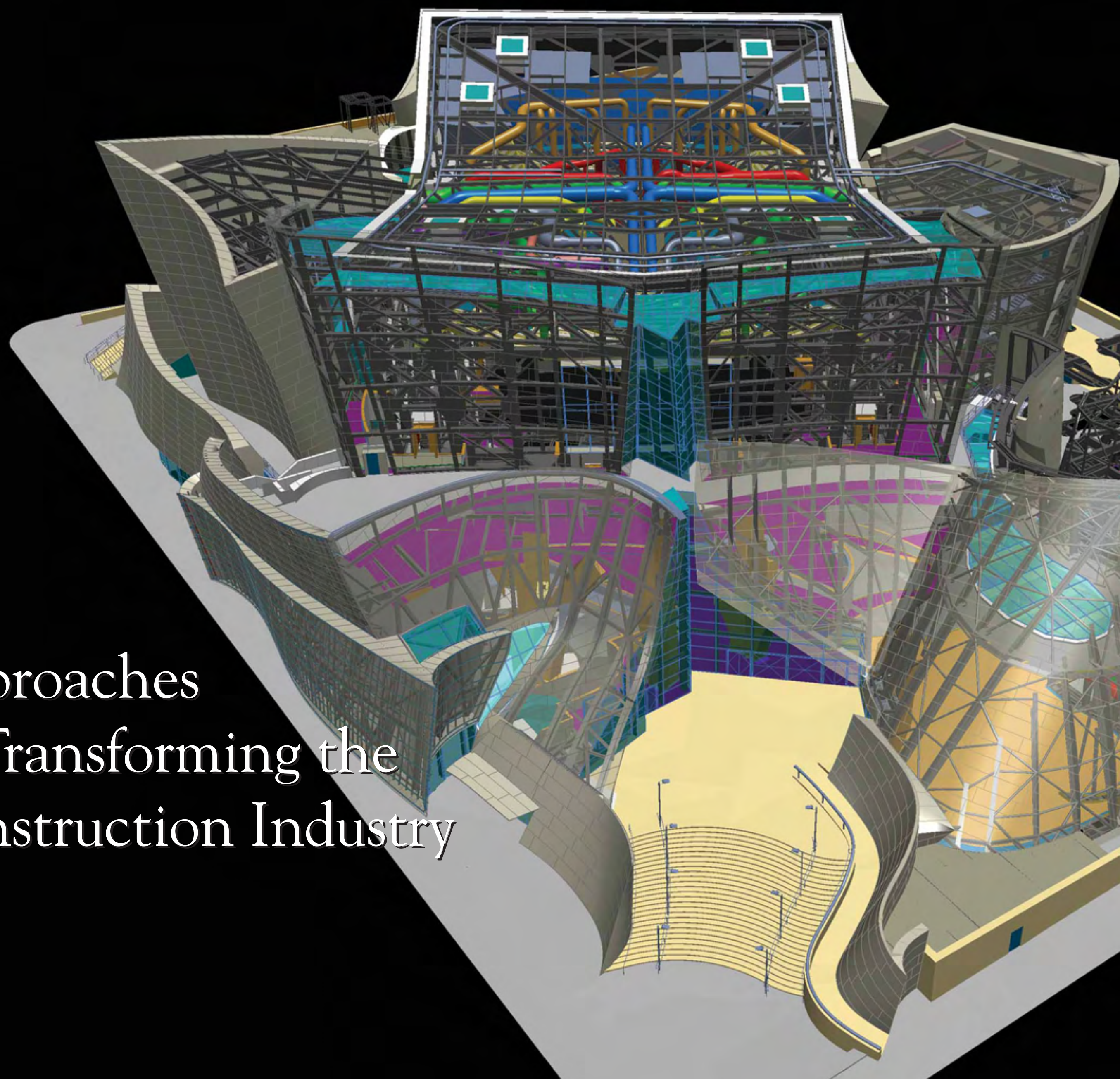

Approaches to Transforming the Construction Industry

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BIM for Construction Handover

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PROBLEM

Along with the keys, facility managers typically receive many "bankers' boxes" full of information about their facilities at construction handover. This information is provided in paper documents that describe equipment warranties, replacement parts lists, building system operating instructions, maintenance job plans, and fixed asset lists. Today those who use the information provided must, at best, pay to have the data keyed into the relevant data systems. At worst, facility maintenance contractors are paid to survey the existing building to capture as-built conditions. In these cases, owners pay twice—once for the construction contractor to complete the documents at the end of construction and again for the maintenance contractor survey.

