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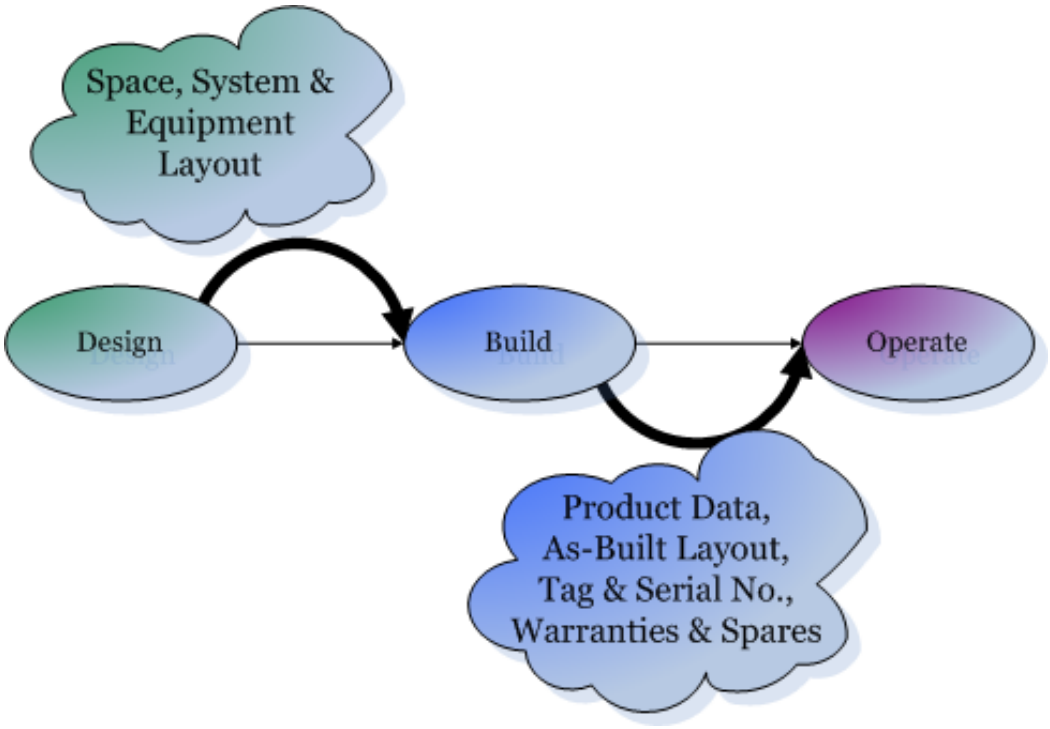
Construction Operations Building Information Exchange (COBIE)

Requirements Definition and Pilot Implementation Standard

E. William East

June 2007



Construction Engineering Research Laboratory

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Requirements Definition and Pilot Implementation Standard

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Final Report

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Abstract: The Construction Operations Building Information Exchange (COBIE) specification denotes how information may be captured during design and construction and provided to facility operators. COBIE eliminates the current process of transferring massive amounts of paper documents to facility operators after construction has been completed. COBIE eliminates the need for post-hoc as-built data capture and helps to reduce operational costs. This report describes the background and process used to create and implement COBIE. An international panel of experts, facility operators, construction managers, and asset managers participated in this project under the auspices of the Development Team of the National Building Information Modeling Standard (NBIMS). This report documents the requirements analysis that led to a pilot implementation standard, specifications for the pilot implementation standard, and the creation of an *Information Delivery Manual* with process maps used to link user requirements into the Industry Foundation Class model.

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Preface

This study was conducted for the National Aeronautics and Space Administration (NASA), the National Institute of Standards and Technology (NIST), the Overseas Building Operations Office (OBO) of the U.S. Department of State, and the U.S. Army Engineer Research and Development Center (ERDC-CERL), U.S. Army Corps of Engineers (USACE). A portion of the following projects supported the efforts described in this report:

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The technical monitors for this project were William Brodt, NASA (HQ-LD030), Jerry Harbison, U.S. Army Installation Management Command (IMCOM-W), Jean Swalley, OBO (PE/DE/DCB), and James T. Wilson, USACE (CEERD-ID).

The work was performed by the Engineering Processes Branch (CF-N) of the Facilities Division (CF), U.S. Army Engineer Research and Development Center – Construction Engineering Research Laboratory (ERDC-CERL). At the time of publication, Donald K. Hicks was Chief, CEERD-CF-N; L. Michael Golish was Chief, CEERD-CF; and Martin J. Savoie was the Technical Director for Installations. The Deputy Director of ERDC-CERL was Dr. Kirankumar Topudurti and the Director was Dr. Ilker Adiguzel.

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The Commander and Executive Director of ERDC was COL Richard B. Jenkins and the Director was Dr. James R. Houston.

1 Introduction

Background

Building owners bear significant costs that arise from the lack of interoperability with regard to electronic facility information [Gallaher et al. 2004]. Some facility managers have attempted to create facility information for use in maintenance management systems or to document as-built conditions, but even on large projects, such efforts are very costly. Although large owners have been able to develop facility-specific or proprietary information exchange formats, those formats directly hinder potential bidders who do not use the required software, or else they increase the cost of work because bidders must use multiple software systems in order to participate. In other words, the lack of data interoperability either excludes otherwise-qualified bidders or pushes higher project information processing costs from the facility owner to the builder.

The current state-of-practice is limited to the exchange of "electronic paper," or *e-paper*. The most successful e-paper method requires that scanned copies of paper documents be provided at project turnover. The requirements for such documents are identified in the Operations and Maintenance System Information (OMSI) specification, developed by the Naval Facilities Engineering Command (NAVFAC). OMSI has now been incorporated into Unified Facilities Guide Specification (UFGS) 01781, which is used by the U.S. Army, U.S. Navy, and the National Aeronautics and Space Administration (NASA) [UFGS 01-78-23, July 2006].

Part of the solution to the data interoperability problem, currently being considered throughout the international construction community, is a non-proprietary construction operations data model created by the International Alliance for Interoperability (IAI). The mission of the IAI is to provide "a universal basis for process improvement and information sharing in the construction and facilities management industries" [IAI 2007]. The common language for the IAI effort, called the Industry Foundation Classes (IFCs), provides a shared framework for the exchange of facility information.

While it is feasible for large facility owners and software firms to develop proprietary standards for information exchange, the variety of such re-

quirements limits the capability of small (or non-integrated) construction industry members to participate. One key criterion for a successful data exchange effort is that it must be very easy for contractors to use. A key to a product- or system-related information exchange, such as those included in OMSI, is that manufacturers who currently provide paper documents must be encouraged to provide digital data instead. Establishing a model for manufacturers to provide electronic product information is the goal of a project under way at the National Institute of Building Sciences (NIBS). The goal of the *Product Guide* portion of the NIBS *Whole Building Design Guide* [http://www.wbdg.org/] is to provide a place for manufacturers to submit electronic information that may be utilized during building design, construction, and operation.

In December 2005, a group was formed in the United States specifically to promote the development of a National Building Information Model Standard (NBIMS). NBIMS Development Team members and interested stakeholders have contributed to the work documented in this report: a component of the NBIMS standard called COBIE, the *Construction Operations Building Information Exchange*. The purpose of COBIE is to improve how information is captured during design and construction, and then provided for operations, maintenance, and asset management purposes. COBIE eliminates the need to create and transfer boxes full of paper construction documents to facility operators following completion of the project. COBIE also eliminates the need for post hoc as-built data capture, and it will help to reduce operational costs.

Objective

The objective of this work was to document the background and process used to create and implement the pilot version of the COBIE specification. This report includes an implementation of the pilot COBIE specification.

Approach

An international panel of experts, facility operators, construction managers, and asset managers participated in this work under the auspices of the NBIMS project. The overall approach to this project consisted of six steps, as shown in Figure 1–1.

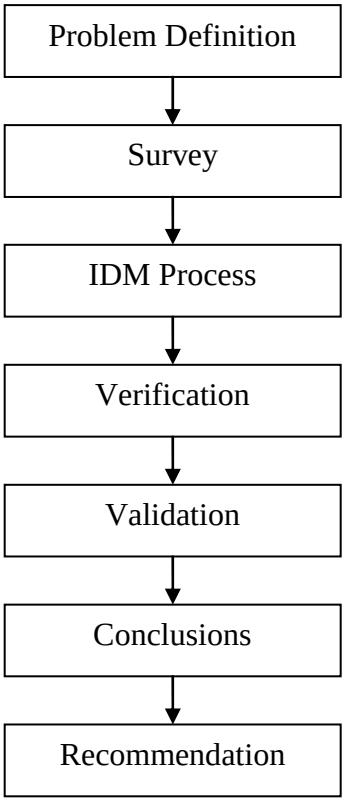


Figure 1–1. COBIE project approach.

The first step was defining the problem to be addressed by COBIE. Part of the problem definition involved identifying assumptions about the problem domain and recognizing which issues are beyond the scope of the project.

The second step was a survey of literature documenting the state of practice and technology related to information exchange between designers, builders, and operators. The survey encompassed publications by academia, government agencies, and not-for-profit organizations. Current contract language for the exchange of information and previous demonstration projects also was identified.

The third step in the research process was the creation of the *Information Delivery Manual* (IDM). IDM is an emerging international standard for the development and creation of interoperable building information models based on the IFCs [IAI 2006]. The IDM has three parts that define the business process, information exchange requirements, and information exchange format, respectively. In the IDM business process step, called the Business Process Modeling Notation (BPMN) [Object Modeling Group 2006], was used to capture the steps relevant to COBIE. Information ex-

changed at specific points in the business process will be identified and described, and the detailed format of the information handoff required between software systems will be described using the IFC model.

In the fourth step, verification took place in a fully open, team-based setting, with guidance and advice shared among project stakeholders, the NBIMS Development Team peer review group, and international IFC modeler peer review group. The participants included, but were not limited to:

- participants in previous and ongoing related projects
- facility operations and maintenance staff
- facility asset managers
- design and construction community members
- government agencies.

In the fifth step, validation of the effectiveness of the COBIE specification and COBIE-compliant software systems, a series of real construction contracts will be modified to include a COBIE specification section. An early draft of some of those COBIE specifications is included in this report.

Mode of technology transfer

COBIE technology is being transferred through multiple channels of activity, including the following:

1. development of contract language that federal agencies may use to require the submission of COBIE data by construction contractors
2. creation of instructions and sample data to help construction contractors to easily prepare the required COBIE data
3. coordination with national and international standards bodies to ensure that COBIE requirements meet international interoperability standards
4. coordination with professional and trade associations to ensure that COBIE requirements meet relevant business needs
5. updating the COBIE format as requirements, business processes, and interoperable technologies change over time.
6. posting templates, guides, and related technical content on the National Institute of Building Sciences (NIBS) Whole Building Design Guide (WBDG) web site [http://www.wbdg.org] to facilitate the widest and most cost-effective dissemination of COBIE standards.

1 Problem Definition

The current handover of information between construction and operations yields, at worst, boxes of papers filled with the technical descriptions of materials, products, equipment, and systems that are stored and never used. In the best situation, documents are provided electronically on CD created following construction and filed on a local area network. While a significant amount of effort is spent to ensure the startup tuning of equipment and systems is correct during commissioning, there is no equivalent process for "data commissioning."

Today there is no way to provide facility operators with non-proprietary, interoperable versions of the data they need to effectively operate modern facilities. Without such information operators must enforce proprietary information systems or re-key information into Computerized Maintenance Management Systems (CMMS).

One recurring theme in discussions about interoperable data standards is a kind of "chicken and the egg" argument. Software vendors state that they can provide whatever software is needed for owners. Owners claim that software vendors are not providing what owners need. The reason such arguments continue is that owners have not been willing to identify their requirements in a generic way.

The problem to be addressed by COBIE is that of the lack of definition of open-source, interoperable requirements for the exchange of information between the construction and operations phase.

Many differences in points of view between contractors, operators, maintainers, and asset managers exist. One of the differences in points of view occurs when thinking about information standards themselves. Many view information standards as bits and bytes of individual data exchange elements. Efforts over the past decades, not resulting in a useable information exchange format, have demonstrated that this approach is incorrect. The COBIE project will attempt to bridge these gaps in perception by identifying the commonality in the processes that of the groups use to accomplish their daily activities. Given the commonality in process, commonality in data sources and uses will be mapped by COBIE.

Given that the requirements for data can be agreed upon by all project stakeholders, the final step will be the creation of the data exchange format itself. This format will need to capture information as it is created, rather than rely on post-construction surveys or audits as is current practice. The format will also need to be based on an open-source platform, the IFCs. Direct use of IFCs alone is not possible, however. Agreements among stakeholder representatives must be created to define what exact information is to be provided by whom, to whom, and when.

2 Survey of Practice and Technology

This chapter surveys the literature of professional practice and that of academia to identify those current and past efforts that inform the current project. Initially, current information exchange practices in the private sector are discussed. Next, the efforts of industry associations to create information exchange standards for the construction industry, related to COBIE, are discussed. Third, the business processes used by for owners and builders related to materials, products, equipment, and systems in the U.S. public sector are described. Systems that facilitate these processes are described as points of potential process convergence. To take best advantage of the points of process convergence, requirements for and constraints changing existing procedures are described in the last section of this chapter.

Private sector state of practice

There are several areas where work on commercial projects has demonstrated information exchange. This section reports on these efforts beginning with efforts by FIATECH and NIST to document current practices. Next, a brief discussion of supply chain management identifies possible linkages between information needed to purchase and install materials, products, equipment, and systems and the handover of such information.

Life-cycle information exchange

In 2002 FIATECH surveyed operations and maintenance personnel to determine their perceived need for information exchange from contractors, suppliers, and manufacturers in the process industry [Wood 2003]. There were several key findings from this study. The finding first was that structural and information technology boundaries separate those who design/build from those who operate the resulting infrastructure. The difficulties surrounding the use of legacy information technology systems that would not be able to accept automated data are of concern to employees of large firms. A significant opportunity for streamlining information exchange exists if data could be captured during design and construction then viewed during operations and maintenance. Finally, construction project deliverables are useful for operators; however, they must be currently processed by hand before the information can be used.

The FIATECH study confirms that (1) the types of information currently provided during design and construction are helpful for operations and maintenance (O&M) staff, (2) there are no general solutions for the automated exchange of project information to O&M, and (3) if there existed a method to directly view project information by O&M staff, large benefits would be accrued.

In 2006 the National Institute of Standards and Technologies and FIATECH published the *Capital Facilities Information Handover Guide*, which identifies a methodology for information sharing throughout the facility life-cycle [Fallon and Palmer 2006]. The four stages of this method are: (1) determine the business cases that drive the capture and use of building information, (2) identify specific business requirements based on these cases that identify what information should be captured, (3) create a plan for the handover of building information, and (4) implement the handover plan using both improved software tools and augmented business processes. While the *Handover Guide* is focused on industrial applications, many of the same issues also apply to infrastructure and traditional facility construction. These issues include the use of interoperable data standards, specification of exchange requirements, information quality management, and information retention policies.

The *Handover Guide* recommends the use of industry standard formats such as the IFC model, instead of proprietary formats since future system upgrades may not be able to read data from previous proprietary formats. The responsibility and methods for the information handover must be clearly spelled out to ensure that information is consistently provided. To insure that information is accurately provided, specific content and timing of information transfer should also be specified. Finally, owners should consider how they will ultimately retain and augment project information throughout the facility life-cycle. Although not noted in the NIST survey, information will need to be retained even past demolition to ensure information is available for potential future litigation.

A follow-on report from NIST for non-industrial facilities [Fallon 2007] identifies two reasons why businesses are starting to adopt BIM technologies. The first reason is that BIM allows the creation of highly accurate design models that eliminate field changes resulting from inaccurate design coordination. The second reason is that improvements in communication with team members regarding construction phasing can reduce job site

crew friction. Case studies in the NIST report document these findings but note that the benefits achieved have limited applicability because they require vertically integrated stacks of software for all team members. As with the original "handover guide," NIST identifies non-proprietary software interoperability as a critical challenge to the capital facilities industry. The efforts of NBIMS and COBIE are specifically identified as potentially improving software interoperability through the U.S. adoption of Industry Foundation Class (IFC) models [Fallon and Palmer 2007].

Supply chain management

While owners track the value of assets installed in their facilities, those who build the facilities do not have the long-term need to track those assets. From the contractor's point of view, those building components are considered part of a supply chain that ends with project handover. Corporate innovation in supply chain management has produced such major economic powerhouses as Dell Computers and Wal-Mart stores. Efforts to study the impact of supply-chain management in construction have been underway for approximately a decade.

Efficiencies gained in manufacturing and logistics management have been achieved by aligning the objectives of suppliers with the lead organization [Tommelein et al. 2003]. Often these objectives are aligned by locking in individual suppliers based on a combination of price and performance. Unlike manufacturing, construction is driven by large numbers of companies that work together for the duration of a construction contract [Shahid and Froese 1998]. O'Brien states that any attempt to improve the process of information exchange related to supply chain management must explicitly address the transient nature of the partnerships and production in construction [O'Brien 1999].

Adopting processes based on long-term relationships in construction contracting are not a realistic ways for large owners, particularly public owners, to realize the benefits of contractor's supply chain management. As a result approaches other than "hard" vertical integration or "soft" partnering directions must be explored. Modeling and standardizing stakeholder business processes may substitute for vertical integration of business interests [Vrijhoef 2001]. Unfortunately, commercial software developers have used business process implementations as classic business "barriers to entry" that keep users locked into proprietary methods of accomplishing their work based on vendor-specific feature sets.

Association efforts

There are many organizations working to develop information standards related to data that may be applicable for COBIE. The first two subsections below describe relevant technical approaches to creating standards for COBIE information exchange. The conclusion to be reached through the review of theses two technical standards is that regardless of the final decisions on the information exchange content, the actual implementation of COBIE in terms of data formats required must be a hybrid approach that follows the building construction industries current practices.

Following the two initial sections, several projects investigating the data requirements for building industry specific information exchanges are described. This section of the report concludes with the description of a not-for-profit web created to support product-related decision making throughout the U.S. construction industry. Information on exchange standards for structural steel (CIS/2) and sheet metal (ductXML) were not included in this report because those standards to not directly relate to COBIE project objectives.

MIMOSA

The goals of the Machinery Information Management Open Systems Alliance (MIMOSA) organization include the creation of open information standards for life-cycle asset management [Johnson 2004]. As shown in Table 2-1 [BP 2004], MIMOSA is one of many standards that have been developed for the exchange of information. MIMOSA began as a standard for the communication between components of complex military systems and later included participation from facility management organizations.

MIMOSA requires the identification of mechanical assets that comprise complex engineered artifacts for such diverse industries as weapon systems, process plants, and heavy industry. The MIMOSA Common Relational Information Schema (CRIS) version 3.0 provides relational database tables to capture manufacturers, asset inventories, system components, condition status, and associated work orders. Members of the petrochemical industry currently use MIMOSA standards for the exchange of product information supporting a range of supply chain activities [BP 2004].

Table 2-1. Data exchange standards for the process industry.

Name	Description	Domains
ISO10303	Step, PIStep, Epistle, many parts, basis of other standards, file transfer only	Equipment data
ISO15926	http://www.tc184-sc4.org/wg3ndocs/wg3n1328/lifecycle_integration_schema.html	Equipment data
MIMOSA	OSA-EAI, OSA-CBM, www.mimosa.org	Equipment data
OPC	http://www.opcfoundation.org/	Process Data, Embedded systems
ISA – SP95	http://www.pera.net/Standards/S95_Presentations/MESA_S95_files/frame.htm and http://www.s95.nl/S95_02_en.htm	Production planning and Equipment data
B2MML	http://www.wbf.org/	Production planning
API690	http://www.pera.net/Standards/API_Standards_presentation/API%20TF%20690%2001-20.pdf	Equipment data
API-689	ISO14224 – see above	Operations and maintenance data
API-610	See above	Procurement, engineering, construction
OASIS	XML only transfer of PSLX see http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=pps	Production planning
OMG MfgDTF	Object Management Group – Manufacturing Domain Task Force, http://www.omg.org/docs/mfg/01-06-06.pdf	Manufacturing software components interoperability via CORBA
ISO/TC184/SC5	JWG 8 (Manufacturing Process and Management Information - administered by ISO/TC 184/SC 4	

Of particular interest to the building sector is that MIMOSA has been capturing manufacturer nameplate data through the use of their CRIS. Analysis of the format for nameplate data reflects an enterprise-view of the management of the assets needed to manage the production of large scale industrial activity [Bever 2006]. Definition of individual product attributes is not prescribed, but supported through the identification of complex types that provide the capacity to transfer agreed upon characteristics of the equipment being provided. This highly flexible format would allow the exchange of all available, or provided data, for any type of equipment nameplate data needed. The benefit to such an approach is that changes are not required to the structure of the data to represent new types of equipment or modified criteria.

IAI

The goal of the International Alliance for Interoperability (IAI) is to develop an open-source framework for exchange of facility information

throughout the project life-cycle [IAI 2007]. The model produced by the IAI is the Industry Foundation Class (IFC) model. The IFC model provides a framework for information exchange and is able to describe the majority of building components, processes, and interactions from many different points of view.

To actually apply broad model frameworks such as IFC or MIMOSA, agreements as to the ownership, content, and timing of information exchanges must be made among project stakeholders. These agreements are made and implemented by the use of software that has certified they support specific information exchanges. The IFC model explicitly identifies conceptual and physical object identities, ownership, and history allowing such information to be tracked through the planning, design, construction, contacting, operational, and disposal/refractoring stages.

To evaluate the use of the IFC model for applicability to the building construction industry exchange of product information a review of version 2x2 was conducted and related information relevant to equipment data has been extracted, as described in the following sections. The information provided in the following is abstracted from the IFC model with respect to the data needed for near-term COBIE efforts.

Structural system and miscellaneous components

In the IFC model structural system components (see Table 2-2) are defined by their placement and physical representation with a given facility. Specific attributes of these components are provided by related enumerations or property sets. In general, the definition of such components for COBIE is a secondary issue whose primary interest is in future reuse, redesign, or recycling of a facility.

During construction, representations of structural components are provided through shop drawings, fabrication, and erection details. It is not the intent of COBIE to require such information in IFC format. Construction required construction submittals will, however, be identified within COBIE but not linked to specific IFC objects the existence of which and utility of is far from certain.

