National BIM Standard - United States™ Version 2

4 INFORMATION EXCHANGE STANDARD

Chapter 4.2 Construction Operations Building Information Exchange – Version 2.26

General Information

Introduction

The Construction Operations Building information exchange (COBie) is a life-cycle information exchange format describing the spaces and equipment within a facility. The primary COBie exchange occurs at construction handover; however, efficiencies will be gained by using COBie throughout the life-cycle whenever information about spaces and equipment need to be exchanged. Owner's criteria management tools can export space and equipment program data in COBie Format as part of requests for proposals. Building Information Modeling software exports COBie data during design. During construction, web- and pen-based software captures the progress of the project in real-time providing real-time as-built progress information. At project handover the information can be automatically consumed by software used by facility managers. When kept updated, such information provides as maintained models of building information.

Technically speaking, COBie is the U.S. implementation of the internationally recognized Facility Management Handover Model View Definition (MVD). The FM Handover MVD is the first internationally recognized MVD for the exchange of non-geometric building information. Additional information about COBie may be found on the Whole Building Design Guide. A complete description of the COBie project is provided as file attached to this ballot.

COBie is not a specific product or software solution. COBie is implemented in commercial software to allow the users of that software to transfer the information from one phase of a project to another without having to repeatedly recapture that same information, as is the case in the capital facilities industry today. As a buildingSMART alliance project, COBie is based upon the Industry Foundation Class (IFC) model. COBie information may be found in one of three formats, the IFC STEP Physical File Format (IFC SPFF), ifcXML, and SpreadsheetML. Readers of this ballot may already be familiar with a common software program using SpreadsheetML, Microsoft Excel™. Although COBie data can be viewed in commonly used spreadsheet software, the focus of COBie is not a software product or program, but a

common method for moving building information through the project life-cycle. The use of the COBie spreadsheet is but one of many different programs that can be used to process COBie data.

The objective of the international project upon which COBie is based is “to improve the life-cycle building information interoperability using commercially available releases of Building Information Modeling (BIM) planning, design, construction, and commissioning software and the Computer Aided Facility Management (CAFM) and Computerized Maintenance Management System (CMMS) applications used in facilities management” [1]. COBie implements the buildingSMART international Facility Management Handover MVD and includes the business rules required in the United States. A general description of the United States COBie project may be found on the Whole Building Design Guide’s COBie website [2].

Since COBie's first release at the National Academies of Science in Washington, DC in July 2008 [3], there have been six (6) public demonstrations of COBie's implementation in commercial software produced in the United States and internationally. A May 2011 presentation entitled "COBie Fact or Fiction" provides an overview of what is contained in the proposed COBie standard and how this information may streamline contracted information exchange processes throughout the project life-cycle [4].

An essential element of this life-cycle concept is that rather than create a new electronic process to reproduce the existing, failed, process to deliver boxes of paper documents, the job of creating a COBie deliverable falls to the party contractually responsible for originally creating that information. Information about building spaces and equipment is required at many different stages of the project. The delivery of COBie information during the project simply requires changing the format of existing contracted deliverables. Depending on the nature of the exchange a full, or partial, the COBie file can be delivered in lieu of previously required paper documents. COBie implementation does not require the creation of new legal theories related to design collaboration. COBie simply replaces current exchange in paper-document forms with exchanges of electronic documents.

Business Case

COBie eliminates duplication of information about facility spaces and equipment throughout the facility life-cycle. A fully populated COBie data set contains the minimum requirements for the transfer of construction project information at beneficial occupancy to the facility manager. From the design-team’s point of view COBie is simply a report of room data sheets and scheduled products and equipment from the design BIM. Subsets of the COBie model capture COBie data during planning, design, construction, and commissioning stages to streamline the delivery of spatial and equipment-related building information. The overall description of the business case may be found on the Whole Building Design Guide’s COBie website [2].

A precise description of the business case may be found in technical reports, related websites, and professional and academic publications used to document the development effort. The first report

describes the development of COBie in 2006 [5]. The second report validates COBie's potential application at U.S. Army installations [6]. The next set of information, the Life-Cycle information exchange (LCie) model, demonstrates the use of appropriate COBie sub-sets throughout the entire facility life cycle [7][8]. A model of the expected cost and benefit that can be obtained from the use of COBie during the project life-cycle (according to the LCie specification) is currently under development at the Pennsylvania State University under a contract from the National Institute of Building Sciences [9]. The resulting "COBie Calculator" will evaluate the estimated savings of a COBie-based vs. document-centric process against individual projects or entire building programs.

Information Exchange Development Process Description

COBie was developed utilizing a spiral software engineering process. In such an approach, an iterative process is used that begins with requirement definition and proceeds through development and testing. Each spiral gathers additional information that needs to be considered in future requirements. Such projects are able to asymptotically approach an accurate solution more rapidly than trying to achieve a complete solution in a single long-duration development step. The spiral approach also assists those developing the project to clearly identify what should be reasonably included, and not included, in each spiral development round.

