LEAN HANDOVER™:
DELIVERING COBIE DURING CONSTRUCTION

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Abstract

The replacement of construction handover data using the Construction Operations Building information exchange (COBie) standard has not been going according to plan. The original COBie specification, first published in 2007, demonstrated how existing construction administration activities could be harnessed to capture COBie data with little to no technology support. In its current form, the COBie Standard is an Industry Foundation Class (IFC) Model View Definition (MVD). While the COBie MVD normalized the original process-based data structure, the meaning of the information derived from the construction process has been lost. This paper re-introduces the original motivation behind the COBie standard and describes a small case study showing how small changes to existing construction administration process may ultimately lead to a new way of working. The benefits to this new way of working are evaluated from the point of view of Lean Construction, hence the effort has been branded Lean Handover™.

Keywords: COBie, Lean, Construction, Handover, NBIMS-US, BIM

Introduction

After the initial publication of COBie, when the first author introduced the topic to new audiences, the question of "business case" would often arise. This question was not unexpected because similar questions had been asked of the first author during the development and implementation of information technology systems and standards developed over the previous four decades. Several approaches to answer this question were attempted, but these proved incomplete (East 2004) (East 2008) or too difficult to explain to practitioners (East 2009). Following the initial development and publication of COBie (East 2007), another approach, "value-added analysis," was applied to construction administration with good result (East 2011). The essential insight of this new approach was to develop business process models with activities defined at an "operational" level with a set of pre-defined verbs to differentiated activities that added-value versus those that did not. Seeing a way to tie-together the business process models required for the Information Delivery Manual directly to the potential benefits of process transformation, the 25 process models in the COBie standard were all developed using the value-added approach (NIBS 2015). The power of the value-added approach to predict the potential effect of a COBie-enabled business processes was demonstrated in the "COBie Calculator" (Fallon 2013). In addition to its use in the COBie standard, value-added analysis approach was also the basis for the Information Delivery Manuals for the Heating and Ventilating information exchange (HVACie), Water System information exchange (WSie), and the electrical system information exchange

(Sparkie) standards published in the National BIM Standard - United States, Version 3® (NBIMS-US V3) (NIBS 2015) and the Building Automation Management information exchange (BAMie) specification.

To those who lead the development of NBIMS-US, the most important contribution of NBIMS-US, V3 was the clear understanding that these specifications needed to become "standards in fact" and not simply "standards in name." Figure 1 demonstrates the extent to which the development of standards that went beyond data schema publication was directly considered in the NBIMS-US V3 process.

The technical portion of each "information exchange" standard was required to address the Information Delivery Manual (Figure 1, Steps 1 and 2) and the Model View Definition (Step 3.a). To provide clearer understanding of the schema, a spreadsheet mapping was also included in the COBie standard (Step 3.b). In the author's personal experience, most discussions about COBie do not pertain to COBie requirements (Steps 2.a thru 2c) at all, but differences in schema mappings between STEP Physical File Format (SPFF) and COBie Spreadsheet format (Step 3.b).