Table 2-2. Structural system and miscellaneous component entities.

Entity Name
IfcBeam
IfcColumn
IfcCurtainWall
IfcRamp
IfcSlab
IfcStair
IfcWall
IfcRailing

Moisture protection component attributes

Of critical concern to facility operators are moisture protection components such as roofing. Anecdotal evidence suggests that the primary cause of building failure is moisture intrusion. Within the IFC mode the IfcRoof element identifies the shape and placement of the roof only. Specific attributes are explicitly identified in the IFC model. Such information may, however, be attached as property sets within an IFC compliant file.

Door and window component attributes

Within the IFC model extensive design-related information is provided for doors and windows. This information is provided below for the reader to review. Given that much of the focus of the creation of the IFC model has been on the design and geometry of these components, only some of the information identified in the IFC model need be referenced in COBIE. The data required by the IFC model for Doors and Windows, and its data type are provided below (Table 2-3 – Table 2-10).

Table 2-3. IfcDoor.

Field Name	Data Type	Size
OverallHeight	Number	Double
OverallWidth	Number	Double

Table 2-4. IfcDoorLiningProperties.

Field Name	Data Type	Size
LiningDepth	Number	Double
LiningThickness	Number	Double
ThresholdDepth	Number	Double
ThresholdThickness	Number	Double
TransomThickness	Number	Double
TransomOffset	Number	Double
LiningOffset	Number	Double
ThresholdOffset	Number	Double
CasingThickness	Number	Double
CasingDepth	Number	Double
ShapeAspectStyle	Text	50

Table 2-5. IfcDoorPanelProperties.

Field Name	Data Type	Size
PanelDepth	Number	Double
PanelOperation	Text	50
PanelWidth	Number	Double
PanelPosition	Text	50
ShapeAspectStyle	Text	50

Table 2-6. IfcDoorStyle.

Field Name	Data Type	Size
OperationType	Text	50
ConstructionType	Text	50
ParameterTakesPrecedence	Yes/No	-
Sizeable	Yes/No	-

Table 2-7. IfcWindow.

Field Name	Data Type	Size
OverallHeight	Number	Double
OverallWidth	Number	Double

Table 2-8. IfcWindowLiningProperties.

Field Name	Data Type	Size
LiningDepth	Number	Double
LiningThickness	Number	Double
TransomThickness	Number	Double
MullionThickness	Number	Double
TransomThickness	Number	Double
FirstTransomOffset	Number	Double
SecondTransomOffset	Number	Double
FirstMullionOffset	Number	Double
SecondMullionOffset	Number	Double
ShapeAspectStyle	Text	50

Table 2-9. IfcWindowPanelProperties.

Field Name	Data Type	Size
OperationType	Text	50
FrameDepth	Number	Double
FrameThickness	Number	Double
PanelPosition	Text	50
ShapeAspectStyle	Text	50

Table 2-10. IfcWindowStyle.

Field Name	Data Type	Size
OperationType	Text	50
ConstructionType	Text	50
ParameterTakesPrecedence	Yes/No	-
Sizeable	Yes/No	-

Mechanical system component attributes

Mechanical equipment components make up the bulk of information currently required for facility maintenance. Anecdotally, mechanical system failures are the primary cause of preventative maintenance, service orders, and work orders. The IFC model reflects the richness of information needed for the design of mechanical components, as shown in Table 2-11 – Table 2-26. Those aspects of mechanical systems that support asset management, operations, and facility maintenance should be required by the COBIE specification.

Table 2-11. IfcAirFilters.

Field Name	Data Type	Size
DirtyPressureDrop	Number	Double
CleanPressureDrop	Number	Double
Efficiency	Number	Double

Table 2-12. IfcAirTerminal.

Field Name	Data Type	Size
AirFlowType	Text	50
Throw	Number	Double
AirDiffusionPerformanceIndex	Number	Double
FinishType	Text	50
FinishColor	Memo	-
MountingType	Text	50
FaceType	Text	50
CoreType	Text	50
CoreSetVertical	Number	Double
CoreSetHorizontal	Number	Double
IntegralControl	Yes/No	-

Table 2-13. IfcAirTerminalBox.

Field Name	Data Type	Size
TerminalBoxType	Text	50
SoundLevel	Text	50

Table 2-14. ifcBoiler.

Field Name	Data Type	Size
HeatTransferRate	Number	Double
ThermalEfficiency	Number	Double
PrimaryEnergySource	Text	50
BoilerType	Text	50
HeatOutput	Number	Double
PressureRating	Number	Double
EnergyInputRate	Number	Double

Table 2-15. IfcChiller.

Field Name	Data Type	Size
HeatTransferRate	Number	Double
ThermalEfficiency	Number	Double
PrimaryEnergySource	Text	50
ChillerType	Text	50
NominalCoolingCapacity	Number	Double

Table 2-16. IfcCoil.

Field Name	Data Type	Size
CoilType	Text	50
BypassFactor	Number	Double
FaceVelocity	Number	Double
FlowArrangement	Text	50

Table 2-17. IfcCompressor.

Field Name	Data Type	Size
PrimaryEnergySource	Text	50
ImpellerDiameter	Number	Double
CompressorType	Text	50
HotGasBypass	Yes/No	-

Table 2-18. IfcCoolingTower.

Field Name	Data Type	Size
HeatTransferRate	Number	Double
ThermalEfficiency	Number	Double
PrimaryEnergySource	Text	50
CoolingTowerType	Text	50

Table 2-19. ifcDamper.

Field Name	Data Type	Size
PredefinedType	Text	50
FrameDepth	Number	Double
SizingMethod	Text	50
CloseOffRating	Number	Double
LeakageAirFlowRate	Number	Double
PercentOpen	Number	Double

Table 2-20. ifcFan.

Field Name	Data Type	Size
PrimaryEnergySource	Text	50
ImpellerDiameter	Number	Double
AirFlowType	Text	50
StaticPressure	Number	Double
FanPressureClass	Text	50
FanWheelType	Text	50
WheelMaterial	Text	50
WheelTipSpeed	Number	Double
DischargeVelocity	Number	Double
HousingMaterial	Text	50
DischargePressureLoss	Number	Double
FanDischargeType	Text	50
FanArrangement	Text	50
FanRotation	Text	50
FanDriveArrangement	Text	50
DrivePowerLoss	Number	Double
MotorDriveType	Text	50
MotorInAirstream	Yes/No	-
FanMountingType	Text	50

Table 2-21. ifcHeatExchanger.

Field Name	Data Type	Size
HeatTransferRate	Number	Double
ThermalEfficiency	Number	Double
PrimaryEnergySource	Text	50
HeatExchangerType	Text	50
HeatExchangerArrangement	Text	50
NumberOfPlates	Number	Double

Table 2-22. ifcPump

Field Name	Data Type	Size
PrimaryEnergySource	Text	50
ImpellerDiameter	Number	Double
PumpType	Text	50
NetPositiveSuctionHead	Number	Double
ImpellerSealMaterial	Text	50
PumpBaseType	Text	50
MotorDriveType	Text	50

Table 2-23. IfcSensor.

Field Name	Data Type	Size
ControlElementId	Memo	-
PredefinedType	Text	50

Table 2-24. ifcTank

Field Name	Data Type	Size
Volume	Number	Double
ReliefValveSetting	Number	Double
PressureRegulatorSetting	Number	Double

Table 2-25. ifcUnitHeater.

Field Name	Data Type	Size
HeatTransferRate	Number	Double
ThermalEfficiency	Number	Double
PrimaryEnergySource	Text	50

Table 2-26. ifcValve.

Field Name	Data Type	Size
CloseOffRating	Number	Double
ValveFlowCoefficient	Text	50
ValveType	Text	50

Additional information about the specific installation of components will be needed for COBIE. Attributes such as a specific valves Valve Tag and room in which a specific valve tags are located will be required. The specific implementation of these relational entities is discussed later in this report.

Electrical system component attributes

Electrical components in IFCs were also considered in depth. The attributes, mostly associated with the design of such objects, are identified in Table 2-27 – Table 2-31. General electrical components, such as appliances and outlets, due to their generality, have relatively few attributes. Specific types of equipment are defined with multiple attributes.

Table 2-27. IfcAppliance.

Field Name	Data Type	Size
ApplianceType	Text	50

Table 2-28. IfcElectricalExtendedProperties.

Field Name	Data Type	Size
ElectricCurrentType	Text	50
InputVoltage	Number	Double
InputFrequency	Number	Double
FullLoadCurrent	Number	Double
MinimumCircuitCurrent	Number	Double
MaximumPowerInput	Number	Double
RatedPowerInput	Number	Double
InputPhase	Number	Double
InrushCurrent	Number	Double
LockedRotorCurrent	Number	Double
CircuitSizePowerInput	Number	Double
FuseSize	Number	Double
Grounded	Yes/No	-

Table 2-29. IfcElectricalMotor.

Field Name	Data Type	Size
MotorWindingType	Text	50
Efficiency	Number	Double
PowerOutput	Number	Double
FrameConfiguration	Memo	-
InsulationRating	Memo	-
MotorHousing	Text	50

Table 2-30. IfcLightFixtures.

Field Name	Data Type	Size
MaximumSpaceSensibleLoad	Number	Double
MaximumPlenumSensibleLoad	Number	Double
SensibleLoadToRadiant	Number	Double

Table 2-31. IfcOutlet.

Field Name	Data Type	Size
OutletType	Text	50

IFC property sets

In addition to the explicit attributes of objects identified in the IFC model, there are also large numbers of “property sets” that define specific types of information associated with specific IFC objects. Separating the property

sets from the actual objects allows the IFC model to provide a more extensible data standard.

The specific property sets that relate to information needed for materials, products, equipment, and systems that are part of the submittal process have been extracted from the IFC model and listed in Table 2-32 – Table 2-36. Note that for readability, the "PSet_" prefix found on all IFC property sets has been removed from the set titles shown below. Readers are encouraged to review the IFC model to review the specifics of these property sets.

Table 2-32. Property set: Electrical Extensions.

Property Set Name	Related ifcObject
CoveringCommon	IfcCovering, IfcCovering-Type
CoveringCeiling	IfcCovering
CoveringFlooring	IfcCovering

Table 2-33. Property set: Shared Elements.

Property Set Name	Related ifcObject
DoorCommon	IfcDoor
DoorWindowGlazingType	IfcDoor, IfcWindow
DoorWindowShadingType	IfcDoor, IfcWindow
WindowCommon	IfcWindow

Table 2-34. Property set: Shared Building Services Elements.

Property Set Name	Related ifcObject
FlowMovingDeviceCompressor	IfcFlowMovingDevice
FlowMovingDeviceFan	IfcFlowMovingDevice
FlowMovingDeviceFanCentrifugal	IfcFlowMovingDevice
FlowMovingDevicePump	IfcFlowMovingDevice

Table 2-35. Property set: Shared Facilities Elements.

Property Set Name	Related ifcObject
Warranty	IfcProduct, IfcSystem

Table 2-36. Property set: Building Controls Domain.

Property Set Name	Related ifcObject
ActuatorTypeCommon	IfcActuatorType
ActuatorTypeLinearActuation	IfcActuatorType
ActuatorTypeRotationalActuation	IfcActuatorType
ActuatorTypeElectricActuator	IfcActuatorType
ActuatorTypeHydraulicActuator	IfcActuatorType
ActuatorTypePneumaticActuator	IfcActuatorType
FlowInstrumentTypeThermometer	IfcFlowInstrumentType
FlowInstrumentTypePressureGauge	IfcFlowInstrumentType
SensorTypeCO2Sensor	IfcSensorType
SensorTypeFireSensor	IfcSensorType
SensorTypeGasSensor	IfcSensorType
SensorTypeHeatSensor	IfcSensorType
SensorTypeHumiditySensor	IfcSensorType
SensorTypeLightSensor	IfcSensorType
SensorTypeMovementSensor	IfcSensorType
SensorTypePressureSensor	IfcSensorType
SensorTypeSmokeSensor	IfcSensorType
SensorTypeSoundSensor	IfcSensorType
SensorTypeTemperatureSensor	IfcSensorType

The Building Controls Domain table (Table 2-36) demonstrates that general IFC objects are applied to specific facilities through the creation and linking of specific property sets for individual entities.

The IFC model also contains property sets for items related electrical objects. These items are noted in Table 2-37.

Table 2-37. Property set: Electrical Domain.

Property Set Name	Related ifcObject
ElectricalDeviceCommon	
ElectricGeneratorTypeCommon	IfcElectricGeneratorType
ElectricMotorTypeCommon	IfcElectricMotorType, IfcFlowMovingDeviceType
ElectricHeaterTypeElectricalPointHeater	IfcElectricHeaterType
ElectricHeaterTypeElectricalCableHeater	IfcElectricHeaterType
ElectricHeaterTypeElectricalMatHeater	IfcElectricHeaterType
LampEmitterTypeCommon	IfcLampType
LightFixtureTypeCommon	IfcLightFixtureType
OutletTypeCommon	IfcOutletType
ProtectiveDeviceTypeCommon	IfcProtectiveDeviceType
ProtectiveDeviceTypeCircuitBreaker	IfcProtectiveDeviceType
ProtectiveDeviceTypeEarthFailureDevice	IfcProtectiveDeviceType
ProtectiveDeviceTypeFuseDisconnector	IfcProtectiveDeviceType
ProtectiveDeviceTypeResidualCurrentCircuitBreaker	IfcProtectiveDeviceType
ProtectiveDeviceTypeResidualCurrentSwitch	IfcProtectiveDeviceType
ProtectiveDeviceTypeVaristor	IfcProtectiveDeviceType
ProtectiveDeviceTypeVaristor	IfcProtectiveDeviceType
SwitchingDeviceTypeContactor	IfcProtectiveDeviceType
SwitchingDeviceCommon	IfcSwitchingDeviceType
SwitchingDeviceTypeEmergencyStop	IfcSwitchingDeviceType
SwitchingDeviceTypeStarter	IfcSwitchingDeviceType
SwitchingDeviceTypeSwitchDisconnector	IfcSwitchingDeviceType
SwitchingDeviceTypeToggleSwitch	IfcSwitchingDeviceType
TransformerTypeCommon	IfcTransformerType

HVAC domain property sets (Table 2-38 – Table 2-41) have been separated, for the purposes of presentation, into (1) property sets related to HVAC components that may or may not be submitted as separate items, (2) HVAC equipment, and (3) valves. While these distinctions may not be entirely correct, it may be useful to separate, for the purposes of COBIE the level of detail needed to support compliance with performance specifications versus the level of detail needed to evaluate mechanical engineering system designs.

Table 2-38. Property set: HVAC Domain (Components).

Property Set Name	Related ifcObject
AirTerminalBoxTypeCommon	IfcAirTerminalBoxType
AirTerminalTypeCommon	IfcAirTerminalType
AirToAirHeatRecoveryTypeCommon	IfcAirToAirHeatRecoveryType
EvaporativeCoolerTypeCommon	IfcEvaporativeCoolerType
EvaporatorTypeCommon	IfcEvaporatorType
FilterTypeAirParticleFilter	IfcFilterType
FilterTypeCommon	IfcFilterType
FlowMeterTypeCommon	IfcFlowMeterType
FlowMeterTypeEnergyMeter	IfcFlowMeterType
FlowMeterTypeGasMeter	IfcFlowMeterType
FlowMeterTypeOilMeter	IfcFlowMeterType
FlowMeterTypeWaterMeter	IfcFlowMeterType
TubeBundleTypeCommon	IfcTubeBundleType
TubeBundleTypeFinned	IfcTubeBundleType
VibrationIsolatorTypeCommon	IfcVibrationIsolatorType

Table 2-39. Property set: HVAC Domain (Equipment).

Property Set Name	Related ifcObject
BoilerTypeCommon	IfcBoilerType
BoilerTypeSteam	IfcBoilerType
ChillerTypeCommon	IfcChillerType
CoilTypeCommon	IfcCoilType
CompressorTypeCommon	IfcCompressorType
CondenserTypeCommon	IfcCondenserType
CoolingTowerTypeCommon	IfcCoolingTowerType
DamperTypeCommon	IfcDamperType
DamperTypeControlDamper	IfcDamperType
DamperTypeFireDamper	IfcDamperType
DamperTypeFireSmokeDamper	IfcDamperType
DamperTypeSmokeDamper	IfcDamperType
FanTypeCommon	IfcFanType
FanTypeSmokeControl	IfcFanType
GasTerminalTypeCommon	IfcGasTerminalType
GasTerminalTypeGasAppliance	IfcGasTerminalType
GasTerminalTypeGasBurner	IfcGasTerminalType
HeatExchangerTypeCommon	IfcHeatExchangerType
HeatExchangerTypePlate	IfcHeatExchangerType
HumidifierTypeCommon	IfcHumidifierType
PumpTypeCommon	IfcPumpType
SpaceHeaterTypeCommon	IfcSpaceHeaterType
SpaceHeaterTypeHydronic	IfcSpaceHeaterType
TankTypeCommon	IfcTankType
TankTypeExpansion	IfcTankType
TankTypePreformed	IfcTankType
TankTypePressureVessel	IfcTankType
TankTypeSectional	IfcTankType
UnitaryEquipmentTypeAirConditioningUnit	IfcUnitaryEquipmentType
UnitaryEquipmentTypeAirHandler	IfcUnitaryEquipmentType

Table 2-40. Property set: HVAC Domain (Valves).

Property Set Name	Related ifcObject
ValveTypeAirRelease	IfcValveType
ValveTypeCommon	IfcValveType
ValveTypeDrawOffCock	IfcValveType
ValveTypeFaucet	IfcValveType
ValveTypeFlushing	IfcValveType
ValveTypeGasTap	IfcValveType
ValveTypeIsolating	IfcValveType
ValveTypeMixing	IfcValveType
ValveTypePressureReducing	IfcValveType
ValveTypePressureRelief	IfcValveType
VibrationIsolatorTypeCommon	IfcVibrationIsolatorType

Table 2-41. Property set: Plumbing Fire Protection.

Property Set Name	Related ifcObject
DrainageCulvert	IfcSystem
FireSuppressionTerminalTypeBreechingInlet	IfcFireSuppressionTerminalType
FireSuppressionTerminalTypeFireHydrant	IfcFireSuppressionTerminalType
FireSuppressionTerminalTypeSprinkler	IfcFireSuppressionTerminalType
FireSuppressionTerminalTypeHoseReel	IfcFireSuppressionTerminalType
SanitaryTerminalTypeBath	IfcSanitaryTerminalType
SanitaryTerminalTypeBidet	IfcSanitaryTerminalType
SanitaryTerminalTypeCistern	IfcSanitaryTerminalType
SanitaryTerminalTypeSanitaryFountain	IfcSanitaryTerminalType
SanitaryTerminalTypeShower	IfcSanitaryTerminalType
SanitaryTerminalTypeSink	IfcSanitaryTerminalType
SanitaryTerminalTypeToiletPan	IfcSanitaryTerminalType
SanitaryTerminalTypeUrinal	IfcSanitaryTerminalType
SanitaryTerminalTypeWCSeat	IfcSanitaryTerminalType
SanitaryTerminalTypeWashHandBasin	IfcSanitaryTerminalType
WasteTerminalTypeFloorTrap	IfcWasteTerminalType
WasteTerminalTypeFloorWaste	IfcWasteTerminalType
WasteTerminalTypeGreaseInterceptor	IfcWasteTerminalType
WasteTerminalTypeGullySump	IfcWasteTerminalType
WasteTerminalTypeGullyTrap	IfcWasteTerminalType
WasteTerminalTypeOilInterceptor	IfcWasteTerminalType
WasteTerminalTypePetrolInterceptor	IfcWasteTerminalType
WasteTerminalTypeRoofDrain	IfcWasteTerminalType
WasteTerminalTypeWasteDisposalUnit	IfcWasteTerminalType
WasteTerminalTypeWasteTrap	IfcWasteTerminalType

To represent a given item, such as pump within the IFC model many different types of data may be provided. For example the design parameters required by the pump may be identified by property sets, the location of the pump may be identified, and the geometry of the pump itself may all be modeled. The agreement of what data in the IFC model is needed depends on the use-cases for the data. In the case of submittal review, the specific pump is an instance of an IfcFlowMovingDevice. The object has a specific value of the IfcPumpTypeEnum which links a required property sets for both PumpTypeCommon and for the specific type of pump identified in the IfcPumpTypeEnum.

IFC-mBomb Project

The goal of the mBomb project was to determine the extent to which commercial software could support the exchange of design related information through construction into operations [Stephens 2005]. The results from this project demonstrated that significant translation efforts remain with regard to commercial software systems.

IFC-PM3 information specification

The goal of the PM3 project was to identify data structures necessary for the use of product information in (1) specifying products during design, (2) selecting products during bidding, (3) compare expected or installed properties of products to initial product requirements, and (4) and selection of replacement equipment during facility operations [Grobler 2002]. One of the contributions of the PM3 project was to identify the use of the IfcConstraint object as the entity that should be used to capture specific requirements needed to specify installed equipment. PM3 did not, however, identify the set of requirements needed for such specifications.

ifcXML

There are several different ways to present IFC model data. One standard method for the exchange of full IFC models is the “EXPRESS” language. Express files are ASCII files that contain building models in very compact format and allow the identification of entity relationships that allow data to be re-indexed when the information is loaded back into a building model server or other IFC-compliant software tool.

Another way to provide IFC data is through an XML file. The ifcXML format has been developed to provide means for transfer of discrete parts of Building Information Models [Nisbet and Liebich 2005]. Using the ifcXML specification methods to represent building elements and related property sets can be easily created. An example of the ifcXML related to product catalogs provides a very good example of a method for information exchange where the detailed attributes of the given component are explicitly identified.

aecXML

The aecXML effort is currently identified as a project whose goal is to promote the adoption if ifcXML schemas within the building industry [aecXML 2006]. There are several ongoing development activities of the aecXML group, but these do not currently overlap with the COBIE effort.

OmniClass

The OmniClass effort is an ISO standards compliant, comprehensive, open-source taxonomy for the (primarily) North American construction industry [OCCS 2006]. Consistent application of the OmniClass scheme to project data ensures that project team members are able to reference and retrieve related information in the future. The U.S. National Building Information Modeling Standard has expressed its interest in adopting OmniClass as its standard taxonomy to be used in conjunction with the IFC Model.