The first round of this spiral began in 2006 when the National Aeronautics and Space Administration and the White House Office of Science and Technology Policy provided funding to the U.S. Army, Corps of Engineers, Engineer Research and Development Center, Construction Engineering Research Laboratory, to evaluate the requirements for electronic (in lieu of paper) facility handover documents. These requirements were translated into software specifications for COBie 1.0. COBie 1.0 was demonstrated by commercial software vendors in July 2008 [3]. An essential part of this demonstration was the use of an automated tool to assess compliance of submitted files against formatting requirements and compliance with North American business rules. During the meeting contract specifications clearly identifying how COBie could be implemented in current design and construction contracts were presented. A key result of this meeting, coming from participating software vendors, was that the COBie requirements should be reviewed and approved by the international buildingSMART alliance (then International Alliance for Interoperability) community.

Following this first round, feedback from those participating in several public "COBie Challenge" events helped to refine the COBie specification. These events lead to the completion of the second round of spiral development, in Dec 2009, with the simultaneous Challenge and buildingSMART international pre-certification event [10]. The public release of the Facility Management Handover Model View Definition reviewed by the buildingSMART chapters in the United Kingdom, German-speaking, and North America published the proposed international MVD [1]. The production of this internationally recognized format, the first internationally recognized format for the open standard exchange of non-geometric building

information, was accomplished to directly respond to software companies' recommendation that COBie, as a potential solution to an international problem, be recognized internationally.

In addition to widening COBie to an international audience, the second round of the spiral development process focused on the use of COBie in practice. In this round, pilot projects began to identify specific users' and software-companies' feedback. Based on these improved requirements, COBie version 2.26 was produced. Version 2.26 was a major simplification and consolidation of the spreadsheet transformations required to produce the FM Handover MVD. While the underlying standard, the FM Handover MVD, did not change, the COBie spreadsheet format for version 2.26 was a more streamlined and easy to use presentation with SpreadsheetML (the XML spreadsheet specification for MS Excel).

One of the changes presented in COBie 2.26 supports the use of COBie in situations where team members need to include project- or customer-specific extensions to COBie. Specifically, three methods to extend COBie were included in the specification. First, the generic classification method used in COBie, noted in the "Referenced Standard" section of this ballot, could be replaced with any proprietary taxonomy. Second, attributes required for specific COBie objects could easily be extended through the creation of generic property sets for all of those types of objects. Finally, the delivery of required property sets (held in the COBie. Attributes worksheet) could be defined and enforced. These customizations go beyond out-of-the-box commercial software supporting COBie; however, with these extensions users of COBie may extend taxonomy, object properties, and specific attributes to reflect the requirements of specific types of buildings, owners, or other needs.

An essential step in the development process was the concurrent development of a light-weight model server toolkit used for transforming, merging, reporting, and checking on IFC SPFF, ifcXML, and SpreadsheetML versions of COBie data [11]. This toolkit is provided free of charge through AEC3 UK [12]. An essential innovation in bimServices was the use of ifcXML as an intermediate transformation format. To go from IFC to COBie formats, an IFC SPFF file is translated to ifcXML, and then the ifcXML is transformed to SpreadsheetML. Through the intermediate step, XML Cascading Style Sheet transformations can be utilized to deliver model subsets, reports, schedules, forms, and web pages directly from the building information contained in the COBie ifcXML file. Reports provided with bimServices include the tools needed to assess format compliance and compliance with data quality requirements contained in the COBie specification. The pattern is reversed to translate a COBie file into an IFC SPFF file.

The Extensible Style Sheet Language Transformations (XLST) used to map COBie to ifcXML are provided free of charge with the bimServices toolkit. This is important since this transformation may be directly implemented in software that does not inherently support IFC SPFF, but still meet the requirements for the IFC FM Handover MVD. While the bimServices toolkit is not part of the COBie standard, without this type of toolkit, it would not be possible to translate between lightweight BIM formats such as spreadsheets and the underlying open international IFC-based standards upon which COBie is now

based. Other toolkits under development include the open source bimServer.org effort, the XBIM program, EcoDomus, and Onuma Systems COBie checking program.

It should be noted that the SpreadsheetML format is the proprietary XML representation of Microsoft Excel Spreadsheets. Tests in 2011 have demonstrated the potential of this toolkit to produce a single spreadsheet XML acceptable to both Microsoft Excel and Open Office applications. Open Office spreadsheet XML documents are expected to be essential to the adoption of COBie outside North America. One example of a non-US standardization effort is the review of COBie by the British Standards Institute underway at the time of the drafting of this document.