There are several problems with the current procedure for construction handover documents. First, construction contractors are required, at the end of a job, to recreate and collate information that has been created by others. Since the construction contractor is not the author of the majority of the information provided, requiring the contractor to recreate the information introduces errors. Second, waiting until the end of the construction contract to receive the information often results in less than satisfactory deliverables, many of which are available earlier in the project, but are not captured.

"Failure of facility management organizations to create standardized, centralized data repositories typically results in information being stored on multiple servers with incomplete access. In the worst case, the data remains in the desk drawer of the individual who ultimately received the disk."

Next, the format of the information exchange is inadequate to allow others to effectively use the information provided. Paper-based documents are often lost, cannot be easily updated and take up a large amount of space. Finally, the information provided is often insufficient to ensure that replaced equipment can be specified to ensure compliance with design intent.

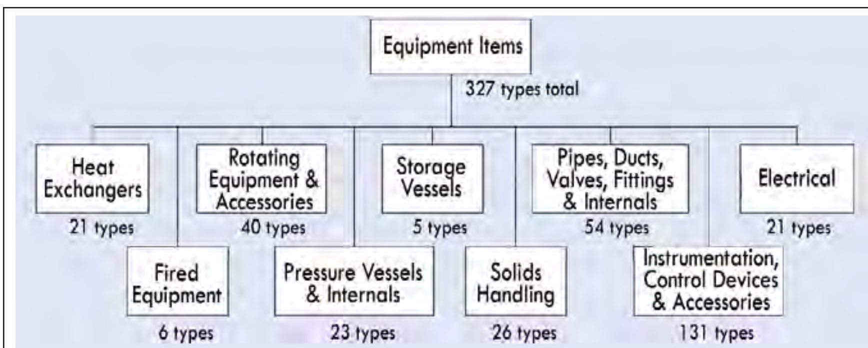

Figure 1 - AEX project entities.

BACKGROUND

In the1990s, the National Institute of Building Sciences, Facility Maintenance and Operations Committee started work to define a standard through which construction handover documents could be captured electronically based upon concepts developed within the Federal Facilities Council [Brodt 1993]. The data structure followed the format defined in the Unified Facility Guide Specifications, Operations and Maintenance Support Information (OMSI) [UFGS 2006].

The typical submittal process requires the construction contractor to provide all cut sheets, shop drawings, etc...as part of the quality control contract requirements. Later the contractor provides the installation information that accompanies installed equipment. Finally systems information is created by the contractor to provide instructions to facility maintenance personnel. The contractor must provide a complete set of all this information as part of handover documents.

In the OMSI approach, images of contract documents already required in standard federal specifications were compiled and indexed, first in hardcopy volumes and later in Portable Document Format (PDF) files. While having all the information electronically available in a single location proved helpful, serious problems existed with this method of delivery. First, scanning existing paper contract documents submitted during the course of public construction is expensive. Commercial contractors providing OMSI creation services typically charge $40K per capital project. OMSI handover documents typically result in a single compact disk with all construction handover data. The cost of OMSI data is an additional cost incurred by the owner to reformat data that already is provided by the construction contractor. Failure of facility management organizations to create standardized, centralized data repositories typically results in information being stored on multiple servers with incomplete access. In the worst case, the data remains in the desk drawer of the individual who ultimately received the disk.

While the author's experience has been associated with large public sector contracts, private owners are certain to have similar problems. An example provided to the authors in November 2006 confirms that private sector projects are not currently capturing information during the process of construction but are also conducting post-construction surveys. The cost of these surveys, according to interviews conducted by the authors, in commercial build-operate configuration is an internal, unburdened cost of $25K. For small projects, it is no wonder that more than one contractor has left the job, and forfeited retainage, rather than complete the as-built survey.