NIBS ProductGuide

The National Institute of Building Sciences ProductGuide is an electronic library of information that defines standards needed for individual products as specified in the UFGS. These product data sheets allow manufacturers to certify the standards met by the individual products.

While general product information contained in building codes provides only minimal performance requirements, the attributes of products that are required by individual standards testing bodies are very specific. The objective of reviewing the ProductGuide data sheets is to investigate the information needed for testing agency requirements. Table 2-42 shows the requirement for data attributes extracted from standards referenced in

UFGS 07212, “Mineral Fiber Blanket Insulation,” for the properties of the insulation.

Table 2-42. Insulation attributes required for certification.

Standard	Attribute	Value Range
ASTM C 665	MadeOf	Rock Wool
		Fiberglass
		Asbestos
ASTM C 665	CoveredBy	NoCovering
		NonReflectiveMembrane
		ReflectiveMembrane
ASTM E 84	FlameSpread	<25
		25 to <75
		75 to 100
ASTM E 84	SmokeSpread	<150
		150 or greater

Table 2-43 defines the properties that are required for the certification of accessory materials used with mineral fiber insulation. Given the differences in types of materials used, there are a wide variety of test requirements for this set of products. Discussion with NIBS staff regarding manufacturer’s acceptance of the ProductGuide has indicated that many manufacturer’s representatives do not have access to testing reports, may not be aware of tests that were accomplished, or have completed previous or later tests than those explicitly identified by specification.

Table 2-43. Insulation accessory attributes.

Standard	Accessory	Attribute
ASTM C 665	SillSealerInsulation	
ASTM C 665	Blocking	Covers
ASTM C665	VaporRetarder	MadeOf
ASTM E 96		Permeance
ASTM E 84		FlameSpread
ASTM E 136		CombustionProducts
TAPPI T803 CM		PunctureResistance
ASTM D 828		TensileStrenth
ASTM C 665	Pressure Sensitive Tape	ManufactuerApprovedList
ASTM E 96		Permeance
	Adhesives	ManufactuerApprovedList
	Mechanical Fasteners	CorrosionResistant
		ManufactuerApprovedList
	Wire Mesh	CorrosionResistant
		ManufactuerApprovedList

Specifiers' property set project

Unfortunately, manufacturers' property set information today is typically stored not as editable alphanumeric information, but as graphical images of paper documents archived in Portable Document Format (PDF) files. As such, the captured information cannot be processed directly by computer programs. Studies at the University of Illinois and ERDC resulted in an initiative to start a new NBIMS Development Team project related to the specification of product property sets (scheduled to begin in December 2007). Project participants are the Specifications Consultants in Independent Practice (SCIP), the Construction Specifications Institute (CSI), and ERDC. The specification will identify the attributes of materials, products, and equipment as used by specifiers within the schematic design, design development, and construction documents design phase. The objectives of this project include:

Property Sets Definition. This project will identify the full set of properties needed to specify materials, products, and equipment to a "typical" level of detail. Additional levels of details for multiple subcomponents may be included in future iterations of this project once a "breadth-first" view of materials, products, and equipment has been defined.

Property Set Processes Maps. This project will identify who is responsible for identifying the requirement for property sets, general classes of properties, type of property specifications, and specific property values. This objective fulfills the first step of the Information Delivery Manual process.

Property Set Exchange Requirements. This project will identify when specific data need to be exchanged at specific points within the Property Set Process Maps. Given the number of different specification methods and differences in practice, the project team will focus on several representative methods and practices.

Property Set Models. This project will map the specifiers' property set requirements to the IFC 2x3 Model. Additional implementation methods including, but not limited to, user-fillable PDF forms, XML schema, and spreadsheet formats may also be considered to assist the exchange of this information.

Dictionary. This project will compile the properties identified and provide them to the Construction Specification Institute for coordination with the International Framework for Dictionary (IFD) classification scheme through the OmniClass classification scheme. OmniClass classification, as the United States facing view of the IFD, will work to include the properties within the OmniClass taxonomy.

Commercial Adoption. While adoption by public-sector stakeholders can be expected as a result of this project, widespread industry acceptance will ultimately depend on commercial support of the properties and exchange methods identified in this project by product manufacturers and service providers.

Given the objectives of the specifiers' property set, the author and several sponsors are expected to support this project into Fiscal Year (FY) 08, with direct coordination with manufacturers initiated in FY09.

Public sector state-of-practice

In the U.S. public sector there are two types of information required at the end of construction. The first type of information captures the set of information that is needed for system maintainers. The second type of information captures the set of information needed for agency asset managers. Two examples of information exchanges for maintenance are provided

in the following paragraphs. Following the examples of maintenance information exchange, asset management data exchange at several U.S. Department of Defense agencies are described.

Operations and Maintenance System Information (OMSI)

Information exchange between construction and O&M, in the public sector, remains awash in paper submittals. The bright spot in the electronic information exchange is the capture of operations data at the end of the project by the Naval Facilities Engineering Command (NAVFAC). UFGS 01781, "Operations and Maintenance Support Information (OMSI)," requires that contractors provide a complete electronic record of materials, products, equipment, and systems. OMSI focuses on a "first-generation" information exchange standard that simply captures the electronic equivalent of paper (e-paper) in the form of a PDF file.

Various studies of the OMSI requirements have attempted to identify the characteristics of the documents captured in OMSI [UFGS 01-78-23]. Investigation of the metadata associated with the documents, unfortunately, does not allow an understanding of the information contained in the specification. Additional studies have attempted to structure preventive maintenance activities to support the automated import of schedules into CMMS [AEC3 2002]. While helpful, these studies have not addressed the basic question of what is exactly required in the OMSI specification, and how may it be captured in computable, i.e., not e-paper, formats.

This following paragraphs and associated tables extract OMSI data to document the type of information that is actually required within the PDF documents. There are two types of OMSI tabular information. The first allows defines, from the point of view of OMSI, a spatial plan of the facility. The second type of tabular information identifies key equipment located within those spaces.

In evaluating the information provided by OMSI for its applicability to COBIE it is important to evaluate what OMSI information was directly created during the construction phase. While it the entire set of OMSI information may be useful, it may not be cost-effective to require construction contractors to provide information that should be provided by information exchange by designers, in advance of the construction contract.

OMSI room attributes

To allow facility managers capture data about the general characteristics of the facility at the end of construction, OMSI requires contractors to identify a number of attributes about each floor and the spaces within these floors. Table 2-44 – Table 2-51 list the room property sets currently required by OMSI.

Table 2-44. OMSI general room attributes.

Field Name	Data Type	Size
Room Number	Text	50
Room Description	Text	50
Room Floor Area	Number	Double

Table 2-45. OMSI room ceiling attributes.

Field Name	Data Type	Size
Room Number	Text	50
Ceiling Type	Text	50
Ceiling Area	Number	Double

Table 2-46. OMSI room door attributes.

Field Name	Data Type	Size
Room Number	Text	50
Door Type	Text	50
Door Count	Number	Double
Door Facing Direction	Text	50

Table 2-47. OMSI room floor attributes.

Field Name	Data Type	Size
Room Number	Text	50
Floor Type	Text	50
Floor Color	Text	50

Table 2-48. OMSI room lighting attributes.

Field Name	Data Type	Size
Room Number	Text	50
Fixture Type	Text	50
Lighting Fixture Count	Number	Double
Lighting Fixture Lamp Count	Number	Double
Watts per Lamp	Number	Double

Table 2-49. OMSI room plumbing attributes.

Field Name	Data Type	Size
Room Number	Text	50
Plumbing Fixture Type	Text	50
Plumbing Fixture Count	Number	Double

Table 2-50. OMSI room valve attributes.

Field Name	Data Type	Size
Room Number	Text	50
Valve Type	Text	50
Valve System	Number	Double
Valve Normal Position	Text	50
Valve Tag Number	Text	50
Valve Location Description	Memo	-

Table 2-51. OMSI room window attributes.

Field Name	Data Type	Size
Room Number	Text	50
Window Type	Text	50
Windows Count	Number	Double
Window Facing Direction	Text	50

OMSI equipment attributes

In addition to a facilities spatial attributes, OMSI requires information be provided related to equipment assets located within the spatial model. Additional data about these assets is also needed to operate and maintain this equipment. The tabular data required by OMSI is identified in Table 2-52 – Table 2-55.

Table 2-52. OMSI general equipment attributes.

Field Name	Data Type	Size
Equipment Type	Text	50
Equipment Serial Number	Text	50
Equipment Location	Text	50
Equipment Accepted On	Date	-

Table 2-53. OMSI equipment maintenance attributes.

Field Name	Data Type	Size
Equipment ID	Text	50
PM Instruction File	Text	50
PM Frequency	Text	50

Table 2-54. OMSI equipment part, fuel, lubricant attributes.

Field Name	Data Type	Size
Part for Equipment ID	Text	50
Part of System ID	Text	50
Part Description	Text	50
Part Number	Text	50
Part Manufacturer	Complex	-

Table 2-55. OMSI equipment training attributes.

Field Name	Data Type	Size
Training for Equipment ID	Text	50
Training of System ID	Text	50
Training Description	Text	50
Training Source	Text	50
Training Provider	Complex	-

Cost of OMSI

OMSI data is gathered at the conclusion of the construction project. Paper documents submitted during the construction and commissioning process are compiled or scanned, verified, and scanned into PDF files. Interviews with the NAVFAC OMSI office indicate that the average cost of gathering the OMSI for a typical NAVFAC project is $40K. A study completed for the Architect of the Capitol concluded that the cost for "data commissioning" of capital projects would range from $50K to $100K [AOC 2005].

Fort Lewis Department of Public Works

The Department of Public Works (DPW) office at Fort Lewis, WA, has recently begun the use of a self-developed format for the identification of equipment and preventative maintenance requirements. The content of the format, specified in their Section 1701 Specification "Operations and Maintenance Manuals," includes paper documents that cover the following types of information required for each building system:

- system description
- installed equipment lists
- start-up procedures
- shutdown procedures
- preventative maintenance requirements and schedule
- layout diagrams
- control devices and schematics
- maintenance procedures
- troubleshooting procedures
- non-standard tools/equipment
- spare parts and suppliers
- warranties
- product data sheets
- hazards and training requirements.

At the Fort Lewis DPW, the operations and maintenance manuals that contain the information above are required to be provided in PDF format. In addition spreadsheets are required for the following information:

Table 2-56. DPW equipment locations.

Device Name
Site
Building
Floor
Room
Department

Table 2-57. DWP additional equipment fields.

Device Name
Equipment Number
Description
Serial Number
Model Number
Manufacturer

Table 2-58. Work order fields.

Device Name
Task Description

Schedule Start Date
Status

One of the main concerns voiced during a site visit to the DPW was a library that was created to handle the large number of documents for all the facilities at Fort Lewis. The library configuration, as opposed to a warehouse of banker boxes that exists at other installations, was identified as a very effective way to use the operations and maintenance information provided during construction. A primary concern, as the library grows, is the amount of space required to house these documents. Over time DPW representatives felt that they would prefer to have everything available on-line versus having paper copies.

Handover documentation

For U.S. Department of Defense projects the handover of information from construction to operations is accomplished using the Department of Defense (DD) Form 1354, *Transfer and Acceptance of Military Real Property*. The form contains basic asset information on any items considered to be "real property" and "personal property." Real property assets are those building components that are a fixed part of the project. Personal property assets are building products and equipment that may be moved. The designation of this handover information, even calling it by the name "property," correctly communicates the "real estate" point of view of asset managers in the Department of Defense.

Another aspect of handover documentation that is present in some commercial projects, but not included in the federal projects identified in this report is the distinction between operations, maintenance, and asset information. In process plant projects, for example, the operations of the installed facility provides a completely different set of instructions from the instructions required to maintain the facility. On many industrial applications the operators, i.e., the users of the facility, are in completely different organizational structures from those who ensure proper facility maintenance.

Handover documentation required at two different Department of Defense installations is provided in the next section. Following these examples there is a sub-section with conclusions.

Fort Eustis, VA requirements

Several electronic versions of the DD 1354 are available one of these versions documents the requirements for the Director of Public Works at Fort Eustis, VA [USA 2005]. Table 2-59 – Table 2-62 identify the asset data required by the Department of the Army at Fort Eustis.

Table 2-59. DPW project header data.

Item Required
Building Number
Work Order Number
Contract Number
Task Order Number
Contract Completion Date
Contract Cost
Project Point of Contact

Table 2-60. DPW project description.

Item Required	Size
Bldg Dimensions	
Main Bldg	
Offsets	
Wings	
No.of Usable Floors	
Ceiling Height	
Door Height	
Door Width	

Table 2-61. DPW project overview data.

Cat Code	Item Required	Size	Unit	Cost
	Building + 5' around		SF	
81242	Electrical Distribution (Underground)		LF	
81241	Electrical Distribution (Overhead)		LF	
81230	Exterior Lighting		LF	
81360	Electrical Transformers		KV	
13510	Communication Lines		LF	
82410	Gas Line		LF	
83210	Sanitary Sewer Line		LF	
87110	Storm Sewer Line		LF	
84210	Water Lines Potable		LF	
84510	Water Lines Non-potable		LF	
84330	Fire Prot Line NP		LF	
89240	Fire Hydrants		EA	
85220	Sidewalk		SY	
85110	Roads, Paved		SY-MI	
85130	Roads, Unpaved		SY-MI	
85210	Parking, Organization		SY	
85215	Parking, General		SY	
85211	Parking, Unpaved		SY	
87210	Fence		LF	
	Storage Tanks (Underground)		GA	
	Storage Tanks (Above Ground)		GA	
83180	Storage Tanks w/ Oil/Grease Separator		KG	

Table 2-62. DPW project components.

Building Component	Type	Type	Type
Foundation	piers	continuous footers	
Foundation materials	concrete	reinforced concrete	
Sub floor	conc slab	wood	
Floor surface	vinyl tile	concrete	
Exterior walls	brick	vinyl siding	
Interior walls	dry wall	insulated panel	
Roof support:			
flat truss	wood	reinforced concrete	
arch truss	wood	reinforced concrete	
joist or beam	wood	steel	slab
roof deck	wood	metal	steel
roof surface	shingles	steel	
Utility connections	**Number**	**Size**	
water			steel
sanitary sewer			steel
storm sewer			concrete
electricity			rubber
gas			
steam			
condensate			
Air conditioning	**Number**	**Size**	
type:			
capacity (tons):			
model:			
serial:			
Fire protection	**Number**	**Size**	
type (pull/sprinkler):			
number:			
conn to fire station?:			
Heating			
source:	furnace	unit heater	
fuel:	elec	gas	
no. of MBTUs:			
model:			
serial number:			
Domestic hot water facilities			
capacity (gal):			
temperature rise:			
type	gas	electric	oil

U.S. Air Force Academy requirements

In addition to the Army, other services have developed their own versions of DD Form 1354 (Table 2-63). The example shown in Table 2-64 – Table 2-74 refers to a document produced by the U.S. Air Force Academy Design and Construction office [USAF 1999].

Table 2-63. USAF general project description.

ESTIMATED PROJECT COST			$	_____	
ACTUAL CONSTRUCTION COST			$	_____	
TOTAL FLOOR SPACE new building					SF
TOTAL FLOOR SPACE addition					SF
TOTAL FLOOR SPACE rehab existing					SF
NUMBER OF FLOORS					NO
Material Types (list predominant type)					
		foundation			
		wall			
		roof			
		flooring			
Utilities Entering Building				size	
		water			
		sewer			
		gas			
		electricity			
		telephone			
		fiber			

Table 2-64. USAF fire protection system.

Category	Fire Protection	QUAN	UNIT		COST
880-211	closed head auto sprinklers	/	SF/HD		_____
880-212	open head auto sprinkler	/	SF/HD		_____
880-216	preaction sprinkler system	/	SF/HD		_____
880-217	afff preaction sprinkler system	/	SF/HD		_____
880-218	high expansion foam		EA		_____
880-221	auto fire detection system	/	SF/HD		_____
880-222	manual fire alarm system		EA		_____
880-231	carbon dioxide fire system		EA		_____
880-232	foam fire systems		EA		_____
880-233	other fire system		EA		_____
880-234	halon fire system		EA		_____
880-235	dry chemical system		EA		_____

Table 2-65. USAF security system.

Category	Security	QUAN	UNIT		COST
872-841	security alarm system		EA		_____

Table 2-66. USAF mechanical/electrical system.

Category	Mechanical/Electrical	QUAN	UNIT		COST
890-126	a/c units		TN		_____
890-125	a/c units <5TN		TN		_____
890-121	a/c unit 5-25TN		TN		_____
	Air Handling Unit				_____
	Evap Cooling				_____
823-111	Heat Pumps				_____
821-115	HTHW converter		MB		_____
821-116	MTHW converter		MB		_____
821-155	Individual boiler plant		MB		_____
	Transformer		KVA		_____
890-180	Utility Meters		EA		_____
890-134	air compressor		HP		_____
890-144	compressed air dist system		EA		_____
811-147	emer power generator		KW		_____
	emer lighting		EA		_____

Table 2-67. USAF Miscellaneous Systems.

Category	Misc	QUAN	UNIT		COST
	Elevators		EA		_____
	Hoist		EA		_____
890-158	Loading Dock		SF		_____
	Appliances		EA		_____
	Rear Projection Screens		EA		_____
	Postal Lock Boxes		EA		_____
	Attached Seating		EA		_____
	Satellite Antennas		EA		_____
	Lockers(permanent)		EA		_____
890-161	Misc Support Structure		EA		_____

Table 2-68. USAF electrical utilities.

Category	Electric Distribution	QUAN	UNIT	COST
812-223	Primary Distro Line Overhead		LF	_____
812-224	Secondary Distro Line Ovhd		LF	_____
812-225	Underground Prim Distr Line		LF	_____
812-226	UG Secondary Prim Dist Line		LF	_____
Category	Substations and Switching Stations			
813-228	Elect Switching Station		EA	_____
813-231	Elect Substation		KW	_____
Category	Elec Use Facilities			
812-926	Exterior Area Lighted		EA	_____
812-928	Traffic Lights		EA	_____

Table 2-69. Heating and cooling systems.

Category	Heat, Gas - Transmission	QUAN	UNIT	COST
821-115	Heat plant 750-3500 MB		MB	
821-116	Heat plant over 3500 MB		MB	
823-244	Gas Storage		CF	
824-464	Gas Mains (list sizes)		LF	
824-468	Gas Valve Facility		SF	
Category	Air Conditioning			
826-122	Air Conditioning 25-100 tons		TN	_____
826-123	Air Conditioning >100 tons		TN	_____

Table 2-70. Water and wastewater utilities.

Category	Wastewater	QUAN	UNIT	COST
831-165	Sewage Treatment Systems		KG	_____
831-168	Wastewater Treatment Bldg		SF	_____
831-169	Sewage Septic Tank		KG	_____
832-266	Sanitary Sewer Main (list sizes)		LF	_____
832-267	Sanitary Sewage Pump Station		SF	_____
Category	**Water Supply and Storage**	**QUAN**	**UNIT**	**COST**
841-161	Water Supply Main			_____
841-165	Water Supply Treatment		KG	_____
841-166	Water Well		KG	_____
841-169	Water Supply Building		SF	_____
841-425	Water Storage Reservoir		KG	_____
841-427	Water Tank Storage		KG	_____
842-245	Water Distro Mains (list all sizes)		LF	_____
842-246	Water Hydrants		EA	_____
842-249	Water Pumping Stations		SF	_____
843-314	FP Distribution Mains		LF	_____
843-315	Fire Hydrants		EA	_____
843-319	FP Water Storage		KG	_____
844-367	Non-Pot Water Storage		KG	_____
844-368	Non-Pot Water Supply System		EA	_____
845-362	Non-Pot Supply Bldg		SF	_____
845-363	Non-Pot Water Mains		LF	_____

Table 2-71. USAF pavement systems.

Category	Roads	QUAN	UNIT	COST
851-142	Bridges		LF	_____
851-143	Curb and Gutter		LF	_____
851-145	Driveways		SY	_____
851-147	Roads		SY	_____
852-261	Parking, org		SY	_____
852-262	Parking, non-org		SY	_____
852-289	Sidewalk		SY	_____
852-287	Pedestrian Bridge		LF	_____
Category	**AIRFIELD**	**QUAN**	**UNIT**	**COST**
113-321	Aprons		SY	_____
111-111	Runway		SY	_____
112-211	Taxiways		SY	_____

Table 2-72. USAF drainage system.

Category		QUAN	UNIT	COST
871-183	Storm Drainage (list sizes,feature)		LF/ea	_____
	pipe			_____
	channel			_____
	catch basin			_____
	culvert			_____
	manhole			_____
	inlet			_____
871-185	Storm Drainage Pump Station		SF	_____

Table 2-73. USAF miscellaneous utilities.

Category		QUAN	UNIT	COST
871-187	Retaining Wall		SF/LF	_____
872-245	Fence, Boundary			_____
872-247	Fence, Security		LF	_____
890-181	Utility Line Conduit/Duct			_____
890-185	Utility Tunnel			_____
890-187	Ultility Vault		LF	_____
	Utility Manhole		LF	_____
	Comm Manhole		EA	_____
135-183	Duct		LF	_____
135-586	Telephone		LF	_____
890-171	Misc Fuel Storage Tank		KG	_____
890-269	Cathodic Protection Systems		EA	_____
	Oil Water Separater		EA	_____
	HTHW Lines (list sizes)		LF	_____
	MTHW Lines		LF	_____
841-161	Irrigation Sprinkler System		HDS	_____

Table 2-74. EMCS.

Category		QUAN	UNIT	COST
890-271	EMCS Central Station		EA	_____
890-272	EMCS Field Equipment		EA	_____
890-273	EMCS Data Links		EA	_____

In addition to the “real property” that is installed with the construction or renovation project there are also many property items that are considered assets, at least in referenced USAF document, that are not permanently

installed in the facility. The items that fall into that category are identified in Table 2-75.

Table 2-75. USAF semi-permanent assets.