An additional reference is being developed at the time of the submission of this ballot that will assist users to adapt COBie to their specific project process. This reference file is called the COBie Responsibility Matrix. This matrix will allow project teams to determine (1) the specific company and Point of Contact necessary for the delivery of each cell in the worksheet, (2) the specific requirement for the delivery of COBie data at each phase of the project, and (3) the customized data specification for each COBie cell to document cases where limitations between software might truncate data. As an amendment to this matrix the mapping between COBie worksheet cells and IFC objects will be extracted from the XSLT file contained in the bimServices toolkit

Stakeholder Representation

User representatives

As the project began in 2006 it was determined that all COBie meetings would have an open attendance policy and were to be held on “neutral ground” at the National Institute of Building Sciences. These policies were adopted to ensure that any interested party could participate. The preface of the 2007 project report acknowledges those persons who in 2006 directly contributed to the initial requirements of COBie and participated in a review of the initial exchange requirement discussions [5]. These individuals are listed below in alphabetical order.

- Robert Bank, U.S. Army, Headquarters, Corps of Engineers
- Lynn Blair, LY Blair & Associates
- Robert Bradford, Burns and McDonnell
- William Brodt, U.S. National Aeronautics and Space Administration
- Beth Brucker, U.S. Army, Corps of Engineers, Engineer R&D Center
- Robert Clarke, U.S. Department of State, Overseas Buildings Operations
- Phillip Columbus, U.S. Army, Asst. Chief of Staff for Installation Management
- William Dunn, U.S. Navy, Naval Facilities Engineering Command
- Bill East, U.S. Army, Corps of Engineers, Engineer R&D Center
- Alan Edgar, Graphic Systems
- Lyle Fogg, U.S. Army, Department of Public Works, Fort Lewis, WA

- Andy Furhman, Open Standards Consortium for Real Estate
- Jerry Harbison, U.S. Army, IMCOM, West Region
- Glenn Hunt, Peripheral Systems, Inc.
- Tom Hinshaw, U.S. National Aeronautics and Space Administration
- Steve Hutsell, U.S. Army, Corps of Engineers, Fort Worth District
- Julie Jones, U.S. Dep. of Defense, Washington Headquarters Services
- George Korte, Total Resource Management
- James Lovo, U.S. Army, Headquarters, Corps of Engineers
- Jim Sims, Instep Software
- Ned Shepherd, U.S. Army, Corps of Engineers, Rock Island District
- Jene Swalley, U.S. Depart of State, Overseas Buildings Operations
- Toby Wilson, U.S. Army, Corps of Engineers, Engineer R&D Center

Since 2006 it is likely that over one hundred United States and international project stakeholders could be identified as having participated in the discussion and identification of user requirements for COBie. Recent featured presentations at Construction Industry Institute [13] and the Construction Owners Association of America [14] demonstrate the breadth of outreach on this effort and level of interest in the user community for the results of the work published to date. Stakeholders have even begun to create social media to support COBie implementation via websites such as LinkedIn and various blog postings.

Conversation records and electronic mail from all open meetings and non-deliberative internal communication may be made available under a one-time-request from the Chair, National Building Information Modeling Standard - US.

Technical Team

The broad technical team developing COBie includes members of both the core technical team and representatives of software companies who have made suggestions for improvement in the logical and physical organization of the COBie data requirements since 2006. The core Technical Team is listed below.

- Bill East, U.S. Army, Corps of Engineers, Engineer R&D Center
- Nick Nisbet, AEC3-UK
- Thomas Liebich, AEC3-DE
- Jeff Wix, AEC3, AEC3-UK

Implementing software companies

Twenty (20) commercial software firms have participated in developing the requirements for and implementations of COBie. All public information about these companies and their implementation of COBie is published under the COBie Means and Methods webpage [15]. The selection of the specific life-cycle sub-set of COBie data applicable to each software system, based on that product's target market,

is also provided on the COBie Means and Methods website. The list is provided below in alphabetical order:

- ARCHIBUS
- AssetWORKS
- Autodesk
- Bentley
- Design Data Systems
- EagleCMMS
- FaME
- Granlund
- Graphisoft
- Instep
- LATISTA
- MicroMain
- Nemetcheck
- Onuma System
- Project BluePrint
- SMB
- EcoDomus (tested under the name TOKMO)
- TMA
- VELA
- Vizelia

Companies are only listed above if their claims of COBie Compliance have been publically verified in accordance with the established procedures, described later in this ballot. There are, however, other firms that may be COBie compliant but cannot be listed as having passed a “COBie Challenge.” There are two types of such firms. The first are those who have announced their use of COBie without having followed the established procedure including external scrutiny and open public presentation. The second are those firms who have stated that consultants are able to provide customized add-on interfaces to produce or consume COBie-compliant data.

Since COBie Challenges are inherently open, public events, all software companies are welcome to participate in future COBie Challenge events such as those regularly scheduled at the National Institute of Building Sciences Annual Conference (in Washington, DC December/January) or the National Facilities Maintenance and Technologies meeting (in Baltimore, MD March).

Reference Standards

A variety of potential standards were reviewed for best match against the COBie business case needs starting in 2006. These are listed below, in alphabetical order. The analysis of each of these standards and their ability to meet the required business requirements may be found in the COBie technical report published in 2007 [5].