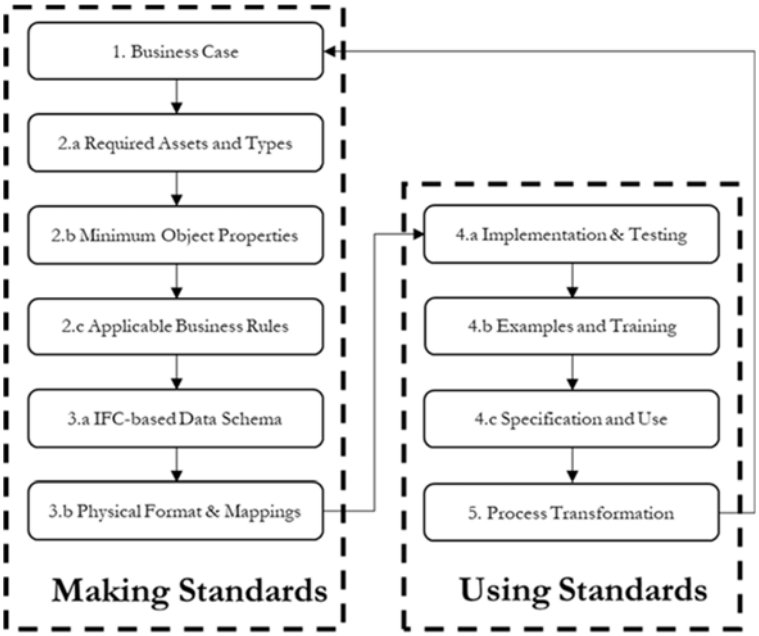

Figure 1. NBIMS-US V3 Information Exchange Standards

Beyond the technical aspects of the COBie standard, NBIMS-US V3 also required documentation that software systems had implemented these standards. NBIMS-US V3 also required that exchanged files could be objectively tested (Step 4.a) against required business rules (Step 2.c) and allowable formats (Step 3a, 3b). As a result, example files and user training resources along with draft contract language supporting a "code," "commentary," and "specification" paradigm consistent with that required of physical construction deliverables were created for the COBie standard. Through common understanding and implementation of the standard, process transformation (Step 5) was expected to validate the original COBie business case, allowing an ongoing process of innovation.

It is clear, however, from the current differences in COBie implementations encountered by the authors in projects around the world that the expected construction industry innovation has been "at best" implemented unevenly. For many, the examples of COBie data (WBDG 2010)(PSC 2017) showing COBie data being provided in spreadsheet format and overloaded IFC 2x3 Coordination

MVD SPFF files appears to be the stopping point when thinking about COBie. As the inventor of the COBie standard, I find it ironic that the aspect of COBie identified as "the most important reason for COBie's success" by a representative of the largest US design software company, has also become its major barrier to common understanding.

Those projects where the first author was directly engaged in capturing COBie data in support of the value-added approach described in the COBie business case (Figure 1, Step 1) have yet to be successful. In the view of the authors of this paper, the reason for that lack of success has been that those directly engaged with the production of COBie data are unaware of where, when, and who creates COBie data during the process of design and construction. As a result, the production of construction handover data (in COBie or any other format) remains unchanged from end-of-project reproduction because "we've always done it that way."

Background

Prior to the formal publication of the COBie standard, Liu (2013) found that half of all Facility Management (FM) technicians had insufficient information to complete work orders. Even when FM staff participated earlier to ensure their requirements were included in the contract, the information provided was inadequate. A detailed case study of the quality of construction handover data demonstrated that almost half of the information provided was incomplete or inaccurate and that collecting the information after construction was not possible due to physical obstruction or coverings (Liu 2018). The most widely cited national implementation of BIM in the UK attempted, as reported in Kelly (2013), was to solve the construction handover problem by mandating that "BIM will provide a fully populated asset data set into CAFM Systems" with the aspiration that BIM use would increase accuracy and speed of information delivery and improve work order efficiency.

An initial question left unanswered in the UK aspiration identified in Volk (2014) was the lack of objectively testable data quality standards. This was resolved with the 2015 publication of the COBie standard which contained the precise set of rules required to automatically verify standard compliance and the steps to validate that information delivered matched information provided in traditional contract documentation.

Once owners began to include COBie data in their contracts additional issues arose. What is clear from every publication reviewed for this paper is that the assumptions made in the top-down implementation of COBie in the UK have turned out to be incorrect. Every case study paper cited in this paper reflects the difficulty of project teams to implement normative standards with the current set of contract processes and technology stacks. Furthermore, the vision of a "BIMutopia" is further complicated by the reality imposed by the required life of data when compared to that of the underlying contracts and technology (Miettinen 2014).