Item	QUAN	UNIT	COST
Appliances (list each)		EA	_____
Air Dryers/Compressors		EA	_____
Auditorium Curtains		SF	_____
Central Vac Sys		EA	_____
Chalkboards		SF	_____
Chapel Equip			
pews		LF	_____
altars		EA	_____
pulpits		EA	_____
baptistry		EA	_____
Chlorinators		EA	_____
Dehumidifiers		EA	_____
Electronic Air Cleaner		EA	_____
Fire Shutters		EA	_____
Room divider curtain		EA	_____
Latrine Equipment			_____
lavatories		EA	_____
commodes		EA	_____
urinals		EA	_____
Playground Equip (list)		EA	_____
Projection screens		EA	_____
Saunas		EA	_____
Scoreboards		EA	_____
Spray Paint Booth		EA	_____
Stadium Seats		EA	_____
Theater Chairs		EA	_____
Wardrobes/Lockers		EA	_____
Window A/C unit		EA	_____

Discussion

The current requirements to document “real” and “personal” property each have their own implications for the COBIE project. When considering the “real” property estimates of space for individual functions should be specified in a consistent method. There are many different methods for

calculating the size of spaces today. For example the space boundaries may be based on the usable space, centerlines of walls or full dimensions including walls. Vertical distances may limit to the ceiling, bottom of the structure, or to the bottom of the floor above.

Today there are competing standards that define the rules for calculating space areas and volumes [Tracy 2003]. American Society of Testing and Materials (ASTM) standard E 1836-01 provides definitions for the measurement of floor areas for "facility management, occupant requirements, space planning, or strategic facility planning." This ASTM standard was initially developed by the International Facility Managers Association (IFMA) "Standard Classification for Building Area Measurements." The Building Owners and Managers Association (BOMA) standard, approved by ANSI, Z65.1-1996, specifies the measurement of industrial and retail facilities.

Anecdotal evidence from the importation of test IFC models has demonstrated that the resulting floor area calculations are different when created by different CADD software vendors. Until efforts to harmonize the IFMA and BOMA standards for real property have been completed, COBIE should not include such requirements in a given specification. If provided, use of different standards could provide different information to asset managers.

Regarding personal property, there appears to be little dispute about the data exchanged or required. The personal property handover data required are (1) the name of the item, (2) that number of items in the building, and (3) the per unit cost. While the name of items and count could be identified from the data identified in COBIE, the provision of cost information by the contractor may not be available. It is not clear, however, from the information provided if the cost figure required in a previous table is first-cost or replacement-cost. In addition, it is not clear that personal inventory is required to be located within the facility. This is in contrast to real property that is identified within a specific room based on the OMSI specification.

Electronic submittal processing at NASA

This section reviews the organization and contents of electronic construction files related to NNS05AA76C with Trans-Gulf Constructors. Contract NNS05AA76C installed underground storage tanks and piping at one of

the propulsion test complex areas at the Stennis Space Center. These files and files for Contract NAS13 01049 were provided by Ms. Michelle Craft, Project Manager, Stennis Space Center.

NNS05AA76C project files

NNS05AA76C contract files were provided in folders organized by media type, e.g., “Emails,” as well as functional type, e.g., “Transmittals.” While not fully evaluated, it is interesting to note that the organization of the files provided on another contract, NAS1301049, were organized in a different set of folders. The use of standard contract folder naming conventions, organized by business processes, commonly found at NAVFAC ROICC and USACE Area Offices were not reflected in the organization of the electronic data.

Within different folders, files could be identified that referenced the same subject. For example under the "Emails" folder a files called "Xmtl 042 John Haynes.rtf" and “Xmtl 042 LDQ.rdf” also pertain to the "Transmittal" folder file “Xmtl 042.pdf” and the "Letters" folder file “05-0220SMO Xmtls 038, 042, 043B.DOC”. Files pertaining to the same “Request for Information” and “Field Change Requests” topic could also be found in different folders.

Many files contained correspondence related to multiple topics. For example, the file name “05-0220SMO Xmtls 038, 042, 043B.DOC” clearly pertains to submittal package 038, 042, and a supplemental submission of transmittal 043B. Tracing the thread of each discussion and identifying the overall status of submittal required the production and maintenance of summary files such as that found in “Transmittal Listing for All.xls.” On the other project, NAS1301049, summary data was maintained in a Microsoft Access database, “Xmtl Info NAS1301049.mdb”.

A view of the entire set of files after the completion of construction somewhat masks the time sequence of the information. One issue of importance is that different files pertaining to the same topic as part of the same process, such as submittal review requires. For example the files called "Xmtl 036A John Haynes.rtf" and “Xmtl 036A LDQ.rdf” both pertain to submittal 036A. These files also contain different responses to the referenced submittal. The dates noted in the emails captured by these files are 20-Jul-05 and 18-Jul-05, respectively. These dates demonstrate good coordina-

tion between the reviewers and prompt review of contractor submitted data.

Electronic submittal files provided by the contractor appear to have been distributed by the "configuration coordinator" who collected the responses. It could be expected that from time to time this coordinator would have been required to adjudicate differences of opinion on submittals, and other matters, as well as ensure that reviews, and other job functions, were completed within the required time frame.

The need for distribution of submittal reviews among personnel from different offices or between facility operator and designers could not be established from the data provided. This is because the office names of users email addresses were stripped out when the email was saved. It would be expected, however, that some larger projects utilize resources outside the office of the configuration coordinator and/or project manager.

Responses regarding the status of individual submittals, RFIs, etc., were found in the "Letters" folder. With the exception of "boilerplate" information about the project, a "disclaimer" statement, and Contracting Officer's Technical Representative identification the submittal information returned to the contractor appeared to be directly compiled from the information provided by submittal reviewers. The timeliness of these responses was very good in the examples specifically reviewed by the author. For example, the letter response for transmittal 036A, "05-0217SMO Xmtl 036A.DOC", was signed on 22-Jul-05, four calendar days following the last review comment submission.

While RFIs and Field Change Requests (FCRs) are submitted on an ad-hoc basis, submittals are provided against a required schedule, or "register," of submittals. This register is a catalog of the materials, components, equipment and systems to be installed on the project. The register also catalogs informational requirements that allow quality control and follow-on O&M activities to be conducted. In the sample project reviewed there was a significant mismatch between the submittal register generated for the project and the actual submittals received from the contractor. There were several possible reasons for this mismatch that could be surmised by examining specific submittal file contents.

In many cases, submittals contained multiple sets of individual transmittal documents, from different sources, that could have been separated into individual submittal documents pertaining to more than one section of the register. For example, submittal 009, related to cast in place concrete pads, contained 16 individual submittals including catalog cuts, mix design, test reports of various kinds, and delivery tickets. Other submittals identified in the submittal register for cast-in-place concrete (and associated) specification sections were not found, by this author, for example rebar delivery tickets or steel test results.

It is interesting to note that transmittals contained information about work accomplished in specific areas of the project. For example, the mix design and aggregate test data could for a specific batch of concrete could have been correlated with the compressive strength test results for concrete placed in a specific location on the project. Such an observation could, no doubt, also be made on documents related to mix design, delivery tickets, and cylinder test results on most projects regardless of agency overseeing the construction.

Noticeably absent from the data disk were daily reports and progress photos. Given the focus on information exchange related to Operations and Maintenance issues, such information may simply have not been provided by the Center.

Opportunities to streamline existing process

Consistent organization of electronic files would greatly improve ability to find relevant documents. A standard organization for construction file folders was not found using a Google search at “site:nasa.gov.” If the organization were based on specific type of business activity, e.g., “submittal” or “rfi”, then tracking issues from inception through conclusion would be more easily accomplished. While this would be a good start, for file-based project archives a desktop or network search engine would also be needed to identify similar content from multiple files. One such free tool that does not post data on outside servers is called Copernic (http://www.copernic.com/).

A key requirement for all file-based document organization schemes is that documents must pertain to a single subject only.

Once organized, distribution of files over the web would create a document repository without requiring the re-transmission of documents by email attachments. Depending on the nature of the repository, information about specific projects could be limited to those contractors or others who have a concern regarding the privacy of contractor pricing or other proprietary data. This repository could also be used by the contractor to provide their transmittal, in lieu of paper copies.

Provision of a web-based file exchange should be designed to allow suppliers and manufacturers to directly provide PDF files of materials and equipment to be purchased. Such PDF cut sheets are widely available as a Google search of most product titles will show. Allowing the supplier or manufacture to provide this information directly will eliminate the cost of scanning documents by owner or contractor.

A standard tool to track the status of individual transmittals and overall submittals would be helpful since the cost to create, maintain, and share individual tools to track transmittal status could be eliminated. The content of the submittal register should be based on the submittal requirements identified by the designer and not the submittals provided by the contractor. The decomposition of large contractor submittals into individual transmittals will also demonstrate better compliance by the contractor with the designer-specified submittal requirements. Smaller files will also allow the owner's representative to more easily verify the contents and resolution of each transmittal. Having a shared, standard tool would further improve productivity since the status of issues would be known to all project stakeholders.

Even if contractor submittals were decomposed into their elemental parts and provided as separate transmittals, these documents typically apply in multiple locations within a submittal register. For example transmittal 008 contains "Installation Instructions" for the underground storage tank. These instructions should be linked both to the submittal for O&M data and the original product submittal. Unfortunately within the context of standard file exchange programs such a linkage could not be supported.

The cross referencing of information within documents to the geometry and components within the facility requires a Building Information Modeling (BIM) approach. COBIE allow information to be linked to all its associated information. This "tagging" is done by the group who initially cre-

ates the data. For example, the geometric layout of a project is identified during the design along with all named equipment, and the location for that equipment. The contractor provides the serial number, instructions, manuals, etc., for the equipment during the process of construction. COBIE supports this life-cycle project information exchange with the result that Computerized Maintenance Management System (CMMS) data can be automatically provided at the end of construction.

A key concern of facility maintainers, operators, and asset managers is that the data currently provided at the end of construction is insufficient for their needs. Unfortunately, the majority of information needed for Computerized Maintenance Management Systems, Computerized Facility Management Systems, and property inventory systems must be retyped from paper files provided at construction handover. Use of the example project files or those from the NAVFAC OMSI system demonstrate that even the capture of e-paper, in the form of PDF files is insufficient to meet the needs of facility maintainers, operators, and managers.

Asset management

While there are differences between facility management, facility operations, and facility maintenance these three aspects of "asset management" are, in the building industry, almost always used synonymously. Overall facility management will have specific requirements, based on the accounting schemes employed by the parent organization to allocate operational mission and costs to individual facilities or spaces. Operations management requires information about the how to use the facility to accomplish the needed production work within the space. Maintenance management is the process of keeping the facility in working operational condition.

A study of information needs by facility managers identified the need for asset inventories, environmental performance requirements, performance metrics, and maintenance plans [Hassanain 2003]. Hassanain's model identifies: an asset as either an individual asset or a part of a group of other assets, tasks associated with the asset, products or collections of products that comprise the asset, and tasks associated with these products.

Systems for asset management require initialization through the entry of information regarding the design, construction, and commissioning phases. To begin operations the asset management system accepts data

from “upstream” in the process. To operate the facility the asset management system must also accept updates to equipment condition and job status.

If an automated asset management system were in place, and could be provided with information on new projects as well as the status of ongoing operations and maintenance activities, then the system should be able to answer six “crucial” questions. [Vanier 2001]. These questions are noted in the list below:

- What assets do you own?
- What is the value of these assets?
- What is the condition of these assets?
- What tasks are required to maintain asset serviceability?
- What how long will the asset effectively operate?
- What is the plan for maintenance of all assets?

Quality control

Given the state of practice described in the previous sections it is clear that there is no simple current standard that can be directly applied to capture the full set of data needed for asset management. While it is possible that the creation of a standard could pull the data from construction contractors and provide it to facility operators, such approaches, e.g., OMSI, have been shown to be expensive and require additional staff to execute. Another way to frame the COBIE standard is to modify currently procedures, methods, and formats for current data exchange.

To ensure that the COBIE standard is widely adopted, COBIE must find operate within the context of existing business processes. Current paper exchange and the public sector OMSI and DPW efforts are, primarily, based on an existing contract-driven process called contractor quality control (CQC). In the CQC process the construction contractor is responsible to ensure that their work has been done in accordance with the performance requirements identified in the contract documents. One of the requirements that demonstrate effective CQC is the submittal that demonstrates compliance of materials, products, equipment, and systems with requirements contained in the construction contract.

The submittal of information about building materials, products, equipment, and systems is a “natural” point of capture of COBIE data during

construction. This is because the data is already being provided. Changing the format of the information, and ensuring that a standard set of data is being submitted based on the specific submittal are the essential aspects of COBIE. COBIE will help clarify the set of information being evaluated during shop drawing approvals and submittal reviews. In addition, COBIE must view the CQC process to include information flows as well as paper submissions. The consideration of these contractual (and collaborative) business flows will be critical to COBIE's long-term success [Arditi and Gunaydin 1998].

While there are several processes within the planning, bidding, design, and construction stages that allow the capture of facility management related information, the clearest and most efficient means to capture information for handoff between construction and operations. As a result, the initial COBIE specification will focus on the collaborative and contractual processes needed to process submittals. The paragraphs below describe the submittal review portion of the CQC process and identify specific areas in which COBIE information could be captured.

Submittal of manufactured components

In public-sector projects, the lead designer identifies all submittals to be provided during construction [NGB 2003]. The description the products and materials with related constraints are be found in design specifications. Specifications that cover a wide range of projects, such as UFGS, are tailored during the design process to describe only those products and materials included in a specific project. Once the specifications have been completed, a list of the products and materials to be included in the project may be generated.

During construction information about each of the products and materials on the project-specific list are used to select materials, equipment, and products meeting the designer's minimum performance requirements. Information about building systems is also required to explain how components are to be integrated in systems, operated, and maintained.

The private industry's use of automated information exchanges for submittal review is based on the electronic transmission of paper documents. Transmitting these documents electronically simply decrease the time required to receive documents, it does nothing to improve the quality of the information exchanged [Bjork 2002]. The difficulty of retrieving the cor-

rect electronic documents is increased since the equivalent of standard paper file folder schemes, required for the storage of paper documents, are difficult to check and enforce when exchanging electronic documents. Document taxonomies and search engine technology can assist, provided all required documents are provided.

Submittal of engineered components

While manufactured products, once selected have a fixed set of information content that is augmented by location and serial number during installation, information describing engineered items becomes more refined through the construction process. For example, shop drawings go through several stages completed by a project-specific (or possibly project-unique) set of manufacturers, fabricators, and installers. These stages include (1) detailed design, (2) fabrication instructions, (3) assembly instructions, (4) erection instructions, and (5) installation instructions [Pietroforte 1997]. The current paper-based coordination processes used to review and coordinate the production of engineered items are prone to errors resulting from miscommunication [Terry 1996].

Trades often need to work together to coordinate their work to ensure the specified outcome. For example in precast concrete panels the precast manufacture, glaziers, and erectors must work together to ensure panels restrict moisture transmission. Operational requirements of such components also are more complex than that of most manufactured products. This is because systems with different materials often have different thermal response properties and require different types of maintenance for each of the types of material in the system.

Efforts to streamline information exchange of engineered components have significant implications legal with regard to the expected accuracy of electronic working drawings. Drawing sets without consistent accuracy or with needs for different levels of accuracy have resulted in claims when these documents are directly applied outside the context in which they were created. To attempt to resolve such issues national trade and professional associations have been developing standards for the legal issues surrounding the exchange of electronic documents. The American Institute for Steel Construction (AISC) has, for example, added a code section governing the use of electronic documents for shop drawing review [Harman 2000]. The concern is often cited by designers and consultants, however, professionals interviewed by this author have also identified prob-

lems associated with construction contracting. For example, reliance on designer produced CADD drawings for construction bidding have resulted in claims by construction contractors due to inconsistent and inaccurately scaled CADD diagrams [Harman 2000].

While the increased accuracy (or inaccuracy) of electronic documents has resulted in claims, there are also benefits to having the electronic documents identified by the author. Audit trails have been used by the author to defend against multi-million dollar construction claims resulting from issues that were fully resolved during the bidding process. Team members have also been able to verify who has received the latest versions of documents to ensure proper coordination [Harman 2000].

Example submittal register

If the 2006 UFGS were applied in their entirety to a given project, there would be a total of 8,319 individual submittals. The SpecsIntact software, used to create UFGS for individual projects, provides a proprietary data exchange format using a comma-delimited text file used to exchange submittal tracking information [http://specsintact.ksc.nasa.gov/]. Table 2-76 shows the position of each field (column 1), the description of the contents of the field (column 2), and the party responsible to provide the data (column 3). The file format contains information that may be exchanged during the construction and other information that is needed at the start of the project.

Designer information is captured in fields 3, 4, 5, and 6. Contractor supplies information in several phases. First the contractor provides the submittal schedule through fields 1, 7, 8, and 9. When the submittal is sent to the owner for action, then fields 2, 10, and 11 are completed. Next the owner, noted as “Government” in the descriptions, takes action on the submittal in fields 12 – 18.

The submittals are categorized by the specification section and paragraph to which they correspond and by the type of information that is required. The submittal type, shown in Table 2-77, identifies what is to be provided with each submittal. Submittals for complex equipment, engineered or fabricated components, or items requiring user choices (such as color) typically have more than one submittal type for a given item.

Table 2-76. SpecsIntact file definition.

Field	Description	Responsibility
1	The Contractor CPM (Critical Path Method) activity number associated with the Submittal item	Contractor
2	The transmittal number assigned by the contractor to the Submittal when it is sent for review	Contractor
3	The Section number	Designer
4	The Submittal Description (SD) and number on the same row as the Section number, followed by each Submittal under that SD on the rows below it	Designer
5	The paragraph number of the Section where the Submittal can be located	Designer
6	Reviewer – Government (G), A/E	Designer
7	The date the contractor is scheduled to submit the item	Contractor
8	The date the contractor requests resolution on the Submittal	Contractor
9	The date the material is needed on site to meet the CPM schedule	Contractor
10	The code for the action taken on the submittal by the contractor's Quality Control manager	Contractor
11	The date of the action	Contractor
12	Date of Submittal receipt	Owner
13	Date Submittal sent to other reviewer	Owner
14	Date other reviewer response received	Owner
15	The code for the government action on the Submittal	Owner
16	The date of government action	Owner
17	Date returned to contractor	Owner
18	Remarks	Owner

Table 2-77. SpecsIntact submittal types.

Submittal Code	Submittal Type
01	Preconstruction Submittals
02	Shop Drawings
03	Product Data
04	Samples
05	Design Data
06	Test Reports
07	Certificates
08	Manufacturer's Instructions
09	Manufacturer's Field Reports
10	Operation and Maintenance
11	Closeout Submittals

Once the submittal file has been produced it may then be imported into a relational database and use as the basis for tracking the status of each submittal. Two systems that import the SpecsIntact file are the WebCM program [Cooper 2006], utilized by NAVFAC) and the Resident Management System (RMS) program [RMS Center 2005], utilized by USACE.

Constraints

There are many constraints that have the potential to limit the usefulness of the COBIE project. Given the previous failure of widespread implementation other electronic technologies, such as CADD, at construction offices it is critical that construction stakeholders participate in the COBIE project [Shen 2005]. Bjork [2002] identifies four constraints on the exchange of construction data to operations and maintenance. First, is that documents to be exchanged are large, thus requiring increased download time. Second, users must accurately flag information so that it can be easily retrieved. Third, is that people in "crisis mode" will resort to standard methods such as telephone and email for communication. Fourth, is that interoperability outside specific sets of proprietary software is not currently available.

The COBIE project plans to address these constraints in the following way. First, server side bandwidth will not be skimped upon. Adequate user bandwidth can be accommodated by cable modem or DSL connections to all project participants. Second, users will be encouraged to use standard classification schemes and folk taxonomies (to be discussed in the next sub-section). Third, capturing the outcome of emergency or face-to-face conversations should be simple to achieve in COBIE. In addition, multiple channels of communication should be integrated and available through COBIE. Finally, interoperability will be achieved through the adoption of the COBIE standard.

From the point of view of standards development the largest constraint will be the need to be pragmatic in the development of exchange requirements. This pragmatism reflects the need for standards to follow and not lead practice. As a result, COBIE will need to be a standard that allows evolving mixed-modes of data capture and exchange. Provided back-end software systems are able to consistently process the necessary information there is no reason that COBIE cannot evolve from individual file exchange formats to fully interoperable IFC-based model exchange. Given

that the full adoption of COBIE, and related technologies, will likely take a decade to accomplish, an incremental approach will be the most effective.

Taxonomic constraints

Ultimately a building model will consist of a hybrid description of building components, products, systems, data, and instructions. [Froese 2003]. A non-proprietary format for building decompositions, the IFC provides the most robust representation of building decompositions. Such data scheme will also need to include product libraries and national standard taxonomies. Classification schemes need to be overlaid on the building model to enable the rapid retrieval of this hybrid data [Gorlick and Froese 1999].

Industry wide metadata classification standard is key to ensuring users will accept and utilize the schema. Particularly when the schema may be different from that used by a persons' own firm. An example of such a classification scheme being developed in the United States is the OmniClass effort developed by the Construction Specification Institute for the United States [CSI 2007]. The standard reported in Brundsted et al. [2007] is one of several European standardization efforts that currently under way.

While classification schemes are needed, it is not clear how well formed these schemes must be before they provide an effective means to link document metadata to building models. The creation of links between taxonomic information allows building data to be automatically cross-classified between various outline views. In addition, these schemes provide multiple perspectives on the data they are meant to classify. In one scheme links are created between views of process, product, project, actors, resource, and systems [El-Diraby et al. 2005]. While it is not clear if a complete cross-referencing of taxonomies will be possible, such linking may reduce the effort required to fully apply all views of a data model.

One approach to cross link standards and taxonomies that are currently being developed in Europe is to create dictionaries that provide the semantic interpretation of building terms, components, systems, etc. [CWA 15142]. The integration of OmniClass and an international dictionary can serve as the basis to streamline the exchange of building information across international boundaries. In addition the creation of such a dictionary will allow different standards organizations to cross-walk their standards to allow translation between standards. A clear example of the need for such a dictionary exists between the IFC object attributes and property sets and the generic attribute sets in the MIMOSA standard.