- aecXML
- Construction Specifications Institute
- International Alliance for Interoperability (now buildingSMART international)
- MIMOSA
- National Institute of Building Sciences
- National Institute of Standards and Technology
- OSCRE

Following the review of these standards, it was determined that the COBie format would be based upon the Industry Foundation Class (IFC) Model - ISO/PAS 16739:2005. The internationally recognized "FM Handover MVD" is the further sub-specification of the overall ISO standard required to represent COBie [1].

Two other standards are suggested defaults within the COBie specification. The first is the Construction Specification Institute's OmniClass taxonomy [16]. Since there will be variation in the classification required on a owner or regional basis, contracts requiring COBie should be explicit about the classification scheme required.

The second is the harmonized ASTM/ANSI space measurement standard. If something other than this default is utilized, the measurement algorithm used must be explicitly stated as required in the COBie specification.

Information Delivery Manual

Process Maps and Exchange Requirements were posted on the Norwegian IDM website [17] in accordance with IAI expected practice in 2006. Rather than reproduce these documents, or their updates, in this ballot submission the COBie information originally posted in 2006 from the IDM Wiki is referenced [18] or repackaged and referenced below from the buildingSMART alliance portal site.

Process Maps

COBie process maps from 2006 derived from the original study are reproduced as one set on the buildingSMART portal [19]. The list of these initial process maps is shown below:

(PM-1) Identify Submittal Requirements
(PM-2) Define Submittal Schedule

(PM-3) Transmit Submittal (PM-4) Approve Submittal
(PM-5) Install Equipment (PM-6.A) Commission Equipment (PM-6.B) Commission Equipment (PM-7) Provide Warranty (PM-8) Provide Spare Parts Sources
(PM-9) Transmit Handover Information

These maps were developed using the MS Visio tool and saved as PDF files. The current best practice for buildingSMART international indicates that such maps are better created through using a tool that supports Business Process Modeling Notation (BMPN) [20]. The ultimate intention is that IDM processes described using the open standard BPMN may be used as form of "process management clip art" where later users could take snippets of existing process models (and associated exchange requirements) to streamline development of IFC standards.

Since the initial development of COBie process maps, a complete set of life-cycle deliverables have been created based on the exchange of COBie data at points during the project life-cycle where traditional projects would exchange paper documents. These contracted information exchange processes show how the use of COBie data throughout the life of the project streamlines the collection of facility handover information. Taken together these specifications are called the Life-Cycle information exchange (LCie) model [8].

Exchange Requirements

Exchange requirements were documented on the international IDM Wiki in April of 2006 [21]. The list of exchange requirement found under "Regional Developments > North America" is provided below.

(COBIE-ER-01) Exchange Project Handover – Project Wrapper
(COBIE-ER-02) Exchange Project Handover – Floor Layout
(COBIE-ER-03) Exchange Project Handover – Space Layout
(COBIE-ER-04) Exchange Project Handover – Asset Catalog
(COBIE-ER-05) Exchange Project Handover – Asset Location
(COBIE-ER-06) Exchange Project Handover – Facility Service
(COBIE-ER-08) Exchange Project Handover – Asset Transmittal
(COBIE-ER-07) *intentionally left blank*
(COBIE-ER-09) Exchange Project Handover – Asset Documentation
(COBIE-ER-10) Exchange Project Handover – Asset Installation
(COBIE-ER-11) Exchange Project Handover – Asset Parts
(COBIE-ER-12) Exchange Project Handover – Warranty
(COBIE-ER-13) Exchange Project Handover – Job Plan Constraints
(COBIE-ER-14) Exchange Project Handover – Job Plan

Functional Parts

Per the ISO standard for IDM, the components of the IFC model that are required to meet the exchange requirements are referred to as "functional parts." The specification of Functional Parts for COBie is available through the buildingSMART portal [22] for the items listed below. The portal file also contains graphical representations of these relationships and the original COBie data dictionary and mappings to IFC that would eventually find their way into later MVD documents.

fp-set-warranty
fp-set-project-context
fp-set-person-and-organization
fp-set-person
fp-set-organization
fp-set-address
fp-select-date-time
fp-represent-polyline
fp-represent-cartesian-point
fp-represent-bounding-box
fp-relate-currency
fp-nests
fp-model-system
fp-model-inventory
fp-model-cost-schedule
fp-model-cost-item
fp-model-asset
fp-model-actor
fp-define-quantity
fp-define-by-type
fp-define-by-properties
fp-control-service-life
fp-control-maintenance-work-order
fp-control-maintenance- schedule
fp-control-maintenance-plan
fp-contains-in-spatial-structure
fp-associate-material
fp-associate-document
fp-associate-cost
fp-associate-constraint
fp-associate-classification
fp-assigns-to-product

fp-assigns-to-group
fp-assigns-to-control
fp-assigns-to-actor
fp-assign-cosntruction-resource-to-task
fp-apply-owner-history
fp-annotate-geometry
fp-aggregates

Model View Definition (MVD)

MVD Description

The Model View Definition for COBie was originally documented in 2008 [23]. Based on the contribution of the international community, including buildingSMART chapters in the UK and Germany-German Speaking the Model View was updated in 2009 as part of the international pre-certification event for the FM Handover MVD. Information from the buildingSMART international Model Support Group/Implementers Support Group may be found here [1].