In interviews with public agencies as recently as March 2007 the first author confirmed that at least one public building owner paid three times for construction handover information. First, the information is included in the cost of completing the design and construction of the project. Second, the information is re-collected at the end of the construction phase and provided in paper boxes along with the keys to the new facility. Since the information in the paper boxes cannot be directly loaded into maintenance management software, the agency pays for the operations contractor to survey the building again to identify existing equipment locations, serial numbers, etc… at the start of their operations contract. The failure of existing handover requirements cannot be more clearly seen than in the case where the construction contractor provided information is, essentially, discarded twice.

While the focus of the information exchanges identified above has been related to the data required by those responsible to maintain facilities, additional problems have been encountered related to the lack of operational and asset management information.

Replacement of specific equipment is made more difficult when the product data is not readily available to public works department or building manager. Rather than retrieving the electronic information and starting a procurement activity, the manager must track down the information on the existing equipment to determine what needs to be purchased. A minimum of one site visit to capture nameplate data, and several hours on the phone is required for each piece of equipment that does not have its own electronic description.

Replacement or repair of equipment that is no longer manufactured is a much more difficult task. Even if the original equipment information was provided, without the design loads associated with the equipment, the building manager doesn't know how close the installed equipment matched the design requirements. Failure to consider the required design loads will result in safety problems, shortened product life, or higher than required cost of replacement part.

PATHS FORWARD

In 2000 the Facility Maintenance and Operations Committee (FMOC), National Institute of Building Sciences

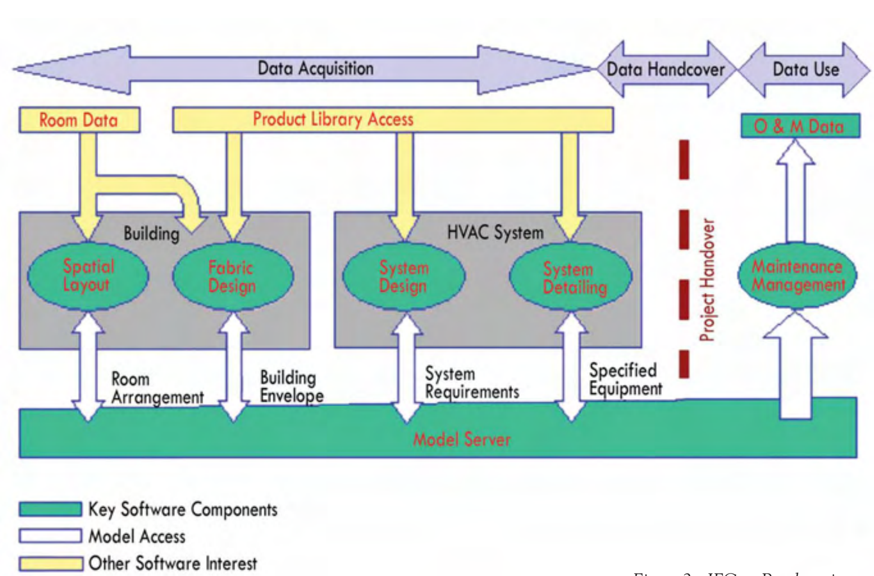

Figure 2 - IFC -mBomb project.

(NIBS) was awarded a grant from the National Performance Review (a component of Vice President Al Gore's Reinvention of Government effort) and commissioned a study to investigate the ability of the OMSI data to be structured to provide critical information from within the OMSI files as separate data elements. This effort created an eXtensible Markup Language (XML) schema that would organize the Portable Document Format (PDF) files merged into an OSMI data file [FFC 2000]. The project was successful in demonstrating that product manufacturers data could be directly provided to owners Computerized Maintenance Management Systems (CMMS) and that software companies could use the schema to extract relevant data from test files. The main difficultly with implementing this work was that the identification the information exchange paths between owner and manufacturer were not fully identified. The schema was incorporated into the International Alliance for Interoperability's Industry Foundation Class model [IAI 2003].