Taxonomic links will breakdown over time as technology and industry structure change. While dictionary efforts attempt to keep such taxonomies current, another approach should instead be used to supplement formalized taxonomies. The method that is currently being used with the classification of amorphous data on the internet is called "folksonomy" [http://en.wikipedia.org/wiki/Folksonomy]. Through the vernacular naming of items, by anyone needing to reference the item, users of the information create taxonomy by their identification of keywords and designation of related information. Examples of folk-taxonomies include the unmediated discovery that "lift" and "elevator" are synonyms, differences in door and frame assemblies in various European countries, and information in photographs being applied to some other purpose than the main subject of the photo.

System constraints

There are several constraints to be considered in systems that implement COBIE with the goal of reducing the cost of existing submittal processing activities. The first constraint is that providing transparent business processes will be essential, both in the administrative and collaborative areas. One researcher has determined that establishing and enforcing the use of transparent procedures is the focal point of designing quality into the facility acquisition process [Burati et al. 1992].

In creating these systems, it is critical that the self-organizational behavior resulting from individual team members are reflected [Bertelsen 2004]. Bertelsen also notes that it is the management of information flows that will enable software to flexibly adapt to the complexity of construction projects and teams.

With regard to Building Information Models, servers form the basis of interactive information workspaces [Liston et al. 2000] that reduce the need for the production, collation, and reproduction. The model servers are able to answer what was done, by whom, and when. Reference documents such as design and shop drawing reviews will answer the why question. Erection and as-built information will answer the how question. One reason that construction management software tools are seen as a burden too many in the industry is that the activities required to collaboration and administrate are separate. If the collaborative effort needed to capture needed data were provided in such a way that it resulted in support for administrative purposes, such as contractor quality control, software for construction efforts would be vastly improved.

Bjork [2002] reports that the benefits of common file repositories represented 0.1% savings. These savings resulted from reduced meeting and travel time and reduction in copying charges. Transparency of communication and reliance on the repositories were increased to the point that team members were unwilling to return to paper-based methods. The author's experience with ProjNet^{sm} software demonstrates that users desire to have a single project repository that is directly linked to all documents across space and time. These repositories are, by default, located where people do their work. Software that implements COBIE must provide the capability to support the long term storage and management of enterprise documents.

As these document repositories become populated (into the terabytes) search becomes more critical. Project stakeholders must search dozens or hundreds of documents to find what they need. Some researchers have attempted to add database with product information however the lack of semantic consistency between design and construction views of project information [Shen et al. 2005] results in differences in data retrieved. Given that the definition of views required for ad-hoc data retrieval may not be able to be fully defined, the use of "folks taxonomies" must be incorporated into effective construction management software.

Team constraints

Construction contracting requires parties to judge decisions according to a cooperation or self-optimization scale [Bertelsen 2004]. The job of the project managers, particularly from the owners' point of view should be to provide the resources and motivation needed to encourage reliable and transparent cooperation.

A key question about resources needed is who should provide the collaborative platform for the team. Such a question is simple to answer, but difficult to implement (at least in the public sector). The organization with the greatest need for the information over the project life-cycle should provide the tools to capture, link, sort, and serve that data. While each stakeholder will have some proprietary portion a shared central trusted repository of record for critical facility model information (in whatever form that takes) is essential to initialize the data for local team servers.

3 COBIE Project Plan

The objective of COBIE is to identify the information that can be captured during the prior stages of facility acquisition in support facility O&M. Some of information need for O&M is created during the architectural programming phase. A good example of such information is the inventory of spaces and their functional requirements. During the design stage the performance requirements of materials, products, and equipment are specified. During construction the instantiation of these requirements results in installed, tested, and commissioned equipment.

Rather than attempt to capture all this information at one time, the approach of the COBIE project is to incrementally identify data exchange requirements that, over time, will build the entire COBIE specification. The selection of how to decompose the entire COBIE project into different components is simplified through the use of the *Information Delivery Manual* methodology, or IDM [Norwegian buildingSMART Project 2007]. IDM allows the creation of incremental, process-based data exchange standards that may be combined within COBIE and other exchange processes. IDM requires that individual business processes and their related information exchange requirements be evaluated and parsed for their exchange requirements. As noted in Section 0, a project with participation by SCIP, CSI, and NBIMS is expected to release a minimum set of these property set definitions. That project is currently under way, with initial results expected in FY08.

To complete COBIE there are several types of processes, occurring in different parts of the design that should be addressed. These include Architectural Programming, Design, Construction Quality Assurance, Supply Chain Management, and Asset Management. During each of these processes some of the information created is relevant to COBIE. These processes also allow the COBIE project to be incrementally created.

The initial COBIE effort focuses on the construction Quality Assurance process. This process captures information about the exact physical materials, products, and equipment that create the facility. Such information and related warranty and spare parts information are the most important sets of information to be captured by COBIE.

Information created during the Architectural Programming phase, which pertains to the functional definition of building spaces, can be used to initiate COBIE. This information is captured as part of the pilot COBIE specification. This specification relies on work currently being done by under the IAI Preliminary Design project and relies on the IFC2X3 Coordination View. Updated spatial project data maintained throughout design and construction make it possible to identify the as-designed location of products and equipment within the facility.

From the design phase COBIE should be able to access specific performance specifications of equipment to be installed by the construction contractor. These requirements, in specifications, codes, and standards, will be captured in future COBIE property sets. This work will rely on efforts currently under way by Specification Consultants in Independent Practice (SCIP), the Construction Specification Institute (CSI), and the International Code Council (ICC) through projects being accomplished as part of the National Building Information Modeling Standard (NBIMS). Along with this requirement data from the Design related to the functional use the material, products, and equipment and identification as fixed or moveable assets can be identified.

Additional property sets, to be defined during the course of the operational use of COBIE, will define full sets of performance metrics with all materials, products, and equipment to verify that the products submitted and selected meet performance requirements. This information, derived from electronic catalogues will streamline purchasing and supply chain management.

A summary of the current COBIE project plan is provided in Table 3-1. The final three portions of the COBIE plan represent an integration of COBIE data with information captured as part of future discussions and current NBIMS projects.

Table 3-1. COBIE development plan.

Status	Scope	Process Focus
Pilot	Replace paper submittals with electronic submittals. Document physical samples. Equipment serial numbers and location. Warranty and spare parts linked to equipment.	Supply Chain, Quality Assurance
Pilot	Extracting equipment location prior to construction. Verification of installed equipment during construction.	Architectural Programming, Quality Assurance
Pilot	Automated identification of fixed vs. movable asset inventories	Design, Asset Management
Pilot	Automated extraction of spatial/functional facility inventory.	Design, Asset Management
Future Property Set Definitions in Progress	Electronic performance specification and verification against submittal data.	Design, Quality Assurance
Future Coordination with Code Checking Project	Automated checking of submittal performance against relevant codes, standards, and specifications	Supply Chain, Quality Assurance
Future Property Set Definitions in Progress	Automated selection of materials, products, and equipment based on performance specifications	Supply Chain, Product Marketing

4 COBIE Analysis of Requirements

While the entire set of information needed to automated the handoff from construction to operations includes information from various stages of design and supply chain management, COBIE focuses on the exchange of information between construction and facility management. The links between the construction contractor's supply chain and the owner representative's quality assurance process are mapped in COBIE as the starting point for the creation of the COBIE standard. The planned additions to the COBIE standard over time are identified in the previous chapter.

To create standards that are part of the NBIMS, the IDM process [Norwegian buildingSMART Project 2007] is used. This chapter describes the use of the IDM and the resulting process models verified during meetings held in the spring of 2006 as part of the NBIMS effort. The focus of the IDM is a reference standard that maps the relevant IFC to the business processes needed. The reference standard would define new and utilize existing exchange requirements to construct the COBIE requirements. Because the focus of work documented in this report is the implementation of COBIE data exchange, this document does not extract new generic exchange requirements that can be reused in later IDM activities. The focus of this report is to document the implementation standard needed to begin using COBIE as soon as possible.

The IDM process defines three layers of information exchange specifications. The first layer is the definition of specific business processes that require the exchange of data within specific contexts. The second is the definition of general information exchange requirements that must take place at each step of the process. The third is the creation of the actual data format "functional parts" needed for technical information exchange among software vendors. Process maps and exchange requirements are described in this chapter.

The COBIE standard focuses on business processes that link together the contractor's supply chain management with the owner representative's quality assurance process. The steps in this process, and the final step

needed to transfer data to facility managers, operators, and maintainers are shown below:

1. identify submittal requirement
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.

Each COBIE process is described in the paragraphs that follow. Each section begins with an overview of the process and discussion of issues that are explicitly within or outside the scope of the COBIE specification. Following this information, activities comprising the process relevant to COBIE are described and documented in a business process diagram.

Several issues of a general nature apply to each of these processes as identified by attendees at the 29 March 2006 COBIE meeting in Washington, DC. These issues are:

Many of the information exchange processes require that information be initially provided in a “batch” mode that contains many individual records. As work continues on the project “packet” transitions also need to occur to either create new data against the “batch” set of information or to update the “batch” information provided.

Not all submittals are included in the COBIE project. For example physical samples will continue to need to be provided, as specified. COBIE will, however, capture data about physical submittals including photographs, test reports, etc...

Design-build contracting methods may not explicitly list submittals. As a result, owners need to be clear about the applicability of COBIE for design build requests for proposals. One reasonable approach discussed at the 29 March 2006 meeting was to require submittals that document product information on all materials, products, or equipment that confers a warranty to the owner.

Regarding the legal implication of electronic documents, it was felt that COBIE should use existing legal frameworks. Under the current approach related to the exchange of Computer Aided Drafting and Design (CADD) drawings, the paper copies "govern." Electronic CADD files are provided for information only. Given that the purpose of COBIE is to eliminate paper submissions, the implication of current legal frameworks is not clear, and for the time being, outside the scope of the COBIE project. The issue of requiring a single paper "copy of record" or fully eliminating all paper submittals will be left up to local legal findings and implementation specifications.

Identify submittal requirements

Overview

The first stage in the identification of submittal requirements during construction is the transfer, from the lead designer to the construction manager, the required list of items that must be submitted by the contractor. This information is called the submittal log. This log identifies each submittal and links the submittal to the specification section in which the requirement for the submittal is referenced. The purpose of the submittal is to provide the information necessary for the construction manager to validate that materials, products, equipment, and systems meet the minimum performance standards identified in the construction documents. The purpose of the submittal lot is to track the team's progress with regard to submitting, evaluating, and (if needed) approving submittals.

The steps needed to complete this process as relate to COBIE are provided below.

Issues within COBIE scope

The production of the construction contractor submittal register by the lead designer initiates the transmission of the register through COBIE. This production takes place within software systems used for the generation of construction specifications.

Issues outside COBIE scope

Although the COBIE project begins its definition of information exchange with the submittal log, the material, products, equipment, and systems identified in the log are not created at this stage. During previous phases of

design decisions are made as to the requirements for, placement of, and alternatives to materials, products, and equipment. The capture of these decisions, and resulting exchange of a robust set of data, is not considered in this project.

Unresolved scope issues

One way to facilitate the production of COBIE information exchange is to require the designer to provide a spatial layout for the building that lists each facility, floor, and room number. This information (created either during planning or design) forms the basis of assigning equipment and products to specific spaces. Given that the designer is the responsible party that creates this data, it makes sense that contractors not reproduce the information later in the COBIE business process.

Process description

Construction docs

The Identify Submittal Requirements process (Figure 4–1) begins, on design-bid-build contracts, with the completion of construction documents. At that stage the complete set of submittal requirements is known based on the construction documents.

The creation of a complete set of construction documents, during design-build contracts occurs at the end of the design-build contract. Depending on the specific type of design-build contract it should, however, be possible to pre-define data requirements for materials, products, and equipment that is expected to result in warrantable end-products.

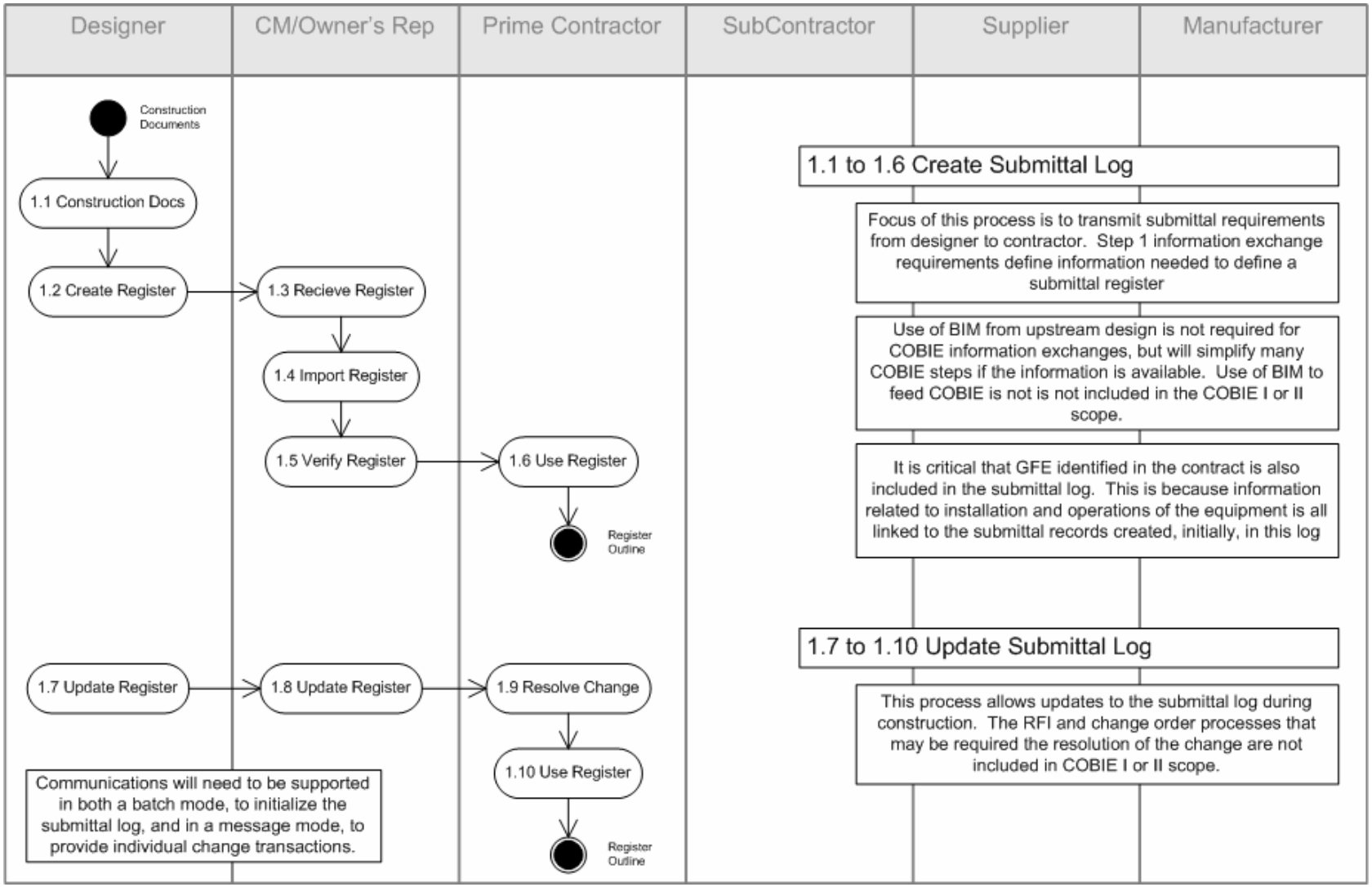


Figure 4–1. Identify Submittal Requirements process chart.

Create register

With the provision of the whole, or part of the construction documents, the actual outline of the submittals required can be automatically extracted from many specification writing software packages. Table 4-1 presents the optional and required information that should be provided with the submittal register. The first part, the optional data, allows the specification register item to reference an external set of reference submittals. The second set of data, the required data, identifies the minimum information needed to create the submittal register. The required data includes the information provided by the specification writing software, as described previously.

Table 4-1. Submittal register data requirements.

Name	Type	Reqd/Opt	Description
RegisterSourceUID	String	Opt.	Link to master set for reference set
RegisterSourceURL	String	Opt.	Link to specific reference
RegisterSourceTitle	String	Opt.	Text title of specific reference
RegisterRefMajorTitle	String	Reqd.	Enabling reference
RegisterRefMajorHead	String	Reqd.	Text of major heading
RegisterRefMinorHead	String	Reqd.	Text of minor heading
RegisterItemID	String	Reqd.	Project-specific ID
RegisterItemType	Reference	Reqd.	One of 11 types of submittals
RegisterItemReview	Reference	Reqd.	Owner approve/Contractor certify
RegisterItemTitle	String	Reqd.	Title of submittal
RegisterItemBy	Contact	Reqd.	Author's contact information
RegisterItemOn	Date	Reqd.	Date item created

While typical specifications based on design-bid-build specifications require submittals based on documents such as Unified Facilities Guide Specifications (UFGS), other types of codes and standards may also require submittals. The "RegisterRefMajorTitle" field allows the creator of the submittal register to identify the source of the submittal requirement. The "RegisterRefMajorHead" and "RegisterRefMinorHead" fields provide sufficient information to access the requirement within the referenced requirement document. For example, if the referenced document is the UFGS, RegisterRefMajorHead would equal the specification section and RegisterRefMinorHead would reference the section number of the section.

"RegisterItemID" provides a reference to a specific submittal that will be provided on the project. This internal reference also may be helpful when

linking submittals directly to building objects in a future Building Information Model. “RegisterItemType” identifies one of the 11 types of submittals previously referenced in this report. “RegisterItemReview” references who will be taking action on the submittal. Typically, the action will be “Owner Approval” or “Contractor Certified,” but other options may be possible in the future. Therefore, the selection is not hard-coded in the data exchange requirement. The “RegisterItemTitle” field provides a description of the time to be submitted.

The information exchange should include the contact information such as name, company, address, telephone, and email of the person who specified the requirement as well as the date one which the requirement was identified. In the case of a single export both of these values may be the same, i.e., the engineer or architect who pressed the button to get the export file. There may, however, be many different authors as these requirements are compiled by individual consultants and designers.

Optional items in Table 4-1 allow specific submittal to be linked to the source document. The “RegisterSourceUID” is a universal identifier provided by the source document publisher. This UID may provide a link back to the master list from which all submittals are created. The “RegisterSourceURL” provides a locator for the specific source document. The type of document and protocol will also be identified as part of this data field. The “RegisterSourceTitle” field provides the generic title for the type of reference that created the requirement. For example the “RegisterSourceTitle” would be set to “UFGS” for requirements identified as a result of Unified Facilities Guide Specifications.

Receive register

Once the register has been created, the designer submits the register to the construction manager or owner’s representative. This submittal should be supported in a ‘batch’ mode so that the entire set of submittals can be imported at one time.

Import submittal register

After receipt of the register the construction manager or owner’s representative will need to import the data into their submittal register software package. The purpose of this register is to serve as the log for all submit-

tals. The primary job of this log is to identify exceptions with regards to items not approved by the contractor's "required by" dates.

Verify register

Once the submittal register has been imported into the construction manager or owner's representative, submittal register software package will need to ensure that the information is correct as transmitted. Given the goal of eliminating paper transfer of submittal related information, the designer should be given view-only access to the construction manager or owner's representative submittal register software package to ensure that the information therein is correct. Future software systems used in construction management offices may allow designers providing CM, or related services, to accept the electronic submittal register.

Update register

Prior to the start of construction full 'batch' mode updates should be able to wipe and recreate the whole set of submittals for the project in question. Once the contractor adds data to an approved register, those records cannot be changed in a 'batch' mode of operation.

Changes to the submittal register based on a 'packet' level of exchange may be made, however, the process may require that an approval process for incoming 'deviations' be approved by the construction manager or owner's representative prior to the change being accepted.

Approvals of changes to the submittal register are explicitly outside the scope of COBIE since these changes could result, depending on the timing of the change, construction change orders.

Define submittal schedule

Overview

The process for defining the submittal schedule is shown in Figure 4–2. Once a project's submittal register has been accepted by the construction manager or owner's representative, the log is provided to the construction contractor to coordinate submittal requirements with their Critical Path Method (CPM) scheduling program. The contractor's analysis of their schedule results in the identification of submit-on, approve-by, and needed-on dates to be included in the submittal log.

With the exception of submittals provided during the mobilization phase of a standard design-bid-build project, construction submittals are not generally permitted until a submittal schedule has been approved.

Subprocesses within scope

The submittal log must be passed from the construction manager or owner's representative to the prime contractor and back. The exchange of information from the construction contractor and prime contractor data systems is part the scope of this business process.

Subprocesses out of scope

The direct linkage between construction schedule activities and submittal register entries is frequently discussed in terms of major "feature of work." For example, several submittals across different reference sections may need to be approved prior to starting a significant feature of work. Concrete mix design, placement plans, and rebar may all need to have submittals prior to the start of cast-in-place concrete construction. Coordinating submittals for various features of work that reflect a project's "work breakdown structure" are outside the scope of this information exchange.