For example, the project identified in Pishada-Borzorgi (2018) encountered difficulties with the use and implementation of commercial software that claimed COBie compliance. Unfortunately, the conclusions drawn was not to pre-test the deliverables and the software using standard-based test protocols and enforce software compliance but hire a staff and to incorporate proprietary requirements. Of these case study papers, the one which reaches the heart of these problems used interview methods from the field of sociology (Abdirad 2019). The primary conclusion reached was that the perception of COBie as a fixed deliverable whose content exists as a new and separate process is in direct conflict with the dynamic practice of construction. Eliminating the need for additional process and adapting to the uneven and changing availability of needed construction data therefore becomes the key to capturing COBie data.

These difficulties are compound since the authors have first-hand experience, as do others (Kelly 2013), of the need to integrate construction handover data with multiple downstream information systems. One recent public owner organization encountered by the first author had different legacy maintenance, operations, asset management, and inventory control software in each of its major facility portfolio divisions.

To address the complexity of construction handover, some authors have suggested adding new process requirements, software, and frameworks to support the delivery of COBie data (Florez 2018)(Matarneh 2018)(Alnagar 2019). Notably, Yalcinkaya (2019) suggests a visual interface to navigate COBie data that some readers will recognize as a "mind-map." As object-oriented data contains information in both relationships and objects, this abstract visualization is intuitively appealing. However, the root problem that COBie data is difficult to capture has not been addressed by adding yet more software and process.

A most comprehensive review of the application of BIM technologies and Lean (Tezel 2019) concludes that none of the abstract frameworks proposed in over 100 publications have demonstrated approaches that would be practical to implement.

Approach

To more clearly communicate how COBie implementation can lead to process transformation, the first author coined the term Lean Handover™. This objective of this language is to emphasize the value-added benefits derived from implementing an integrated COBie data collection method. This term also emphasizes that construction-phase COBie data is not created in "Building Information Modeling" activities, but in construction contract administration processes identified and documented in the original COBie specification (East 2007) and listed below.

1. Identify submittal requirements
2. Define submittal schedule
3. Transmit submittal
4. Approve submittal
5. Install equipment
6. Commission equipment
7. Provide warranties
8. Provide spare parts sources
9. Transmit handover information

The book "Lean Handover™: COBie for Contractors" (East 2019) discusses the following topics: process-specific data mappings, procurement method variation, change processes, and delivery of real-time as-built project data. The Lean Handover™ process was bench-tested by two Mechanical, Electrical, and Plumbing (MEP) subcontractors participating. One based in the US, the other based in the UK. The project used for this testing was the "East Dormitory Project," a publicly available set of life-cycle building data (PSC 2017) based on a small, but complete, two-story building. The first story of this building contains dining, recreational, and meeting spaces. The second story of this building provides single bedrooms. As with other Dormitory project data, construction-stage COBie data is available to use under Creative Commons License. In this paper, we introduce one portion of this larger case-study. The portion pertaining to the definition, preparation, and transmission of construction submittals.

Traditional Submittal Processes

The selection of products occurs three times during a project: bidding stage, submittal stage, and purchasing stage. Our case study considered the "submittal stage" process.

The construction submittal process has two primary variants. Value-added process maps for the Design-Bid-Build variant were first published in (East 2011). The Design-Bid-Build submittal process often begins with the designer creating a master "submittal register" whose contents are delivered by subcontractors to the prime contractor and owner's representative for acknowledgement or approval. Subcontractors typically provide a single package of submittals for their awarded set of technical contract provisions. Unless an extensive manual effort is undertaken, usually by the owner's representative, to match the designer's register with the contents of large subcontractor transmittal packages, most as-built submittal registers have little bearing with what was originally required by the designer. The matter is further complicated by having a list of individual types of documents provided by the selected products' manufactures. Some of the required documents may be provided in a manufacturer's consolidated file; others may not be available at all.