MVD Diagrams

- MVD Graphic Form, with Binding Concepts [24]
- MVD Tabular Form, with constraining business rules [25]

MVD Concepts

At the time of the development of COBie the description of IDM Functional Parts was thought to be equivalent to MVD Concepts. For the purposes of this ballot, please refer to section B.3 IDM Functional Parts for the information required in this section.

Conformance Testing

Testing Procedures

Testing against objective standards has been the hallmark of the COBie effort from the first demonstration in 2006 until today. As part of the process for each public presentation of COBie software implementation, objective standards for the evaluation of results were provided to participants and freely available objective testing software was utilized. The testing procedure has evolved from an initial effort to provide software quality control for participating vendors to now being a quality assurance process based on established models and file checking software. The current testing procedure takes one of two forms, depending on the need to produce or consume COBie files. Some software consumes COBie data and allows users to update that information, then produces downstream COBie files. These tools are required to undergo both COBie consumption and production testing.

Software consuming COBie information is checked to ensure that the set of information appropriate for the consuming software is actually imported and that the information relevant to that imported set of

information has been correctly imported. The COBie files imported are the Duplex Apartment models found on the Whole Building Design Guide page for that testing event. The March 2010 example is the current standard for these testing files [26]. A checklist guides this quality assurance procedure, first accomplished by the vendor, and then re-checked by the designated analyst. The checklist for COBie consuming software is provided through the buildingSMART alliance portal [27].

In the current context of COBie, all software used prior to the facility management phase, first consume and then produce COBie data. Before December 2010 the testing of the production of COBie data was required to be accomplished and tested live before a national audience. Since December 2010 production of COBie files is accomplished as a quality assurance, and not quality control process. This means that the producer of the COBie file is required to:

(1) Import the previous project phase information using one of three equivalent forms: STEP-Part21, ifcXML, or SpreadsheetML. For example, construction-oriented software would import the design phase COBie deliverable.

(2) Update the information noted in the later project phase file using the commercial tool. For example, construction-oriented software, would update (among other things) product manufactures information and equipment installation dates.

(3) Export COBie data using one of three equivalent forms: STEP-Part21, ifcXML, or SpreadsheetML.

(4) Run the free bimServices COBie checking tool to determine compliance with the logical and business rules required by both the FM Handover MVD and the COBie specification.

(5) Prepare materials for publication on the Whole Building Design Guide based on the requirements from the March 2010 COBie Challenge event. These materials include: the file that was imported, the file that was exported (in native and COBie format), the results of bimServices testing, software configuration guides, technical support points of contact, and a 15 minute presentation.

(5) The designated COBie Challenge analyst reviews these materials for correctness. If the information is correct a recommendation is made to NIBS that the information on the new or updated software be added to the COBie Means and Methods page [15].

Repository of Vendor Results

All vendors' results are provided through the COBie Means and Methods [15] pages. The results are provided in a common format so that the results from different vendors may be compared.

Vendor results include files produced by programming, design BIM software, construction, and commissioning software. Vendor results include the native file, SPFF File, COBie File, and analysis results. For consumers of COBie data, files containing self-tests and review of COBie import data, as described above, are also provided. Configuration and/or setup documentation is also provided by the vendor.

Repository of Proof of Vendor Conformance

All vendors' results are provided through the COBie Means and Methods [15] pages. The results are provided in a common format so that the results from different vendors may be compared.

Ultimately the proof of vendor conformance is the ability of good software (that which meets COBie requirements) to be used well. Testing under a "COBie Challenge" provides only a simulation of the use of software to import or export COBie on a real project. As information becomes available regarding differences between "COBie Challenge" compliant software and the versions or configurations of software commercially available, the Means and Methods page [15] is updated to reflect the latest results.

Implementation Resources

Repository of Sample Models

The buildingSMART international's COBie event in 2009 required the use of a small reference file [28], however, for that first meeting all vendors were free to use a building model of their own choosing. The resulting submissions yielded files in three COBie data formats (STEP-Part 21, ifcXML, and SpreadsheetML). An additional rail yard maintenance facility was also provided for reference [29]. Authorization for the public release of the rail yard project was obtained in 2006.

COBie used several sets of models during its development. Public models may be found on the Whole Building Design Guide's COBie website [2]. As of March 2011 the examples provided on the COBie website are of a duplex apartment building. Authorization to publically release this model was received by its author in 2009. The duplex apartment building example is sufficiently small to allow users to see a single complete example. Another reason for the selection of the duplex apartment building project is that this model was used as part of the buildingSMART international pre-certification event (as described in a later in this document).

Example COBie files for different stages of the delivery of COBie information are provided as examples. These examples show the exchange of COBie information between major project phase changes: planning-design, design-construction, construction-commissioning, commissioning-operations. In addition, a blank COBie template is provided. An important aspect of this COBie template, as expressed by individuals looking to implement COBie, is that the complete set of classification and object identifiers required in the COBie specification are listed in the "pick-lists" worksheet.