Concurrent with the FMOC project, the National Institute of Science and Technology (NIST) and FIATECH were developing a data exchange format to support the life-cycle information needs for industrial equipment construction. The Automating Equipment information eXchange (AEX) project evaluated the shared information requirements to design, procure, and install centrifugal pumps [Turton 2006]. **Figure 1** identifies the entities created for the AEX project [Teague 2004]. One of the best results of this project, from the point of view of operability, was that only a very limited subset of each individual stakeholder's information needed to be exchanged among all parties in the context of heavy industrial construction.

In 2002 an international project, named "IFC-mBomb," demonstrated one approach to capturing data during design and construction, then handing over the data to facility operators. The framework for the project, completed in June 2004, is shown in **Figure 2**.

Within the last several years U.S. Army, Department of Public Works (DPW), Fort Lewis, WA began to consider the use of spreadsheets to capture a minimum subset of critical information needed by the DPW between the acceptance of a project at beneficial occupancy and the full financial handover. By having the contractor fill in required spreadsheet fields, the DPW had planned to capture equipment lists and preventative maintenance activities that were required before beneficial occupancy.

Regardless of the approach taken, these groups searched for a no-cost, sustainable approach that would ultimately create a single set of data that could be directly loaded into Computerized Maintenance Management Systems (CMMS), Computer Aided Facility Management (CAFM), and Resource/Asset Management Systems (RAMS).

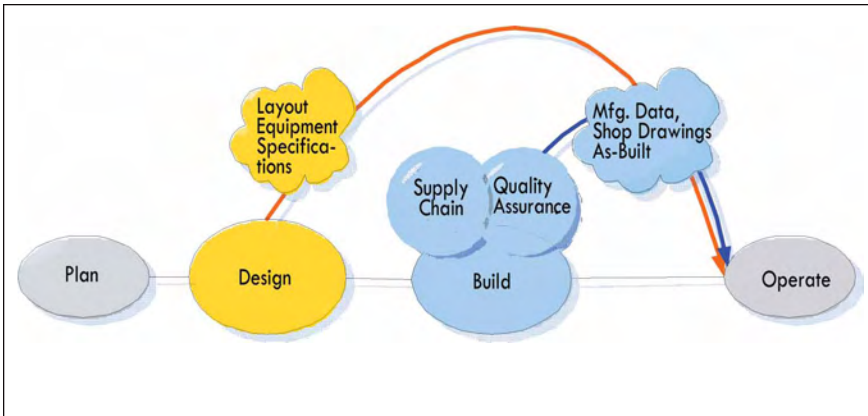

Figure 3 - COBIE data capture.

THE COBIE PROJECT

With the completion of the International Alliance for Interoperability, Industry Foundation Class (IFC) model (version 2x3), the stage was set for the development of exchange standards based on international standards. In 2005, the Facility Information Council of the National Institute of Building Sciences (NIBS) formed the National Building Information Model Standard (NBIMS) effort [NBIMS 2006]. One of the objectives of this group was to speed the adoption of an open-standard BIM, through the definition of information exchange standards based upon the IFC model.

Given the work that preceded NBIMS related to facility operations and maintenance, a project was started under NBIMS to support the handoff of projects between builders and operators. The Construction Operations Building Information Exchange (COBIE) project was initiated in December 2006. The objective of this project is to identify the information exchange needs of facility maintainers, operators, and asset managers of data available upstream in the facility life-cycle (for example, during design and construction).

The COBIE project acknowledges the practical constraint that much of today's information content is locked within documents or images of paper documents. An example of the type of information currently locked in e-paper documents that are of critical importance to facility maintenance personnel are replacement parts list. If the data was available in an interoperable format, Information Technology (IT) integration efforts would allow the maintenance worker to directly order parts during the triage of malfunctioning equipment. COBIE is designed to allow the current e-paper documents to be transmitted, but when manufacturer provided data is available, COBIE may also directly accept that information.