Under the Design-Build procurement method, each subcontractor maintains a running "register of what has been submitted." There is no issue with a mismatch between what is submitted and what is required, because the only list required is the list of what has been submitted. This does, however, beg the question as to the quality of what was submitted. As a starting point in this case study we obtained examples of real Design-Build submittal packages for Design-Build projects. A cursory review of these documents identified missing, inconsistent, and duplicative information. The review had to be accomplished manually as manufacturer data was only available as images with fixed page numbering.
As was demonstrated in the value-added analysis of the construction submittal process, the management of the submittal documents can be streamlined when compared to postal mailing or even emailing (East 2011). Today, we see several software vendors providing services to support the routing and distribution of submittal documents using internet-based services. However, the authors are aware of no systems that has addressed product selection stages and the collection of associated COBie-required data.

Lean Handover™ Submittal Processes

The most critical COBie-required construction handover data, manufacturer and model number, is created during the construction submittal process. In a document-centric submittal process, this information is found in PDF documents identified with manually-added boxes or arrows. The information itself is only found by human interpretation. In our Lean Handover™ process, we capture COBie.Type.Manufacturer and COBie.Type.ModelNumber as part of the submittal process itself by making a slight change to the contractor's transmittal form. A portion of the overall COBie-based transmittal form for our case-study project's specification section "22 00 00 - PLUMBING, GENERAL PURPOSE" is shown in Figure 2.

In our case study project, we generated the complete set of all required submittal forms directly from the federated Dormitory design file. In the first column of Figure 2, is the list of COBie.Type(s) identified against the related specification section. In columns two through five, the submitter must provide the manufacturer, manufacturer's model number, supplier, and product data file name. The manufacturer and supplier names link to a submittal back-page requiring the provision of COBie-compliant company information. In column five, the file name of the original manufacturer's product data sheet is provided. This file name can be copied and pasted to minimize data transcription errors. Within that product data file will also be the boxes or arrows used to identify the specific model number selected. By copying and pasting the

product model number, the COBie-based submittal form again minimizes transcription errors.

Name & Description	Manufacturer	Model Number	Supplier	Product Data
Bath Tub (Bath Tub_1675 mmx915 mm - Private)	Kohler	K-715	Champaign Lowe's	bath tub_K-715_spec.pdf
Lavatory - Vanity 1200 750m (Lavatory - Vanity 1200 750m_760 mmx455 mm - Private)	Corian - DuPont Corp	810	Champaign Lowe's	lavatory vanity_810.pdf
Lavatory-Vanity (Lavatory - Vanity_760 mmx455 mm - Private)	Elkay	EFU131610TC	Amazon	sink efu131610tc_spec.pdf
Lavatory-Wall Mounted (Lavatory - Wall Mounted_510 mmx455 mm - Public)	PickCompany	n/a	PickCompany	n/a
PLU-BallValveA (PLU-BallValve_15mm)	Milwaukee Valve	UPBA-475B 1/4"	Champaign Lowe's	valves UPBA475B.PDF

Figure 2 COBie-based Submittal Form (Part 1)

In addition to collecting manufacturer and model number when the product is first submitted, the fourth row of data in Figure 2 also highlights the benefits of clearly identifying each product. In the fourth row, the wall mounted lavatory data was not been provided. Because the list of each COBie.Type is provided, this omission is obvious to anyone familiar with this form. In a traditional submittal, this omission would have required careful review of the submittal package by experienced quality control/assurance personnel.

Submittals for most products are not limited to Product Data files. Either by requirement or convention, files containing information related to manufacturer testing, warranties, installation instructions, and operations and maintenance manuals may also be required. These files may also be identified in that same COBie-based submittal form to the right of those shown in Figure 1. In Figure 2, additional documents types were added for our case-study. We provided a fixed set of possible documents that may be provided, or not, depending on what is available from the manufacturer. In the bath tub example, two separate files are provided. In the case of the vanity, submittal data of three different types is available in the same file.