As useful as the spreadsheet version of COBie is for users, information exchange standards are ultimately meant to be implemented by computer systems. From this point of view model repositories must have all needed physical models that implement the required data specification. For COBie, these physical models include not only SpreadsheetML, but also ifcXML and STEP-Part 21. The COBie submission to the NBIMS-US will be based on the combination of the STEP-Part 21 specification of the

FM Handover MVD with business rules established by the COBie specification to allow use of FM Handover MVD within the context of US business practices.

Another public website associated with COBie is the Life-Cycle information exchange (LCie) project [7]. On this site a complete set of COBie-based information exchanges are provided for both the Duplex Apartment building and a 52,000SF Medical Clinic. Authorization to publically release redacted versions of this model was received by its owner in 2010. The information exchanges listed on this page demonstrate all three formats of COBie data (STEP-Part 21, ifcXML, and SpreadsheetML)

The ultimate international repository that should be used by all buildingSMART efforts, to ensure the widest possible collaborative effort, is an international repository for open standard models [30][31]. The intention of this repository is to provide the entire community with a rich set of models upon which to conduct tests and experiments. This repository follows several custom-purpose information exchange platforms used for specific certification events or to support specific project efforts.

Repository of Vendor Samples

Prior to the creation of the buildingSMART portal, a commercial forum tool was used. For the last four years the buildingSMART alliance portal [32] has been used to exchange these files. In the lead-up to testing events, the information contained in these folders is kept private. Following the testing event, the set of tested files and information is made public. Publically available information is provided through the COBie Means and Methods page [15].

The COBie Means and Methods pages [15], including the vendor repositories, provide details about the specific data each system has presented for testing under a COBie Challenge event. This information may be used by COBie users to evaluate various tools for compliance with contracted information exchange requirements.

Repository of Vendor Configuration Documents

Vendor configuration documents are a mandatory requirement of all COBie testing events, starting with the first event in 2008. All documents are posted on the buildingSMART portal under a folder for each vendor. Following a successful test these configuration documents are released with vendors sample files through a standard format through the COBie Means and Methods [15] pages.

Repository of User Implementation Tools

There are multiple types of user implementation guides serving different purposes. The guides required to effectively configure and use compliant software are provided under the vendor-specific pages of the COBie Means and Methods pages [15].

There are also a number of different types of resources required to support the implementation of COBie. The essential consideration to user implementation of information exchange standards is that such standards must be included as contract requirements. Even with the explicit specification of such

requirements it is probable that without management supervision such requirements will initially be resisted or ignored. As a result a suite of user implementation materials must be provided to reduce the time required to learn about and implement COBie. All user implementation guides and materials, aside from those directly provided from software manufacturers may be found on the Whole Building Design Guide COBie website [2] and the international FM Handover MVD project page [1]. A list of implementation resources on these websites is provided below.

sample design contract specifications
sample construction contract specifications
sample commissioning contract specifications
sample building operator contract specifications
templates and example models
training - overview presentations
training - detailed file descriptions
frequently asked questions
free model checking and reporting tools
social networking site for peer-to-peer support

Two of the most important resources that can be used by project teams to implement COBie is the sample specification [33] and the COBie Responsibility Matrix [34].

COBie Sample Contract Specification [33]

The COBie sample contract specification describes the required delivery of specific COBie data at specific design, construction, commissioning, handover, and facility operations. The exchanges identified in the specification mirror standard deliverables found in existing design-bid-build, and design-build contracts used in typical United States federal government Unified Facilities Guide Specifications. For each of these typical deliverables the responsibility for the completion of specific COBie worksheets and columns are provided. The choice to continue simultaneous paper deliverables along with the COBie file is left to the specifier and owner to determine.

At the beginning of the project, the delivery of COBie information is limited to room data sheets. As the project progresses the delivery of product and equipment schedules is added. During construction documents, installation, and commissioning information are delivered.

The COBie specification is the first performance-based specification for open-standard building information exchange in the United States. As such this specification is a significant departure from proprietary, technology-based Building Information Modeling specification used throughout the United States today. If this performance-based approach replaces today's proprietary, technology-based specification it is likely that the complete set of information technology systems used in the future will

contain a common set of schema and structure, based on COBie, streamlining the capital-facility industry's global supply chain.

COBie Responsibility Matrix [34]

The COBie matrix currently focuses the first of three types of information needed to practically apply COBie to specific project teams, processes, and software platforms.