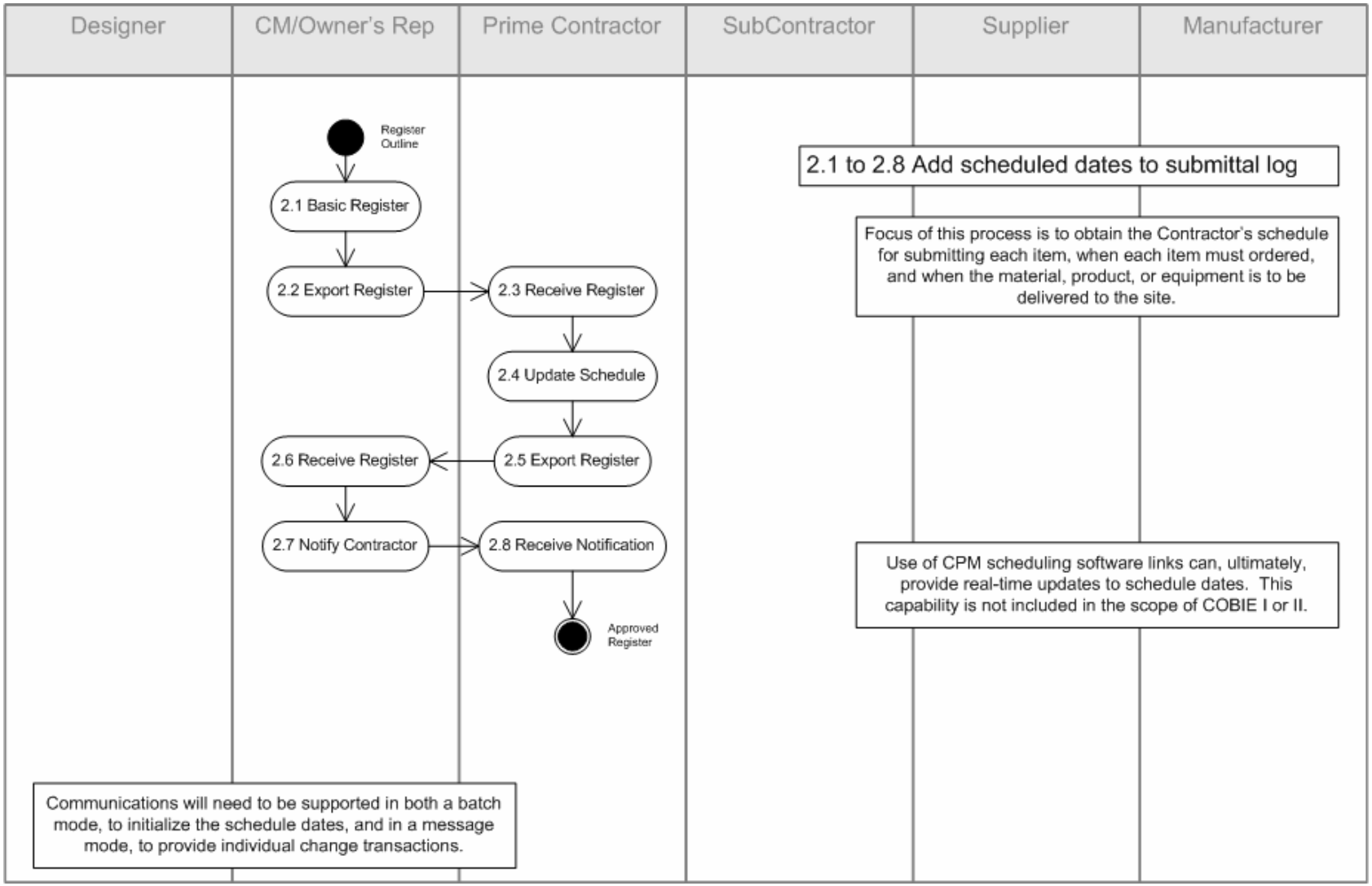


Figure 4–2. Define Submittal Schedule process chart.

Process description

Basic register

The process of defining the submittal schedule begins with an approved submittal register outline, provided by the previous process.

Export register

The construction manager or owner's representative exports a copy of the submittal register outline for transmission to the prime construction contractor in 'batch' mode. The format for this exchange is exactly that created under the previous process. In keeping with the need for a pragmatic "implementation" standard, the format for the register may be Excel, ifcXML, or other agreed-upon format.

Receive register

The prime construction contractor receives the register in the office appropriate to manage that project. Depending on the size of the contractor's office and/or project size the contractor may have dedicated project office engineering staff, a site manager, or have a shared purchasing department manage the submittal register. It is expected that the construction management software tools used by individual team members are able to accept the register file and process the information consistently.

Update register

Once this office receives the register and verifies that it contains the required information, then the appropriate prime contractor representatives can develop the plan for completing these submittal requirements. Subcontractors (some of whom may not be identified at the phase of the contract when the register and schedule are created) may also need to provide input to the submittal register. As a result, the prime contractor may also allow the data to be fed forward to authorized subcontractor personnel.

The data required to be provided by the prime contractor back to the construction manager or owner's representative is shown in Table 4-2. The first required register data "RegisterItemID" is a read-only field to the prime contractor and subcontractors. This ID is unique to the project submittal register (but the value may be repeated on other projects). The needed schedule dates for submission, approval, and delivery are provided

based on the CPM schedule activity. The final set of data is the contact information for the prime contractor or subcontractor who made the request and the date on which the request was made.

Table 4-2. Submittal Schedule data requirement.

Name	Type	Reqd/Opt	Description
RegisterItemID	String	ReadOnly	Project-specific ID
RegisterScheduleCPMTask	String	Reqd.	Construction schedule link
RegisterScheduleSubmitBy	Date	Reqd.	Planned date for item transmittal
RegisterScheduleApproveBy	Date	Reqd.	Needed date for item approval
RegisterScheduleDeliveryBy	Date	Reqd.	Needed date for on-site material
RegisterScheduledBy	Contact	Reqd.	Author's contact information
RegisterScheduledOn	Date	Reqd.	Date action taken

Export (updated) register

The contractor will compile its own information and, possibly, the information provided by its subcontractors, and submit it to the construction manager or owner's representative.

Receive (updated) register

The construction manager or owner's representative receives the batch file of the prime contractors submittal schedule and imports that information into the construction manager or owner's representative software tool.

Notify contractor

The construction manager or owner's representative evaluates the content of the prime contractor's updates and provides notification back to the contractor indicating the acknowledgement or non-concurrence with the submittal schedule as provided. Table 4-3 identifies the information exchange requirements to facilitate this discussion.

Table 4-3. Submittal Schedule Approval data requirement.

Name	Type	Reqd/Opt	Description
RegisterItemID	String	ReadOnly	Project-specific ID
RegisterStatusType	Reference	Reqd.	Contractor certified/Non-Concur
RegisterStatusBy	Contact	Reqd.	Author's contact information
RegisterStatusOn	Date	Reqd.	Date action taken
RegisterStatusNote	Memo	Opt./Reqd.	Required if "Non-Concur"

As with the previous information exchange the “RegisterItemID” is a project specific ID number that can track a submittal back to its original requirement. “RegisterStatusType” is the identification of the status of the approval of the register schedules at this ‘atomic’ level. Next, the contact information of the person completing the transaction and the date on which the status was evaluated is provided. If there is a “Non-Concur” status, then the construction manager or owner’s representative must provide the “RegisterStatusNote” data that explains the issue of concern to the construction manager.

If helpful, there may be another field added that is currently not shown in Table 4-3. The possible “RegisterStatusCode” may give a preset list of values for reasons for which submittals may be returned with a status of “Non-Concur.” One example may be cases where dates required provide insufficient time (under 5 or 10 business days) for approval. Intelligent agents reviewing the schedule could automatically deny such schedules and provide standard reason codes.

Receive notification

In this process the submittal register schedule entries are returned to the prime contractor who, in the case of a “contractor certified” status, proceeds to execute the project. In the case of a “non-Concur” status, the prime contractor will need to initiate an off-line (as far as COBIE is concerned) dialog regarding the issue, and resubmit a change that can be agreed upon by the construction manager or owner’s representative.

Update schedule (not pictured)

Not included in the diagram is the method for updating the schedule over time. There must be several business rules governing the updating of this information. First, once a submittal has been provided the data regarding planned dates may not be changed. Second, all changes to the dates must be approved by the construction manager or owner’s representative.

A standard expectation is that schedule dates should not change more than once per month and be synchronized with changes to the CPM schedule. While direct synchronization with the CPM schedule is not required, reports that compare data between the schedule and related CPM schedule tasks should provide “reasonable” results. For example, the expected material delivery date must be before the related CPM schedule

task can begin work. Submittal and approval activities must provide sufficient time prior to the delivery of equipment to allow review.

Transmit submittal

Overview

During this process the prime contractor's quality control representative or project manager receives information on each submittal required in the submittal log from the prime contractor's purchasing offices, subcontractors', suppliers, or manufacturer staff. This information is packaged by the prime contractor and provided to the construction manager or owner's representative for review.

Subprocesses within scope

The most basic type of process for the creation of a draft submittal by contracting stakeholders and then submitting that information to the construction manager or owner's representative is covered in the scope of this process

Subprocesses out of scope

The prime contractor is responsible to ensure that subcontractors receive information from suppliers and manufacturers in a timely fashion. The time-management business processes required are not included in this scope of work.

Process description

Evaluate requirement

As shown by process 3.1 (Figure 4–3), following the completion of the submittal schedule individual submittals are provided by the prime contractor or subcontractor. Information for the submittal is often provided directly by the supplier or manufacturer. The process of creating and transmitting a submittal begins with the prime contractor's evaluation the submittal requirement. Based on this evaluation, preparation of the submittal package may be completed by the prime or subcontractor. Following the evaluation the responsible party the submittal is assigned to the appropriate responsible party.

If COBIE is to support the processing of submittal information, then standard for the exchange of submittal data prior to the actual transmission of the submittal may be needed. The information required, to support this specific process, is information that allows submittals to be assigned to individual team members. There are two types of information needed for this assignment. The first is the identification of the individuals on the team.

Three tables (Table 4-4 – Table 4-6) are needed to capture individual team member information, as shown below. This information, while not part of a specific packet that transfers responsibility, is needed as part of any system implementing the COBIE standard. An independent, authoritative source for user information is needed, but providing such a source is outside the scope of COBIE.

Table 4-4. Person data requirement.

Name	Type	Reqd/Opt	Description
PersonID	String	ReadOnly	Person-specific ID
PersonAddressID	String	Reference	Reference to AddressItemID
PersonOrganizationID	String	Reference	Reference to OrganizationID
PersonFamilyName	String	Reqd.	
PersonGivenName	String	Reqd.	
PersonMiddleNames	String	Opt	
PersonPrefixTitles	String	Reqd.	
PersonSuffixTitles	String	Reqd.	
PersonTelephone	String	Reqd.	
PersonEmail	String	Reqd.	

Table 4-5. Organization data requirement.

Name	Type	Reqd/Opt	Description
OrganizationID	String	ReadOnly	Address-specific ID
OrganizationParentID	String	Reference	Reference to OrganizationID
OrganizationAddressID	String	Reference	Reference to AddressItemID
OrganizationName	String	Reqd.	
OrganizationNote	Memo	Opt.	

Table 4-6. User Address data requirement.

Name	Type	Reqd/Opt	Description
AddressID	String	ReadOnly	Address-specific ID
AddressLine1	String	Reqd./Opt.	Reqd. if PostalBox blank
AddressLine2	String	Opt.	
AddressPostalBox	String	Reqd./Opt.	Reqd. if AddressLine1 blank
AddressTown	String	Reqd.	City, or town
AddressRegionState	String	Reqd.	Region, e.g., U.S. state name
AddressPostalCode	String	Reqd.	In the US, zip code
AddressCountry	String	Reqd.	Standard country list included

Given that the team members can be identified and contacted, information provided in the previous tables, matching the team members to the specific submittal is the next set of data that must be captured. Table 4-7 identifies the data needed to express the assignment of individual team member with a specific submittal item.

Table 4-7. Submittal Assignment data requirement.

Name	Type	Reqd/Opt	Description
AssignID	String	ReadOnly	Assignment-specific ID
AssignItemID	String	Reference	Reference to RegisterItemID
AssignUserID	String	Reference	Reference to Person ID
AssignBy	Contact	Reqd.	Assigner's contact information
AssignOn	Date	Reqd.	Date assignment made

Implementations of the assignment function should allow those assigned to a specific document to directly provide the draft submittal documents. Only the prime contractor's designated staff has the ability to manage the entire submittal process or transmit the documents to the owner's representative or construction manager.

Receiving request for submittal

The person receiving the request for submittal may update that assignment by indicating their availability or applicability to completing the task (see Table 4-8). Implementation of the assignment must allow the user who is assigned to (1) reassign the item to another person at their office, (2) indicate that they are not the right person to complete the job, (3) indicate that they will be out of the office during the timeframe required, or (4) to say that they have completed the task. There may also be multiple people, even from different organizations, responsible to draft the submittal.

The separation of the task for the preparation of the submittal package from the actual submittal is needed so that those preparing the submittal can update the status of their own work without affecting the status of others or that of the underlying submittal.

Table 4-8. Submittal Assignment Status data requirement.

Name	Type	Reqd/Opt	Description
StatusID	String	ReadOnly	Assignment-status specific ID
StatusAssignID	String	Reference	Assignment-specific AssignID
StatusCode	Reference	Reqd.	Current status of the assignment
StatusNotation	Memo	Opt.	Additional status information
StatusBy	Contact	Reqd.	Assignee's contact information
StatusOn	Date	Reqd.	Date action taken

Processing request for submittal

Once the correct team member has been assigned and is preparing the draft submittal, the submittal is prepared by gathering the required information and submitting that information to the prime contractor. The specific format for the data to be gathered will begin at a minimum level of Portable Document Format (PDF) files. As required, individual submittal may have additional requirements for information transfer. The specific requirements are not described in this section.

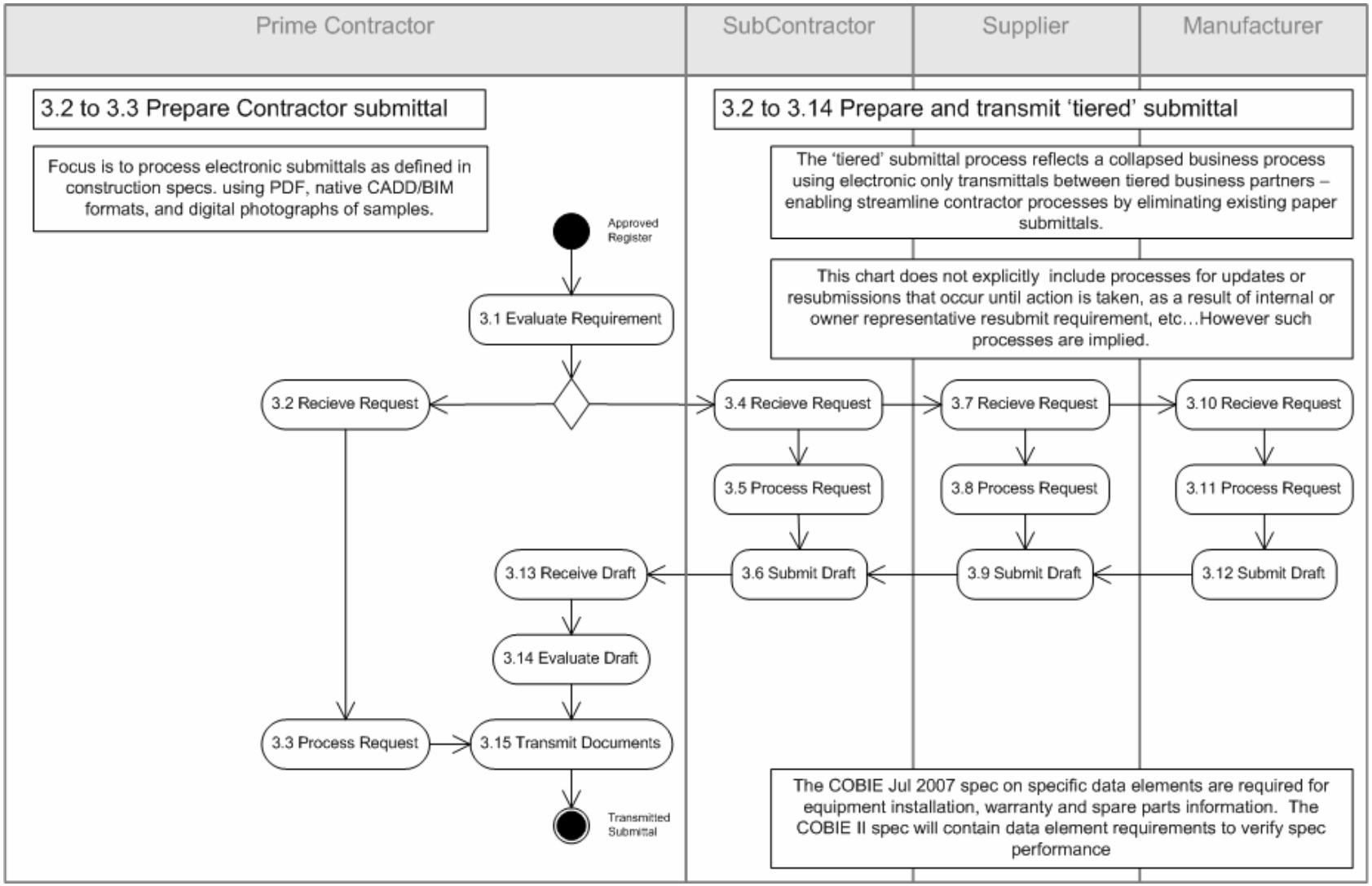


Figure 4–3. Transmit Submittal process chart.

Receive draft

Once the submittal has been processed by the assigned users, and transmitted, as a draft submittal to the prime contractor, the status of the assignment should be changed to indicate that the submittal is waiting review by the prime contractor prior to being transmitted to the owner's representative or construction manager. Data required to represent this transactional information was noted in a previous table.

While tracking information on the source of submittal data will be of interest to the prime contractor, such information should not be part of the transmittal since the transmittal is required to occur as part of the formal contractor quality control process.

Evaluate draft

The prime contractor will review the draft submittal package and may require that the package be revised. If this is the case a new assignment can be created that documents the updated requirement. Data required to capture this reassignment has already been defined.

Transmit documents

When the prime contractor has either completed their own submittal or reviewed the draft submittal package provided by their subcontractors, suppliers, and or manufacturers, then they are prepared to transmit the package of documents to the owner's representative or construction manager.

The tool used by the owner's representative or construction manager to capture the submittal data must capture source of each file sent, and additionally required data, along with the related submittal.

Table 4-9. Transmittal data requirement.

Name	Type	Reqd/Opt	Description
TransmittalID	String	ReadOnly	Transmittal-specific ID
TransmittalItemID	String	Reference	Reference to RegisterItemID
TransmittalPersonID	String	Reference	Reference to PersonID
TransmittalRevisionID	String	Reference	Reference to Transmittal ID
TransmittalRevisionNo	String	Required	Order of Revision submitted
TransmittalOrderID	Integer	Required	Order of Items submitted
TransmittalPrettyName	String	Reqd.	File Name of the File Sent
TransmittalFileName	String	Private	Local File name
TransmittalOn	Date	Reqd.	

Resubmit documents (not pictured)

Since items within a given transmittal may need to be revised and resubmitted, the previous table provides the required data fields to keep track of versioning of submittal documents.

Approve submittal

Overview

The process for owner's action on a submittal depends on the type of submittal being provided Figure 4–4). There are three types of initial submittals that will be considered in this process. The first type of submittal describes project specific engineered components. These submittals require the provision of shop drawings, fabrication drawings, erection instructions, and as-installed documentation. Items such as these are required to be approved by the A/E firm.

The second type of initial submittal in this process is those materials, products, and equipment that can be fully described by manufacturer provided data such as "cut-sheets." Information for these submittals will be provided in a file-based format that contains the appropriate manufacturer's instructions. In addition to the electronic equivalent the currently processed paper submissions; attributes will also be defined for each type of item. Attribute sets will be comprised of several parts. The first type of attributes defines the source of the document such as owner and date submitted. The second type of attribute describes the performance characteristics of the item submitted.

The third type of submittal is requires submission of physical samples or product data. Materials that require color selection are a good example of this type of submittal.

Subprocesses within scope

In general, COBIE1 will include "source" attributes and "characteristics" metadata associated product-independent attributes such as warranty requirement, spare parts suppliers, etc. COBIE2 will include the minimum set of product-specific characteristics needed to ensure compliance with specifications, codes, and standards.

Subprocesses out of scope

Attribute data for physical samples will be considered out of scope however the cut-sheet information associated with the physical samples is within scope.

Process description

Receive submittal

When the owner's representative or construction manager receives the submittal the submittal register date fields documenting the 'actual' dates corresponding to the planned transmittal date must be updated.

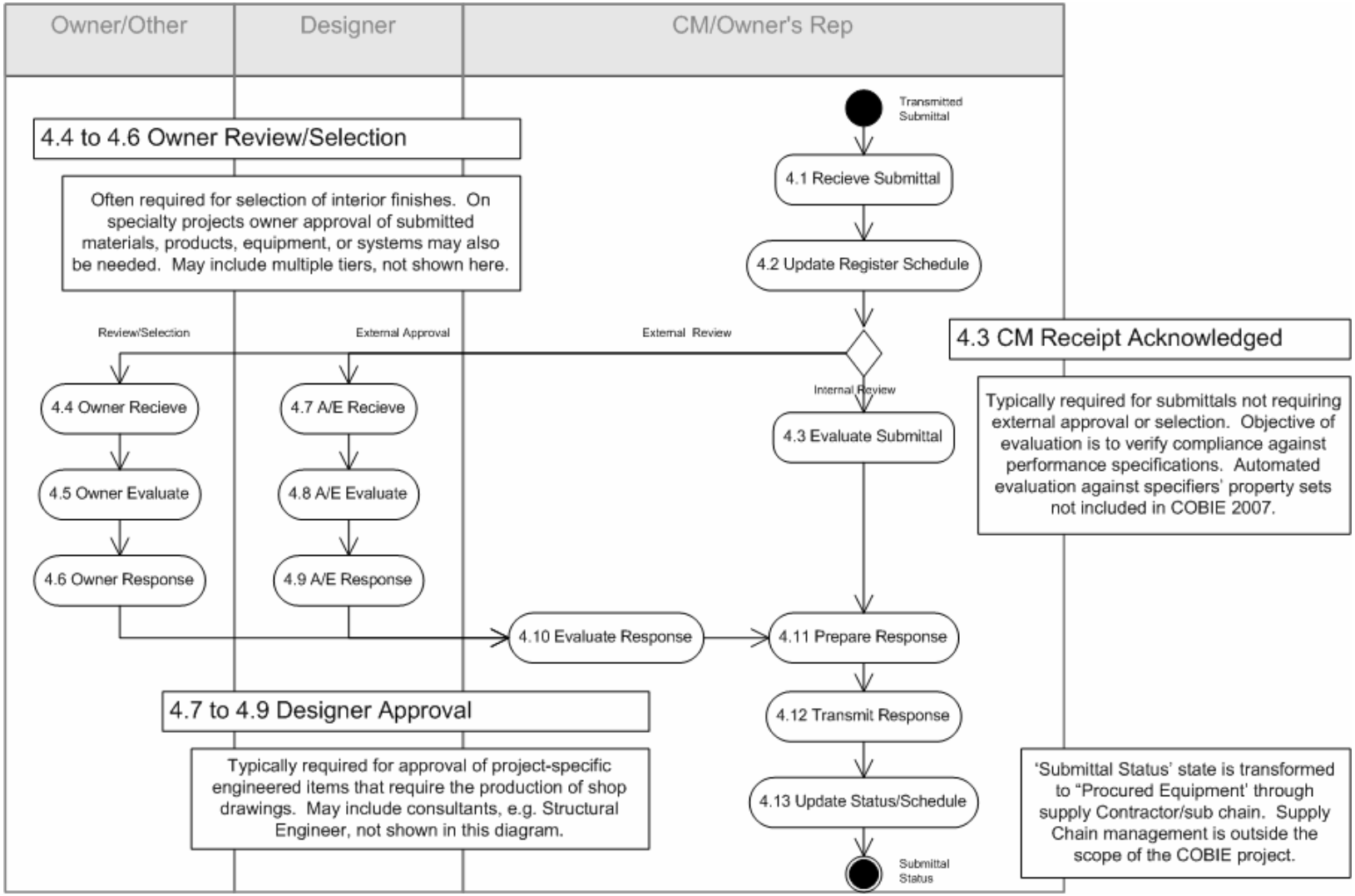


Figure 4–4. Approve Submittal process chart.