Name & Description	Mfg Test	Mfg Warranty	Instructions	O&M
Bath Tub (Bath Tub_1675 mmx915 mm - Private)	n/a	Kohler_warranty.pdf	bath tub_K-715_install.pdf	n/a
Lavatory - Vanity 1200 750m (Lavatory - Vanity 1200 750m_760 mmx455 mm - Private)	n/a	n/a	n/a	n/a
Lavatory-Vanity (Lavatory - Vanity_760 mmx455 mm - Private)	n/a	sink efu131610tc_warranty.pdf	sink efu131610tc_install.pdf	sink efu131610tc_manual.pdf
Lavatory-Wall Mounted (Lavatory - Wall Mounted_510 mmx455 mm - Public)	n/a	n/a	n/a	n/a
PLU-BallValveA (PLU-BallValve_15mm)	n/a	n/a	n/a	n/a

Figure 3 COBie-based Submittal Form (Part 2)

While fixtures and other simple products can capture COBie-based submittals in a single row for each COBie.Type, some products are more complex. Such products will also have "accessory" products. It is not possible to specify these accessory products *a priori* since the details of each assembly are manufacturer-dependent. As a result, a "pivot table" version of the COBie-based submittal form is also required, Figure 4.

Action:	Product Type:	Manufacturer	Model Number	Supplier
Initial	Air Handling Unit (Air Handling Unit_63300000 J)	VES Andover Ltd	MAX37/A/SW/S	VES Andover Ltd

Attached Data Files	
Product Data:	Air Handling Unit.pdf
Mfg Test Report:	n/a
Mfg Warranty:	Air Handling Unit Warranty.pdf
Instructions:	Air Handling Unit Operation.pdf
Maintenance Manual:	Air Handling Unit O&M.pdf
Replacement Parts:	Air Handling Unit Warranty.pdf
Field Test Reports:	n/a

Accessory Products	Accessory Name	Attached Data file
Product Data:	Fitted & Pre-Wired Isolator To Suit 1	Air Handling Unit.pdf
Product Data:	24V Open Close Damper Motor	Air Handling Unit.pdf
Product Data:	Filter Pressure Switch - Fitted	Air Handling Unit.pdf
Product Data:	Magnehelic Gauge To Suit 0-250 Pa	Air Handling Unit.pdf
Product Data:	Airflow Pressure Switch - Fitted	Air Handling Unit.pdf
Product Data:	ELGN1050 Motor Isolator Supplied Fi	Air Handling Unit.pdf
Product Data:	Filter Pressure Switch - Fitted	Air Handling Unit.pdf
Product Data:	Magnehelic Gauge To Suit 0-250 Pa	Air Handling Unit.pdf
Product Data:	Airflow Pressure Switch - Fitted	Air Handling Unit.pdf
Product Data:	ELGN1050 Motor Isolator Supplied Fi	Air Handling Unit.pdf
Product Data:	Fitted & Pre-Wired Isolator To Suit 1	Air Handling Unit.pdf
Product Data:	24V Open Close Damper Motor	Air Handling Unit.pdf

Figure 4 COBie-based Pivot Submittal Form

While the basic information found in Figure 2, is found at the top of Figure 4, the COBie-based Pivot Submittal form lists manufacturer documents vertically down not horizontally across (as in Figure 2 and 3). The size of this accessory list cannot be known because the list of accessory products is manufacturer dependent. In Figure 4, the case-study subcontractor listed twelve accessory products to the main Air Handling Unit whose information is also specified in the manufacturer's product data literature.

Observations

In this case study, two subcontractors were asked to download a set of simulated construction drawings. The complete set of COBie-based submittal forms were prepared by specification section. One example COBie-based Submittal form and one pivoted example form were provided and explained during a brief training session. Following that introduction, specification sections were assigned to each subcontractor by the authors and the assigned forms provided. Observations made from written communications between the authors and case-study participants are described in the paragraphs below.

Initial discussion about the differences between US and UK construction were determined not to be differences in English-language dialects, but differences in Design-Bid-Build and Design-Build procurement methods. While the process of product select in Design-Bid-Build projects is prescribed by tradition and contract requirements, the variety of "flavors" of Design-Build procurement methods, means that the creation of a set of submittal forms prior to construction should not be expected. Regardless of the specifics of the Design-Build procurement, the responsibly to produce COBie-based submittal forms should fall to the design consultant (or subcontractor's designer) who develops the construction documents (or shop-drawings). For subcontractors who do not yet follow Lean Handover™ methods, production of COBie-based submittal forms may, fall to the general contractor's BIM Coordinator when each subcontract is signed.