The first set of information provided as of July 2011 deals only with project team assignments. Typically COBie information is created in a process starting with the design and completing at handover. Since different parties will be responsible for different parts of the COBie file, the team needs to clearly assign the responsibility for each part. To assist in this task the "COBie Responsibility Matrix" was provided. The Matrix lists the names of the columns in each of the COBie worksheets. Assignments are made by color coding each column to identify who is responsible for that COBie data. If certain COBie columns or worksheets are not used, these can also be colored in to indicate that those worksheets are not required for that specific project. Ideally the team could meet through a webinar and, starting with the owner, proceed through the life-cycle of the project with each party taking responsibility for the portion of the COBie data that they will deliver. Saving the file in a PDF and distributing it at the end of the webinar will let the team refer back to the required assignments at any later time.

The second of the three parts of the COBie responsibility matrix, not yet completed as of the time of this second update to the COBie ballot, will help the team specifically define which worksheets are required for each type of COBie deliverable throughout the life-cycle. The default requirements for each of these exchanges may be updated based on specific contractual requirements for a specific project.

The third of the three parts of the COBie responsibility matrix, not yet completed as of the time of this second update to the COBie ballot, will help the project team translate data model information found in the COBie technical reports, published documents, and free bimServices transformations into a single location. This third worksheet will provide the COBie spreadsheet data dictionary, IFC 2.4 model mappings, and model mapping programming notes.

Repository of Cost/Benefit Analysis

The first COBie implementation report from 2008 [6] provided the first validated business case with strong endorsements from the Deputy Commander, Department of Public Works, Fort Lewis, WA and his staff. It was determined based on this study that COBie could save Ft. Lewis Department of Public Works one full-time data entry clerk and reduce by half the need for a full-time CADD operator.

Most recently, public meetings at the 2010 NIBS Annual Conference provided specific examples of benefits achieved through the use of COBie. In one dramatic statement from a hospital facility manager given a COBie case study presentation stated that what previously took 3 man-years to do they could now do in under 3 minutes.

In order to support anecdotal evidence of the efficacy of COBie, Penn State University has been commissioned to complete an economic benefit calculator for COBie that was begun by the Engineer Research and Development Center. At the Dec 2010 NIBS Annual Convention and in March 2011 representatives of the Pennsylvania State University presented their efforts to develop the COBie Calculator [9]. The objective of this calculator will be to allow a company to assess the impact of transforming one or more of their existing business process from the current document-centric process to an information-centric process as defined by the information exchanges identified in the LCie specification. The COBie calculator will be provided free of charge following its release through a new buildingSMART alliance page. The COBie calculator represents a predicted effect of implementing COBie but the authors of this tool cannot be certain of its accuracy without testing. An upcoming COBie pilot effort jointly supported by NIBS, ERDC, and COAA will benchmark several existing processes and compare the results of their projects to the predicted results of the COBie calculator.

Revision Plans

Discussion of Ongoing Extensions

COBie began with the requirement to capture spatial and equipment information for the purpose of construction handover. Deployments of COBie to date encompass the entire solution space of the information included in the FM Handover MVD. An example of an area not currently covered by COBie extensions are the re-use of facility operations information to provide the complete set of as-operated facility information from one Operations and Maintenance service provider to another one. While this use case is very important and is the predominate requirement for the development of the FM Handover MVD in Germany , this case is not covered under the current COBie specifications, test sets, or software implanters.

Another extension that is currently under discussion is a worksheet to identify “impacts” of building projects on owner’s and occupant’s health, safety, sustainability and/or environmental concerns. Another type of impact is economic impacts. Researchers have, for example, augmented COBie data files to evaluate the total cost of ownership of products and systems based on expected resource utilization, equipment efficiencies, and cost of operation. The identification of these impacts in a COBie “issue” worksheet is currently under consideration as a mandatory addition of COBie to support European Union countries requirements.

There are two uses of COBie that should be addressed in this sample ballot submission. The first is the extension to COBie that allows the support of product assemblies. This extension is directly part of the original COBie use case but was not implemented until a firm platform for off-the-shelf products had been defined and implemented in commercial off-the-shelf software. While the end-user result is clearly specified in existing contract documents, the software implementation of this extension has been the subject of debate among software vendors currently implementing COBie. The extension that planned

for release in Dec 2011 will support the logical representation of components into assemblies such as electrical panel boards and air handling units.

The second use of COBie is to further specify the precise set of information needed for each of the exchanges leading up to the handover of the FM information. A project that defines each of these exchanges is called the Life-Cycle information exchange (LCie) [7]. LCie has defined a mini-model view definition for exchanges starting prior to the inception of a new project to the recycling of the facility [35]. Within this LCie framework there are several additional exchanges that bear noting.

Early in the project life-cycle, the required space functional requirements of a facility and the implementation of those requirements through design, construction, and project renovations can be captured within the COBie data format as a mini-MVD. This specification was originally described in 2007 as the Spatial Compliance information exchange (SCie) buildingSMART alliance project [36]. This information is now more clearly specified through the LCie project's Space Program deliverable specification [37].

As manufactured data becomes available during the design, specification and construction submittal process, LCie specifications demonstrate how such information may be directly used and merged within a COBie-compliant building model. The LCie specification for as-designed product requirements, manufacturer product submissions during the submittal process, and products approved through submittals have all been defined in the LCie project as mini-COBie specifications. These "mini-COBie" specifications provide both a light-weight, human-readable format and a mapping that defines the open, IFC-based standard for such exchanges. For more information on this project please consult the Specifiers Properties information exchange (SPie) project page [38].