Several critical individual data elements were, however, identified by facility maintainers, operators, based and asset managers. The COBIE team concluded that the minimum critical set of data needed by O&M staff is the location, warranty duration, and parts suppliers for installed equipment. For asset managers the COBIE team indicated that area measurement and property replacement values were of critical concern. Other information needed may, for the time being, be captured through the association of documents to specific BIM entities.

The COBIE Pilot implementation standard was published as Appendix B of the National Building Information Model Standard [NBIMS 2007]. The underlying IFC model description of the COBIE Pilot standard was also published for international evaluation [IDM 2007].

COBIE EARLY ADOPTERS

While the COBIE format has not been fully evaluated by all members of the design, construction, operations, maintenance, and asset management communities, some organizations are taking the steps to implement the current pilot standard. For example, several federal agencies have, or are in the process of, including COBIE requirements in their contracts: the General Services Administration, Corps of Engineers, Department of State, and National Aeronautics and Space Administration. The need for COBIE data is so critical that the U.S. Army is working to adopt COBIE as the required import mechanism to translate asset data and maintenance management requirements into their financial system.

Of critical concern to this project, and other NBIMS development projects, is that the information required for the exchange is already captured, or can easily be captured, within the context of existing IT and contract practice. While a future practice of shared BIM's for all project teams is a commendable goal, near-term projects must be executed within the context of existing contract documents that include options for COBIE data. The capture of COBIE data currently takes place at the conclusion of construction. The clearest implementation of COBIE is to simply replace the requirement to provide banker's boxes with the COBIE data disk. Of course, this is not very efficient given that the majority of the data required at building handover is created by designers or manufacturers.

Some project teams and owners are considering the adoption of IT that would allow the capture of COBIE data during the design and construction life cycle. Design-build firms may use BIM software and capture COBIE data as the project progresses from inception to completion. Owners may require the submission of partial COBIE data sets based on the timing of when the data is created as shown in **Figure 3**. Designers load COBIE data sets with room function and layout, named equipment and specifications requirements. During construction, manufacturers' data captured from the contractors' procurement processes is captured along with as-built changes to building layout and equipment position. Capturing the data as it is created will increase the accuracy of the "data commissioning" process and reduce contractor's cost since design and manufacturer data will no longer have to be transcribed during post-construction surveys.

Today there are two NIBS-sponsored efforts underway to support COBIE. The first is the post-project creation of a COBIE data set for a completed project. The objective of this project is twofold: (1) to provide an example of a COBIE data set and (2) to create a COBIE guide book to assist contractors to complete the COBIE spreadsheet. The objective of the second project is to (1) provide an IFC to COBIE spreadsheet translator using the IFC 2x3 coordination view as the baseline, (2) provide two sample COBIE spreadsheets, and (3) provide tools that would allow the comparison of incremental submissions of COBIE data. At this time there are three firms who can assist in the creation of COBIE data for specific projects Burns&McDonnell, Peripheral Systems Inc., and AEC3. TMA Systems a CMMS vendor has also been working toward importing COBIE data sets.

BROADER SIGNIFICANCE

There has been much "philosophical" discussion of open-standard BIM and its impact in the NBIMS Version 1.0, Part 1, the FIC-BIM list server, and general public and trade publications. From the authors' point of view, these discussions have begun to whet the appetite of users who need open-standards based BIM information exchanges. The inclusion of the COBIE Pilot standard in the multiple agencies' federal government construction contracts is the first result that begins to practically address the life-cycle information exchange needs of our capital facilities industry. As the construction of these projects near completion a follow-on paper will document the results of these efforts.

The potential for capture and transmission of COBIE data through design and construction, with the inclusion of information provided by product manufacturers provides a compelling business case for the adoption of life-cycle BIM that goes beyond the discussion of 3-D CADD.

The development of COBIE demonstrates the benefits that can be achieved using a requirements-driven approach. Through a requirements-drive approach different groups of constituents that exist naturally in our industry today are able to their information needs. These needs are consistently translated into the IFC model through NBIMS and IAI with appropriate implementation standards that facilitate the capture and transmission of the data. By the consistent definition of each of these groups the answer to the question "What is a BIM?" can be answered at the level of specificity that allows open-standard interoperability.

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