Subcontractors in the US and UK found the COBie-based Submittal Forms similar to those encountered on traditional projects. This was a critical finding since the foundation of the Lean Handover™ approach is based upon the idea that small changes to existing methods may have profound effects. Subcontractors reported that they completed all forms in the same time required to prepare traditional submittals. The ultimate result of this observation is that providing COBie-based Submittal Forms, instead of discussing COBie itself, can eliminate the need for project teams to hire additional COBie-specific resources or conduct post-construction surveys to recollect approved submittal information.

While the general use of COBie-based forms was understood, case study participants were less clear about the use of the forms in some important ways. First, the forms provided did not support or enforce a complete set of COBie-compliant company contact data. As a result, company details did not always exactly match the information provided by case-study participants. Next, while the organization of products by specification section is consistent with traditional practice, there were situations where this was not completely satisfactory. For example, some specification sections included the delivery of general products that would have been purchased by different subcontractors. In some cases, the subcontractors suggested that product listings by product category might be relevant.

The third aspect of the COBie-based forms noted by the subcontractors was the need to reference the list of individual components when selecting products. While initially created COBie-based submittal forms included a linkage to show the individual COBie.Component(s) and spatial containment, these more complicated forms were not presented to the case-study participants. Our study identified that such information may be helpful in some situations but would not be applicable across the board.

Our subcontractors recognized the internal value to capture equipment manufacturer and model number before building the project. Given subcontractor's familiarity in working with PDF submittal documents, they were able to copy and paste file name and model numbers into the COBie-based Submittal forms for most products. For image-based product data, we did not determine if users would process files through optical character recognition software or would manually enter correct model numbers. We did not access the accuracy of manual data entry when only locked product data files were available.

A basic assumption that specification sections could be used as the basis for the pre-production of all COBie submittal forms from COBie.Type data was found applicable to Design-Bid-Build projects. Depending on the "flavor" of Design-Build procurement, either a contractor-hired design team or a subcontractor-hired design team will be responsible for COBie.Type definition. As a result, the Lean Handover™ process must flexibly adapt to project-specific requirements

Although participating subcontractors have extensive experience using BIM software for construction coordination, they had not previously considered nor were concerned about the coordination of BIM and COBie data. This observation clearly speaks to the understanding, by subcontractors, that COBie data is not directly linked to the BIM processes in the construction trailer. It was also understood that unless the construction back-office data were captured in a way that allowed COBie data to be linked to BIM, that some owners might require them to manually re-type some of the COBie data within those BIM platforms.

Discussion

The transformation of small, corner groceries to the interconnected just-in-time business networks of Tesco and Walmart were not caused by client-facing technological innovation. The

innovation we see today on a myriad of phone-apps are the affects, not the causes, of information technology innovation. Innovation in back-office processes led to the consolidation of retail and industrial sectors happened long before you could buy groceries on your phone. Today, the construction industry is awash in technology chasing users. It is awash in affects without causes. Demonstrations of user-facing technology shown to be wildly successful, are only so if the project has overheads to manually process and enter information across multiple systems. Such innovations cannot become mainstream. Each example is just another technology pilot project that (ironically) creates its own unique "Standard Operating Procedure."

The only way to allow our industry to grow without mandating a "data wrangling" tax to every project is to fundamentally transform the systems that create and back-office information. This paper demonstrated one of the most fundamental of these processes, that of construction submittals. Rather than introduce new user-facing processes, terminology, and technology, the Lean Handover™ approach leverages existing processes, terminology, and technology. These small process changes that become second-nature to the project team will have a more profound and enabling effect upon innovation than our collective BIM aspirations.

Here are some of the befits that can be expected as a result of having real-time as-built information about the spaces and equipment in our buildings based.