It would be expected that additional uses of COBie to implement specific transactional exchanges, as opposed to the phase-change exchanges, that have been the focus of prior public COBie events, will be explored. An example of such an exchange would be the use of a mini-COBie view to update specific building elements to add equipment installation information or space condition. The LCie project has demonstrated that "survey-type" information may be exported from a building model to create worksheets that allow the simplified submission of updates applied directly to the building model. The modeling of these exchanges results in an as-built BIM simply by workers completing the jobs they complete today with one crucial difference. The difference is that rather than providing paper or web-form information the information the worker provides directly merges back into the owner' s building information model.

Revision Cycle Planning

Following the inclusion of the logical and physical representation for assemblies such as electrical panel boards and air handling units there are no major revisions planned to the COBie format.

There is an additional use planned that may require some future modification to the nature of COBie implementations. At this point, it is too early to determine if additional changes will be needed. COBie also contains the required logical and physical model needed to implement building information model checking routines. Several current research projects are utilizing the “issues” worksheet in COBie (that maps to ifcConstraint objects in IFC) to contain the definition of model checking rules. Through this self-referential device rule humans needing to check a specific COBie file, or mini-COBie file, will simply import the COBie file that contains the checking rules for that required COBie file subset. In the future checking engines may implement these rules to test the consistency of model checking algorithms.

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Change Log

2011-06-01 Original version submitted to NBIMS

2011-06-15 Updated based on responses from NBIMS Technical Committee

1. Verify all URL's identified in the" G. REFERENCE" section
    1.1. All URL's cited on dates updated to confirm each link was tested
    1.2. All URL's reference information left in MS Word file to assist with transformation to PDF format prior to ballot updating.
    1.3. Reference [1] link updated to point to new URL
    1.4. Reference [9] bSa portal document number corrected
    1.5. References [10] [12] [14] word processing formatting kept URL from connecting, link recopied
    1.6. References [17] [18] the original international IDM web site is periodically down a note was added stating that all referenced documents have been copied to the bSa portal.
    1.7. References [21] [22] updated citations to clarify that these references point to documents on the bSa portal originally posted on the original international IDM website.
    1.8. Reference [24] [25] [28] documents copied from buidlingSMART-tech.org to bSa portal to enable use in NBIMS-US ballot without free login to buidlingSMART-tech.org. Provided references to original international website for those on the IFC Model Support or Implementers Support Groups.
    1.9. Reference [29] reference corrected and supplemental also reference provided

2. Updated Content of Section B.1 to list the required Process Maps.
3. Updated Content of Section B.2 to list posted names of exchange requirements and new link to original content as posted on bSa portal.
4. Updated Content of Section B.3 to list all functional parts, rather than simply referencing the file.
5. Updated content of section C to list all three required sections and provide reference for section C.3 back to Functional Parts per NBIMS Technical Committee recommendation.

2011-07-26 Updated based on responses from NBIMS Working Group

1. In response to the (paraphrased) comment "add a section about providing COBie data from BIM":

An improved description of the life-cycle delivery of COBie data from appropriate sources, including from design BIM software, have been provided in the following sections: Section A.4 Description, Section A.5 Business Case, and D.2 Repository of Vendor Results.

2. In response to the (paraphrased) comment "include a section on the COBie specification in three or four paragraphs":

A description of the draft COBie specification is provided in some level of detail under section E.4 Repository of User Implementation Tools along with a description of the COBie responsibility matrix. New footnotes 33 and 34 were added to highlight those sections.

3. In response to the (paraphrased) comment "it would help to know what data is provided by what system":

An additional paragraph indicating that the COBie Means and Methods pages provide detail examples of the worksheets and data fields provided under section E.2 Repository of Vendor Samples. Including that information directly would extend this ballot document unnecessarily when the information is available on the referenced location.

The COBie Responsibility Matrix will also provide a full mapping between the spreadsheet and IFC formats of the FM Handover MVD as noted in Section A.6.

4. In response to the (paraphrased) comment "please update the name of TOKMO to EcoDomus," There also was concern that software not tested as part of a COBie Challenge result, i.e. the Onuma System Checker.

The agreement made with the working group was to add an appropriate parenthetical statement citing EcoDomus when referring to the former TOKMO product. The checking software listed was highlighted as innovations resulting from existence of a open-standard building information exchange format. As a result the software listed there will remain as the software needs not be part of a COBie Challenge to be identified as demonstrating innovation. EcoDomus was added to the innovators utilizing their own checking tools per comment from Igor Starkov.

5. In response to the (paraphrased) comment “please proof-read the document again”:

The document will be reviewed one more time; however, limitations in time prohibit the application of experienced technical editors as is normally the case for published technical reports. It is recommended that NIBS technical editing staff be assigned to this ballot, if finally approved, prior to final publication.

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