Table 4-10. Submittal Receipt data requirement.

Name	Type	Reqd/Opt	Description
RegisterItemID	String	ReadOnly	Project-specific ID
RegisterSubmitPersonID	Reference	ReadOnly	Reference to PersonID
RegisterSubmitOn	Date	Reqd.	Date submitted
RegisterSubmitIsCertified	Boolean	Reqd.	Ctr. Certified to meet rqmt.
RegisterSubmitIsDeviation	Boolean	Reqd.	Contains deviation
RegisterSubmitNote	Memo	Opt.	Required if deviation

Assign submittal evaluation

Once the submittal has been received, the owner's representative or construction manager determines, from the original submittal register, who is to evaluate the submittal. A submittal assignment is made using the data requirements identified in the previous section.

Evaluate submittal

The action code provided on submittals evaluated by owner/other and/or designers are noted on the submittal evaluation assignment. Since there may be multiple evaluations of a given submittal, the owner's representative or construction manager will need to separate the recommendation made by external reviewers from that provided back to the prime contractor.

One issue to keep in mind during this process is that when the entire submittal is approved, all the transmitted files are also approved. It may, however, be possible to have a submittal that requires multiple files, some of which are approved and some of which are not approved. In this case, the requirement to resubmit specific files, and not the entire package, needs to be modeled. The data requirement for capturing the submittal evaluation status is shown in Table 4-11.

Table 4-11. Submittal Action data requirement.

Name	Type	Reqd/Opt	Description
RegisterItemID	String	ReadOnly	Project-specific ID
RegisterActionTransmittalID	Reference	ReadOnly	Reference TransmittalID
RegisterActionPersonID	Reference	ReadOnly	Reference to PersonID
RegisterActionOn	Date	Reqd.	Date submitted
RegisterActionType	Referece	Reqd.	List of available actions
RegisterActionIsDeviation	Boolean	Reqd.	Contains deviation
RegisterActionNote	Memo	Opt.	Required if deviation

Direct action on a given submittal should triggers the designated stats on the latest version of all associated documents. Similar action on the latest version all associated documents may provide the owner's representative or construction manager with the option of approving the entire submittal. Resolving the status on all documents, however, does not automatically impart the same status to the over-arching submittal since there may be documents yet to be transmitted.

Evaluate transmittal

Evaluation of each transmittal may be made individually. Once each individual transmittal has been reviewed, then the overall submittal may have action taken on it. The list of possible actions allowed is contingent on the type of the overall submittal. The data fields needed to track actions on individual submittals are shown in Table 4-12.

Table 4-12. Transmittal Action data requirement.

Name	Type	Reqd/Opt	Description
TransmittalActionID	String	ReadOnly	Action-specific ID
TransmittalActionRegisterID	Reference	ReadOnly	Ref. to Register Item ID
TransmittalActionTransmittalID	Reference	ReadOnly	Ref. to Transmittal Item ID
TransmittalActionPersonID	Reference	ReadOnly	Ref. to Person ID
TransmittalActionType	Reference	Reqd.	List of possible actions.
TransmittalActionReqResubmit	Boolean	Reqd.	Resubmission required
TransmittalActionIsDeviation	Boolean	Reqd.	Action contains deviation
TransmittalActionOn	Date	Reqd.	Date of action
TransmittalActionNote	Memo	Opt/Reqd.	Required if deviation

Once all transmittals have been reviewed, and appropriate action taken, then action may be taken on the overall submittal. Any action other than "receipt acknowledge," "approved," or "approved w/deviation" on all

transmittals would disable the options to approve the entire submittal. Having all positive transmittal actions, however, does not ensure that all transmittals have been made against the submittal requirement. Therefore automated approval of submittals should not be allowed based on the status of individual transmittals. The data required to represent the submittal approval is shown in Table 4-13.

Table 4-13. Register Action data requirement.

Name	Type	Reqd/Opt	Description
RegisterActionID	String	ReadOnly	Action-specific ID
RegisterActionRegisterID	Reference	ReadOnly	Ref. to Register Item ID
RegisterActionPersonID	Reference	ReadOnly	Ref. to Person ID
RegisterActionType	Reference	Reqd.	List of possible actions.
RegisterActionReqResubmit	Boolean	Reqd.	Resubmission required
RegisterActionIsDeviation	Boolean	Reqd.	Action contains deviation
RegisterActionOn	Date	Reqd.	Date of action
RegisterActionNote	Memo	Opt/Reqd.	Required if deviation

There are times when the submittal can be reviewed and action taken as a whole. In this case the action taken on the submittal should be assigned to each of the individual transmittals. Implementations of this condition would simply the submittal that has a single transmittal (which would often be the case). In this situation, the “approved” event on the submittal form would, for example, trigger the approval of the individual submittals

Install equipment

Overview

During the Install Equipment process, information related to each piece of material, equipment, and product are provided by the manufacturer to the subcontractor or contractor (Figure 4–5). This information includes the as-installed model number, specific serial number, and name plate data. In addition, the location where each individual item is installed will be known by the contractor or subcontractor. Finally, there may need to be a certification that the material, product, or equipment is installed in accordance with the manufacturer’s instructions.

Subprocesses within scope

Capturing equipment installation information during construction eliminates the need to perform surveys to baseline facility information models at the conclusion of a project. Adding these requirements during renovations and maintenance activities allows building models to be aggregated during operational activities.

Subprocesses out of scope

Support for the contractor's supply change is outside the scope of this process. The internal procurement systems used by contractors, subcontractors, suppliers, and manufacturers are beyond the scope of COBIE.

Eventually the information to be provided by manufacturers should be required to be provided on RFID tags. Data on these tags would provide electronic nameplate data. Scanning the RFID tag would allow the automated capture by the site superintendent with minimal interruption by the installer.

Equipment installation data requirement

Extract nameplate data

Ultimately the specific attributes, or metadata, for each material, product, equipment, or system component installed in the facility should have its associated data set provided directly by the manufacturer with the electronic invoice. Unfortunately the only current reliable method to gather such information today is manual survey. In COBIE the minimum level of information about each piece of equipment will be provided based on a combination of a general header data set, plus specific data sets for product-dependant attributes. Table 4-14 provides the header data set to be collected for all building components that confer a warranty to the owner.

Table 4-14. Generic Installed Component data requirement.

Name	Type	Reqd/Opt	Description
InstalledItemID	String	ReadOnly	Equipment-specific ID
InstalledItemRegisterD	Reference	ReadOnly	Ref. to Register Item ID
InstalledItemTransmittalID	Reference	Opt.	Ref. to Transmittal Item ID
InstalledItemModelNo	String	Opt.	
InstalledItemSerialNo	String	Opt.	

Information from the prime contractor or subcontractors, suppliers, and manufacturers may, eventually be added to this standard component set. Such information based on, for example, barcode (or preferably RFID) tag information might include the manufacturing date, plant and run number, shipping information, sensor information (such as if the unit was dropped), location and condition of equipment during intermediate storage locations. Such information vital to manufacturers for the tracking of issues related to warranty defects and recalls, is currently not provided by manufacturers and, therefore, is not described in this COBIE specification.

Space model information

In the existing OMSI specification data related to the location of installed equipment and product placement is required to be provided based on post-hoc site survey. In the COBIE specification this information is required to be completed as each material, equipment, product, or system is installed.

Equipment data installation in OMSI requires that the room number be linked to the specific serial number of the equipment that is installed in the room. In order to create the linkage between the physical building spaces (inside and outside the facility) and the installed equipment, spatially-related data about the building configuration should be initially provided. Such information ultimately may be provided by the designer during the preliminary design stage, but in the early phases of COBIE implementation, that information will have to be provided by the prime contractor. The data tables required to link together the installed equipment back to the original submittal are shown below.

Building data requirement should include geospatial reference to ensure that information provided by COBIE can be tracked against external data sources. The specific format for the location will be determined by the user group.

Table 4-15. Facility Horizontal data requirement.

Name	Type	Reqd/Opt	Description
FacilityID	String	ReadOnly	Building/Facility specific ID
FacilityLocation	Complex	Opt.	Format to be determined
FacilityName	String	Required	Name of the facility

Table 4-15 identifies the facility and provided the information needed the horizontal placement of the facility with geographic space. Table 4-16 identifies the "stories" associated with the vertical placement of spaces within the facility. As with the "FacilityLocation" information, the "VerticalLevelLocation" format is yet to be determined.

Table 4-16. Facility Vertical data requirement.

Name	Type	Reqd/Opt	Description
VerticalLevelID	String	ReadOnly	Storey specific ID
VerticalLevelFacilityID	Reference	ReadOnly	Building/Facility specific ID
VerticalLevelLocation	Complex	Opt.	Format to be determined
VerticalLevelName	String	Required	Name of the story or level
VerticalLevelHeight	Number	Opt.	Distance "slab to slab"

Once the vertical levels with the building have been identified, then the spaces that comprise these levels may be identified. The attributes identified in Table 4-17 are extracted from existing OMSI specifications for space definitions. Information needed to summarize the functional capabilities of the facility are also noted in the table, these include "SpaceFunctionID," "SpaceUsableArea," and "SpaceUsableHeight."

Table 4-17. Space Data requirement.

Name	Type	Reqd/Opt	Description
SpaceID	String	ReadOnly	Space specific ID
SpaceLevelID	Reference	ReadOnly	Building/Facility specific ID
SpaceFacilityID	Reference	ReadOnly	Story specific ID
SpaceLocation	Complex	Opt.	Format to be determined
SpaceNo	String	Opt./Reqd.	Reqd. if a building
SpaceName	String	Required	Name of the space
SpaceUsableArea	Number	Opt.	Usable floor area
SpaceUsableHeight	Number	Opt.	Distance "floor to ceiling"

Note that the definitions of "SpaceFunctionID," "SpaceUsableArea," and "SpaceUsableHeight" should be evaluated based on the capability of existing software systems, such as BIM-based CADD, and requirements from real estate and asset management standards.

In COBIE the specific positioning of the facilities, vertical levels, and spaces need not be included in the model. Specific owners who have pre-

defined formats may, however, add this additional requirement to their implementation of COBIE.

Installed equipment location

Given a definition for spaces within the possible multiple facilities and vertical levels in a given project, it is possible to inventory the installed equipment within each space. The exact location of individual items with a space is not explicitly required in COBIE. Table 4-18 provides the required data.

Table 4-18. Installed Equipment data requirement.

Name	Type	Reqd/Opt	Description
InstalledItemID	Reference	ReadOnly	Reference to Item ID
InstalledItemSpaceID	Reference	ReadOnly	Reference to Space ID
InstalledItemPersonID	Reference	ReadOnly	Reference to Person ID
InstalledItemOn	Date	Reqd.	Date item was installed
InstalledItemPhoto	Blob	Reqd.	Photos of installed item
InstalledItemDeviation	Boolean	Reqd.	Is installed w/deviation?
InstalledItemNeedCert.	Boolean	Reqd.	Is external certification needed
InstalledItemNote	Memo	Opt/Reqd.	Required if deviation

Note that the required data requires that digital photos of each equipment installation be taken and notations of deviations from manufacturer's installation instructions be identified. It may be possible to remove the "InstalledItemNeedCert" item from this table if the data is provided elsewhere. One appropriate location for this information is to identify this requirement in the initial submittal register.

As-built space descriptions

In addition to the equipment inventory required for COBIE, product descriptions of each of the spaces also include a variety of additional information in the current OMSI specification. The objective of the OMSI information is to provide an asset inventory, therefore the COBIE specifications will conform to that asset management requirement.

Specific as-built descriptions are required in OMSI for the products in the list below (see Table 4-19). These items, or additional items, may be included in an implementation of the COBIE specification through the "SpaceComponentType" data field:

- Ceilings
- Doors
- Floor
- Lighting
- Plumbing
- Valves
- Windows.

Two OMSI data files associated with electrical fixtures are not included in the as-built space data requirement. This data "Lighting Fixture Lamp Count" and "Watts per Lamp" are not included because this information should have already been identified by the referenced submittal.

Table 4-19. As-Built Space data requirement.

Name	Type	Reqd/Opt	Description
SpaceID	Reference	ReadOnly	Reference to Space ID
SpaceItemTypeID	Reference	ReadOnly	Reference to Type ID
SpaceItemRegiserID	Reference	ReadOnly	Reference to Submittal ID
SpaceItemCount	Number	Reqd.	Number of components
SpaceItemColor	String	Opt.	Color of component
SpaceItemDirection	String	Opt.	Direction of action (e.g., door)
SpaceItemSystem	String	Opt.	Name of component's system
SpaceItemTagNo	String	Opt.	
SpaceItemPosition	String	Opt.	
SpaceItemNote	Memo	Opt.	

Future COBIE specifications should more explicitly require the exchange of a building information model, rather than simply an asset inventory. Such requirements will, most likely, not be placed on construction contractors, however, since the information should already exist in "schematic" and "construction document" phases of design.

Installation certification

Certification of some types of equipment is needed to ensure that warranties can be enforced. Equipment of this type must have a certification that the equipment or product was installed according to manufacturer's instructions. The specific requirement for installation certificates should have been identified in the submittal register. If this is the case, then the transmittal documents provided with the submittal will meet this requirement.

Other than the certification submittal associated with a given requirement, COBIE will not address the specifics of the certification. For example, if a certification provided for a single installation of a single piece of equipment the current representation may be adequate. If, however, a certification is needed for multiple equipment installations, it is not clear that the specific requirement for individual or multiple certifications can be adequately addressed with COBIE, at this time.

Submit test results

In this information exchange, test results are provided from the testing organization, whoever may be performing the test, in a "document" format and provided, as identified in the submittal register as individual submittals (Table 4-20). To represent situations where test results apply to multiple submittals, for example HVAC equipment. The test submittal must also be linked into the specific equipment covered by the test.

Table 4-20. Test Results data requirement.

Name	Type	Reqd/Opt	Description
TestID	String	ReadOnly	Unique test ID
TestRegisterReportID	Reference	ReadOnly	Reference to test report ID
TestRegisterItemID	Reference	ReadOnly	Reference to subject of test ID
TestItemNote	Memo	Opt.	Addl note if needed

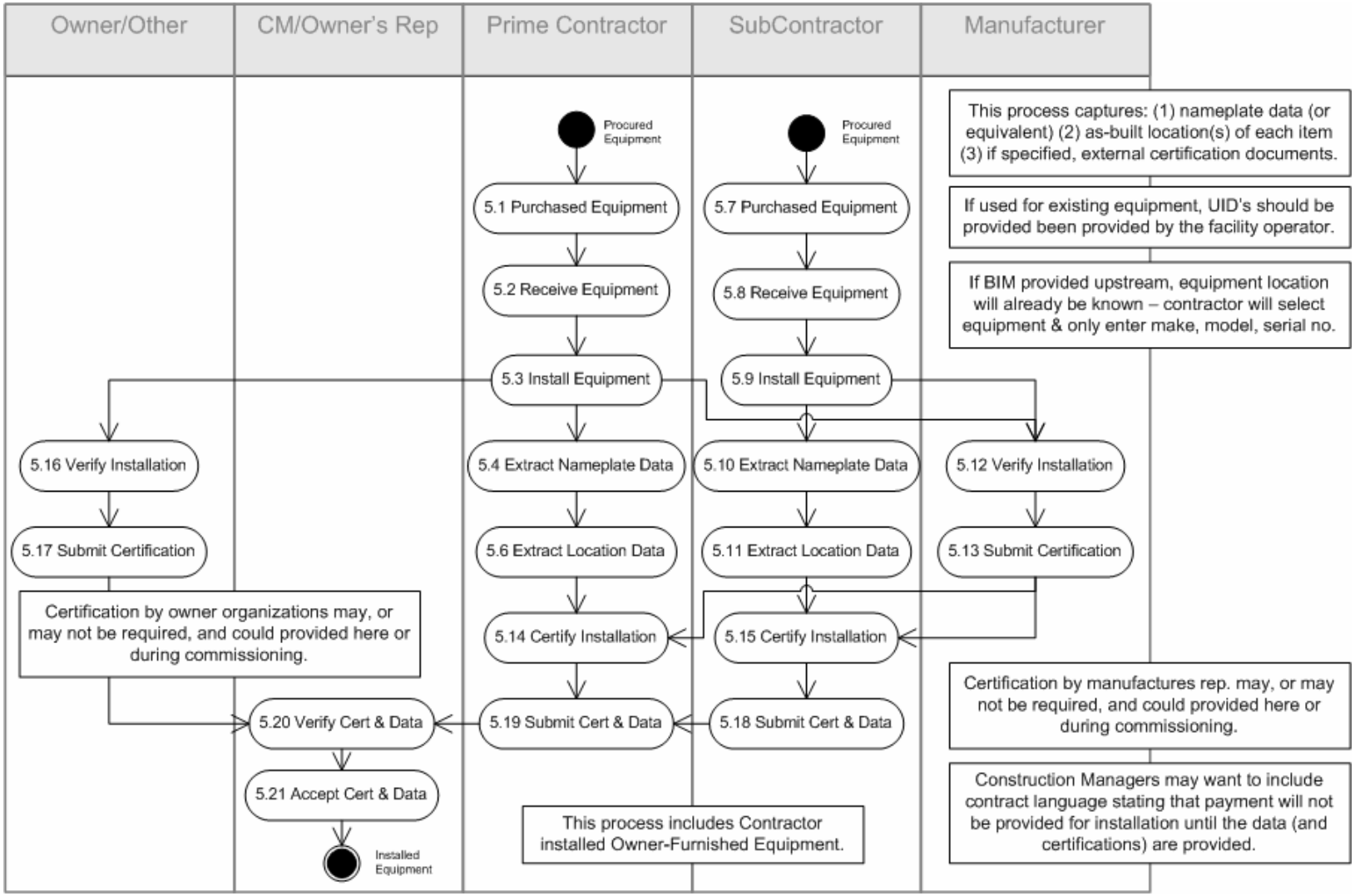


Figure 4–5. Install Equipment process chart.

Commission equipment/systems

Overview

Following the installation of building components and their respective systems the commissioning process ensures that the components and systems are functioning in accordance with their overall performance requirements as defined in the contract, code, or standard (Figure 4–6). Three types of information are generated as a result of the commissioning activity: (1) test results, (2) preventative maintenance instructions, and (3) operational instructions. The capture of each of these types of data may be accomplished through COBIE.

The format for preventative maintenance schedules and operational instructions from the OMSI standard were documented in an ArchiBusFM review of OMSI. Review of this business process will determine if the schedule and instructions information should be provided in consolidated PDF format or in computable format as part of COBIE1 or COBIE2.

Subprocesses within scope

To be determined.

Subprocesses out-of-scope

To be determined.

Commissioning data exchange requirements

Submit operations and maintenance manuals

For the most part COBIE considers O&M manuals electronic equivalents of current document formats. As such, these submittals are currently called out in the register and provided as individual transmittal documents per those requirements. There are, however, two types of information that are currently required by the OMSI specification that may be captured using the COBIE specification. These requirements are preventative maintenance instructions and minimum equipment training requirements.

Table 4-21. Maintenance Schedule data requirement.

Name	Type	Reqd/Opt	Description
PMScheduleID	String	ReadOnly	Unique schedule ID
PMScheduleRegisterItemID	Reference	ReadOnly	Reference to subject of test ID
PMScheduleNote	Memo	Opt.	Addl note if needed

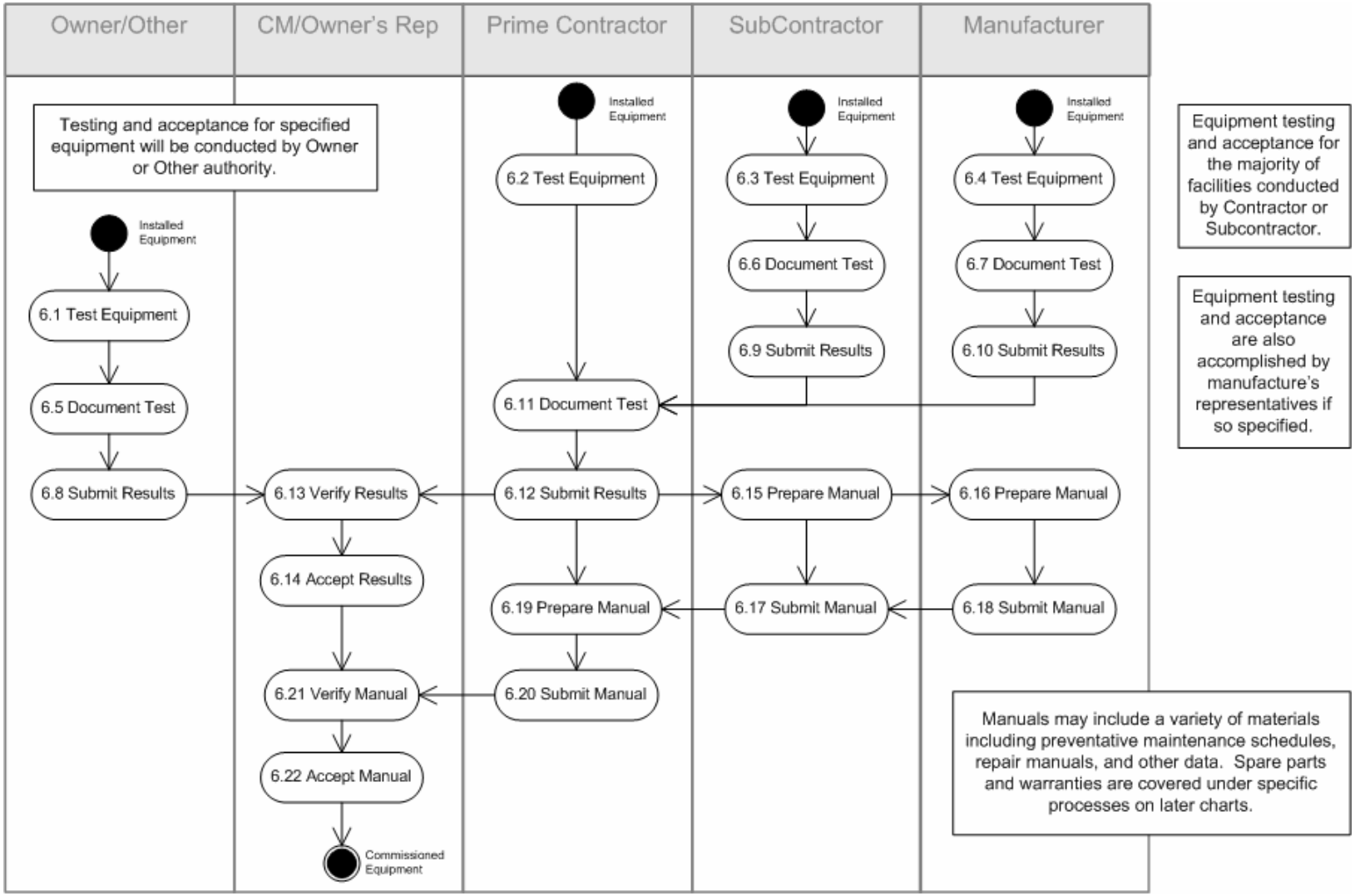


Figure 4–6. Commission Equipment process chart.