Today, contractors, subcontractors, and facility operators must go search for information by returning to the shop, gang box, or jobsite trailer. It was reported from a leading US university facility manager that a detailed audit indicated their operators had a "time on tools" value of 20%. Mechanics we know would rather work their trade than drive around looking for information or getting the right tool for six (6) hours a day. Unnecessary trips to the shop, gang box, or project trailer can be eliminated through the Lean Handover™ process.

Most facility managers will recognize that their parts inventory supply system is broken. This can be seen by multiple half-used boxes of the same type of part from different suppliers. With COBie data delivery of spare parts can be managed the same way as just in time delivery of parts for manufacturing lines. There is no need for each crew to have its own set of specialized tools, if the use of those tools can be tracked and shared. The wasted cost and accounting for parts and tools inventories can be eliminated through the Lean Handover™ process.

Today, there is no way to determine if construction administration or handover information is correct. This means that people, correctly, provide something that is likely to be incomplete and possibly incorrect. Without a common way to assess what is required, it is not possible to understand when a job is completed. The wasted effort spent going back to complete partially finished handover data can be eliminated through the Lean Handover™ process.

Today, even when we attempt to use electronic file cabinets, the lack of an underlying organization and version control for those documents means that multiple copies of virtually every document are kept by all parties with the resulting confusion. Knowing exactly what was approved, installed, and tested is only possible
through a shared understanding of a common workflow. The wasted effort finding and moving duplicate versions of product data can be eliminated through the Lean Handover™ process.

Today, project reams wait until the fiscal completion of a building before preparing facility management data. Often this is months or years after the building has been occupied. In addition to having to recollect information that already exists, this delay typically means that product manufacturer warranties are voided since recommended maintenance activities were not completed by the contractor following prior to occupancy, or by the owner after occupancy. The wasted effort spent chasing and as-built and maintenance information can be eliminated through the Lean Handover™ process.

The authors of this paper have been engaged in the application of computers in the construction office since they first arrived in the 1980's. A significant portion of the time spent by users of this "more efficient" technology has been spent arguing about computer outputs on paper or screens than has been spent talking about the project. This is the case because users with different backgrounds and experience have different expectations of what is to be accomplished. Without a common understanding of the overall system in which work is to take place, no agreement about the use of technology is possible. The wasted effort spent chasing each emerging technology as the next magic solution can be eliminated through small changes to existing construction administration practice.

Conclusions

Owners know that traditional construction handover information is just incorrect enough to be unusable. As a result, large portfolio owners conduct a post-occupancy surveys at a cost of millions of dollars per year. Owners are starting to demand a higher-quality construction handover product, but many are unclear exactly how to proceed. This case study demonstrates the most important of that information - product manufacturer and model number - can be captured during the project to eliminate, at least this, cost of the post-construction job survey.

Today, contractors wait until the end of the project to send experienced staff or bespoke subcontractors to re-collect information known to subcontracting staff who selected and installed those products. There is international agreement that the tens or hundreds of thousands of dollars spent on document-based handover deliverables is wasted effort. The question for contractors and subcontractors is how to deliver faster, cheaper, and at higher quality products their competitors. This case study has demonstrated that the most important handover information - product manufacturer and model number - can be captured regardless of the final output format required by the owner.

While the full presentation of the Lean Handover™ approach is published in book form, the purpose of this paper was to identify issues where contractors and subcontractors expressed difficulty in adopting a single, generic approach. Those difficulties are to be expected given the deeply held conventions used to exchange building information today and the dynamic, yet enduring, set of construction information.

From the research and development perspective, this case study, and the body of work cited in this paper, should give pause to anyone who thinks that the development of a software tool or IFC MVD will be enough to motivate construction industry change. This includes the many who consider development of an MVD as the end-goal of a research project or a business opportunity. It is one thing to create a data schema and even to mandate the deliver of specified data in contracts, but as the case of COBie demonstrations, wishing does not make it so. Changing contractor behavior requires orders of magnitude more effort. An effort that demands working directly with people who create and use that data daily.

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