For a given PM schedule there will be specific items that must be completed to accomplish the work. While references to manufacturer web sites might be appropriate, it is unlikely that owners will be able to control the specific content of manufacturers' sites in the future. As a resulted, copies of externally referenced materials identified in a checklist item should be included as separate uploaded files with that item. The set of data needed to represent the schedule are shown in Table 4-22.

Table 4-22. Maintenance Schedule Item data requirement.

Name	Type	Reqd/Opt	Description
ScheduleItemID	String	ReadOnly	Unique test ID
ScheduleID	Reference	ReadOnly	Reference to schedule ID
ScheduleItemOrder	Number	Reqd.	Reference to subject of test ID
ScheduleItemNumber	String	Opt.	Text to organize display/print
ScheduleItemDescription	Memo	Opt.	Addl. note if needed
ScheduleItemReference	Blob	Opt.	Addl. Material if needed

OMSI specification also requires that the training courses required prior to operation or maintenance of the equipment be identified for the facility manager. In the OMSI specification, both system- and equipment-level training are identified. Without a definition of equipment systems, the link between training requirements and equipment systems cannot be defined. As a result, training data requirements begin with the definition of building systems for which training is required. Note that the description of testing reports and certifications may also require the definition of facility systems as well.

Table 4-23. System Definition data requirement.

Name	Type	Reqd/Opt	Description
SystemID	String	ReadOnly	Unique test ID
ScheduleItemDescription	Memo	Opt.	Addl. note if needed
ScheduleItemReference	Blob	Opt.	Addl. Material if needed

Table 4-24. System Component data requirement.

Name	Type	Reqd/Opt	Description
ComponentRegisterItemID	Reference	ReadOnly	Reference to subject of test ID
ComponentSystemID	String	ReadOnly	Unique test ID
ComponentItemOrder	Number	Reqd.	Reference to subject of test ID
ComponentItemDescription	Memo	Opt.	Addl. note if needed

Now that the systems upon which training are required have been defined, the following training programs and individual training steps can be identified. Note that an additional set of data is required. That set of data links the training program to the relevant system or the equipment needed. Given that a single training program may be required to service multiple equipment this data requires the definition of a many-to-many relationship.

Table 4-25. Equipment/System Training Program data requirement.

Name	Type	Reqd/Opt	Description
ProgramID	String	ReadOnly	Unique training ID
ProgramNumber	String	Opt.	Text to organize display/print
ProgramDescription	Memo	Opt.	Addl. note if needed
ProgramReference	Blob	Opt.	Addl. Material if needed

Table 4-26. Equipment/System Training Item data requirement.

Name	Type	Reqd/Opt	Description
TrainingID	String	ReadOnly	Unique training ID
TrainingRegisterItemID	Reference	ReadOnly	Reference to register ID
TrainingItemOrder	Numbet	Reqd.	Reference to subject of test ID
TrainingItemNumber	String	Opt.	Text to organize display/print
TrainingItemDescription	Memo	Opt.	Addl. note if needed
TrainingItemReference	Blob	Opt.	Addl. Material if needed

Provide warranty

Overview

Capture of warranty information is one of the first major requirements for the COBIE project (Figure 4–7). There are three types of information that need to be captured with regards to warranty. The first of these three types of information is to what the warranty applies. The second are the terms of the warranty and certificate. The third is information identifying the guarantor of the warranty.

Subprocesses within scope

Generic metadata defining the duration and scope of the warranties are included in the COBIE initial specification. This metadata also include the contact information for the warrantor and specifically link the warranty

metadata to the precise materials, products, and equipment to which the warranty applies.

Subprocesses out-of-scope

To be determined

Warranty exchange requirements

Terms and certificate

The "WarrantyCertificate" is a PDF facsimile of the signed warranty certificate provided by the manufacturer. Data related to the "WarrantyStartOn" and "WarrantyEndOn" dates must also be provided with the "WarrantyID" record (see Table 4-27). COBIE is not prescriptive of the definitions or implication of the dates of the warranty based on installation or occupancy. Such information should, however, be clarified since manufacturers' warranties typically begin on the date of installation.

Table 4-27. Warranty Terms and Certificate data requirement.

Name	Type	Reqd/Opt	Description
WarrantyID	String	ReadOnly	Unique warranty ID
WarrantyStartOn	Date	Reqd.	Start date of warranty
WarrantyEndOn	Date	Reqd.	End date of warranty
WarrantyCertificate	Blob	Reqd.	Copy of certificate

Applicability

Identification of the equipment covered by the warranty is provided through a linking table that identifies the warranty and each individual piece of equipment to which the warranty applies (Table 4-28). Typically warranties will be assigned against the general submittal item. In COBIE a separate submittal will be required to model situations where different equipment of the same type applies to different warranties. Table 4-28 shows the linking between the warranty item and the warranty.

Table 4-28. Warranty Applicability data requirement.

Name	Type	Reqd/Opt	Description
ApplicabilityWarrantyID	Reference	ReadOnly	Reference to warranty ID
ApplicabilityRegisterItemID	Reference	ReadOnly	Reference to subject of test ID

Guarantor

Designation of the Guarantor is simply the linking between the specific warranty and the responsible organization (Table 4-29).

Table 4-29. Warranty Guarantor data requirement.

Name	Type	Reqd/Opt	Description
GuarantorWarrantyID	Reference	ReadOnly	Reference to warranty ID
GuarantorOfficeID	Reference	ReadOnly	Reference to office ID

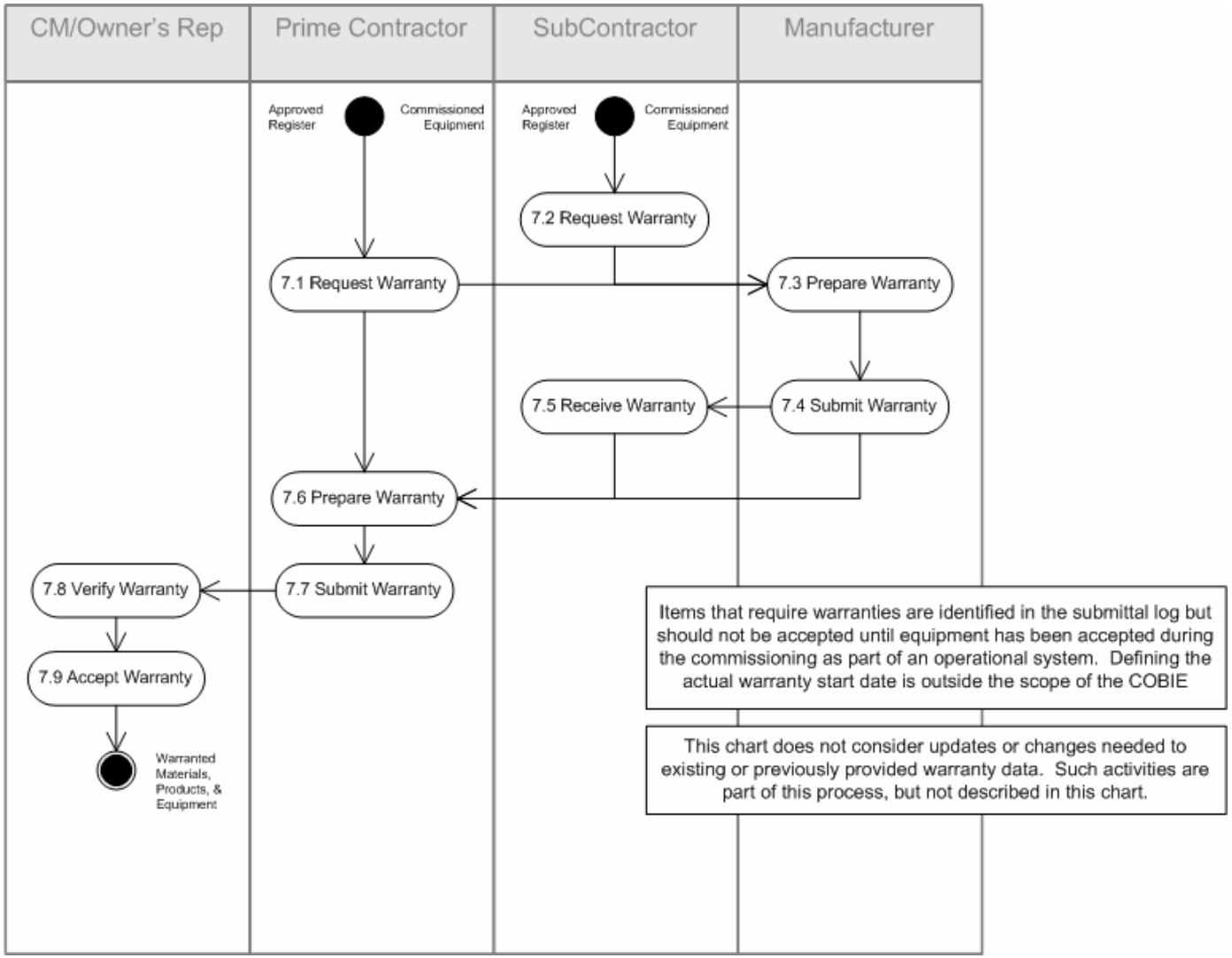


Figure 4–7. Provide Warranty process chart.

Provide spare and replacement parts sources

Overview

There are three key types of data to capture and exchange related to spare and replacement parts information (see Figure 4–8). One is the identification of the parts list with appropriate manufacturer (or supplier) stock numbers. The second is the applicability of the parts to specific products and equipment. The third is the list of suppliers who are able to provide the needed set of replacement parts if one of the spares on hand has been used. These data requirements are identified in the sections below.

Subprocesses within scope

Generic metadata defining the names of parts, their item numbers and suppliers are included in the initial COBIE standard. This metadata also links the spare parts and supplier to the precise materials, products, and equipment to which they apply.

Subprocesses out-of-scope

To be determined

Exchange requirements

Parts sets

The identification of a set of parts may contain a specific parts list and/or a diagram showing where the parts are located. The Spare Parts Set data requirement allows the capture of diagrammatic representations of the spare parts list. The Spare Parts List requirement identifies the list of parts that could be provided in a table. Such information is preferred, in the long term, since request for quotes from suppliers could be automatically generated from the combination of data found in Table 4-30 – Table 4-32.

Table 4-30. Spare Parts Set data requirement.

Name	Type	Reqd/Opt	Description
PartsSetID	String	ReadOnly	Unique ID for part set ID
PartsSetDescription	String	Reqd.	Description of the parts set
PartsSetOrder	String	Opt.	Order used for display
PartsSetNote	Memo	Opt.	Any needed addl. information

Table 4-31. Spare Parts Set data requirement.

Name	Type	Reqd/Opt	Description
PartsListDocSetID	Reference	ReadOnly	Reference to part set ID
PartsListDocDescription	String	Reqd.	Part name
PartsListDocFile	Blob	Reqd.	Copy of associated documents
PartsListDocOrder	String	Opt.	Order used for display

Table 4-32. Spare Parts List data requirement.

Name	Type	Reqd/Opt	Description
PartsListID	String	ReadOnly	Unique ID for part ID
PartsListSetID	Reference	ReadOnly	Reference to part set ID
PartsListDescription	String	Reqd.	Part name
PartsListNumber	String	Reqd.	Part number
PartsListOrder	String	Opt.	Order used for display
PartsListNote	Memo	Opt.	Any needed addl. information
PartsListDocumet	Blob	Opt.	Copy of associated documents

Applicability

Identification of the equipment covered by a given parts list is provided through a linking table that identifies the parts set and the class of equipment to which the warranty applies. Typically warranties will be assigned against the general submittal item. In COBIE a separate submittal will be required to model situations where different equipment of the same type applies to different warranties. Table 4-33 shows the linking between the warranty item and the warranty.

Table 4-33. Part Set Applicability data requirement.

Name	Type	Reqd/Opt	Description
ApplicabilityPartSetID	Reference	ReadOnly	Reference to warranty ID
ApplicabilityRegisterItemID	Reference	ReadOnly	Reference to subject of test ID

Sources

Spare parts sources are described by a linking table that joins the parts set with one (or more) suppliers who could provide the parts (Table 4-34). Given the identification of the parts from the previous lists and contact information available through the linked data in this table COBIE could provide direct services to support facility managers' supply parts procurement process.

Table 4-34. Spare Parts Sources data requirement.

Name	Type	Reqd/Opt	Description
GuarantorPartsSetID	Reference	ReadOnly	Reference to warranty ID
GuarantorOfficeID	Reference	ReadOnly	Reference to office ID

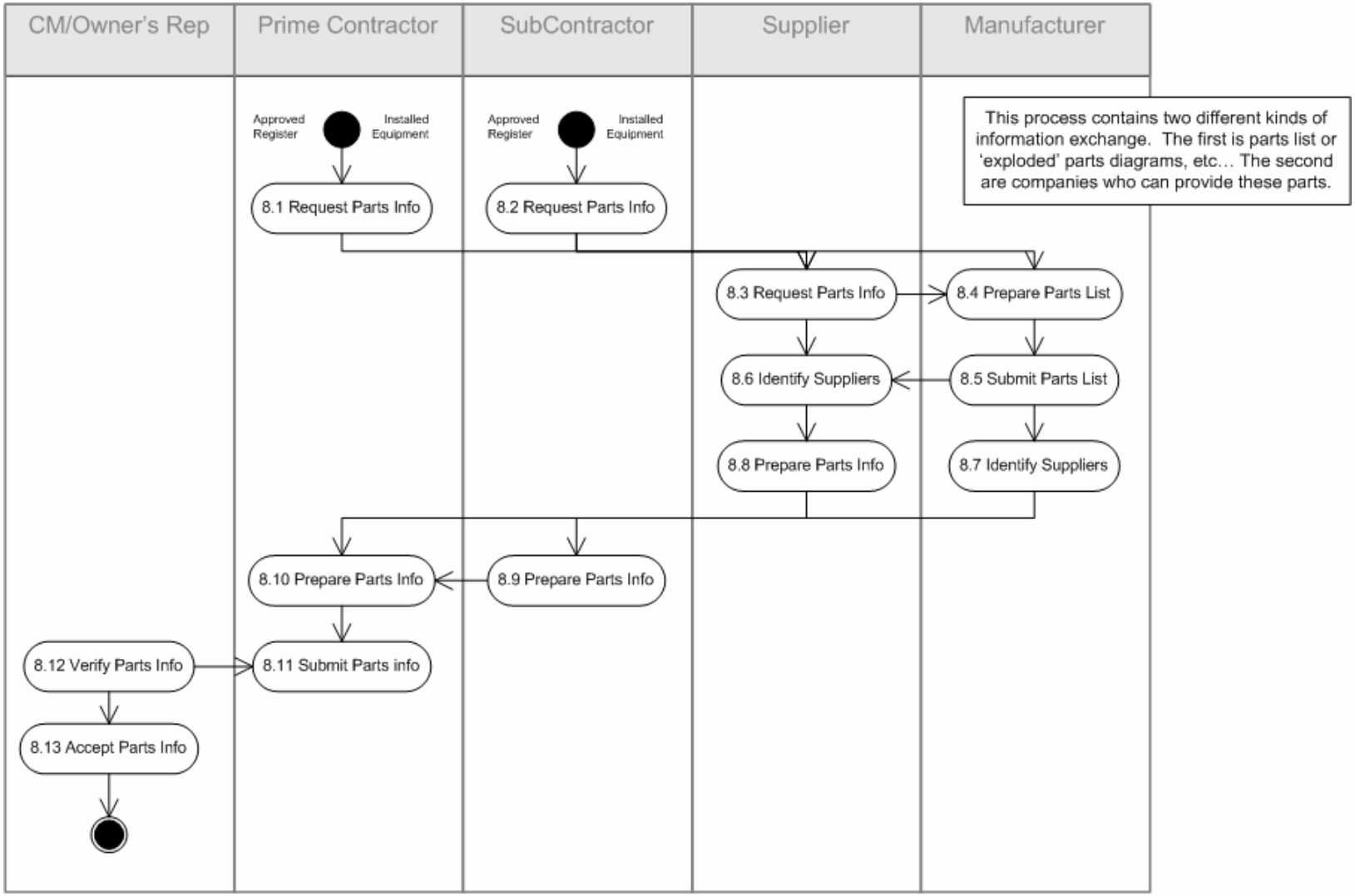
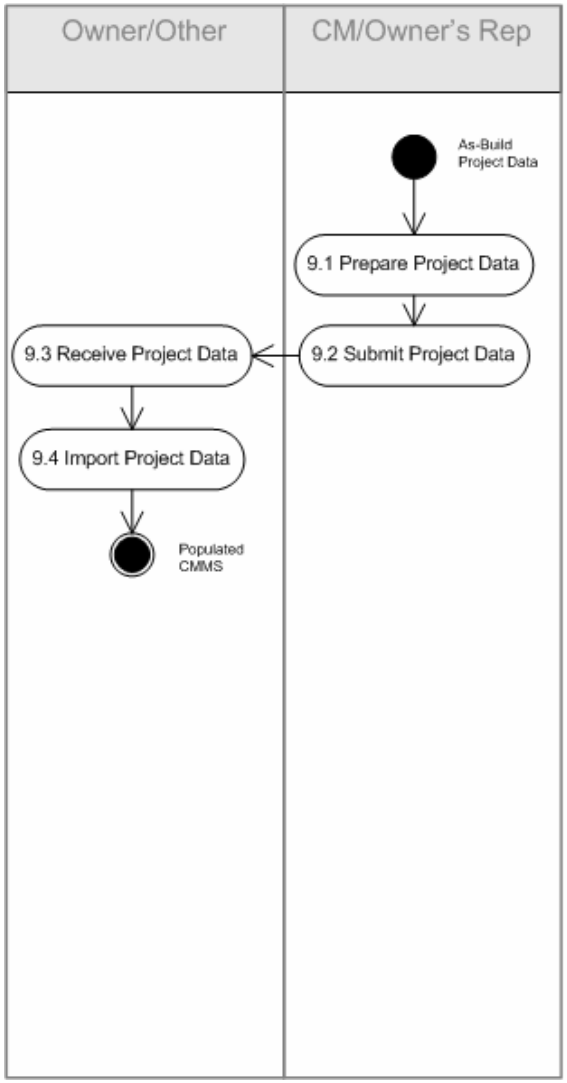


Figure 4–8. Provide Spare Parts Sources process chart.

Transmit handover information

All of the previous data requirements are pulled together during the steps under this process (see Figure 4–9). In COBIE, the data provided to facility managers will include the information from the contractor's supply chain captured during the constructor's quality control and owner's representative or construction manager's quality assurance process. Other processes accomplished by other parties at different times may, in the future provide additional data, or allow the data to be provided prior to the COBIE process. An example of such information would be the provision of a space-oriented building model within which material and equipment would be located. If such information were provided during the architectural programming and schematic design phase, then the construction contractor need only to identify the equipment purchased and match specific equipment with the generic identification of where the equipment of that type was to be placed.

For COBIE, the information to be transferred from contractors to operators will be, primarily, limited to material, product, and equipment specifications for the purposes of providing unsupervised data loading into computerized maintenance management systems. The specific coding if this information exchange will be defined in ifcXML format, however, the data will be that already described in the sections above.



The complete set of O&M and as-built facility information is to be provided by the CM/ Owner's Rep to the Owner or Owners Operation and Management agent. If COBIE is used during design and construction, this step is a quality control check of the data already submitted to the owner.

COBIE July 2007 allows designers to identify if submittals are for items that represent "fixed" or "movable" products/ equipment. This facilitates counting during building turn-over.

COBIE Jul 2007 requires identification of equipment type and space function in accordance with the OmniClass categorization. Owner's will need to map their internal taxonomies to the OmniClass scheme or substitute their classification schema.

COBIE Jul 2007 includes optional data for asset management functions. Determining the requirement for space and asset management management data should be accomplished by the owner, and identified in the design and construction contract.

Figure 4–9. Transmit Handover Information process chart.

O&M synchronization

When information is accepted by the facility operator, this information must be harmonized with information that already exists within the operator's maintenance management systems. It is vital that information about existing facilities or repair efforts to existing equipment be correctly updated with new COBIE data otherwise building information model data will not be able to grow over time to reflect as-built conditions. COBIE will address the requirements for new facilities, or new portions of existing facilities only.

The use case supported from this process will be to allow the contractor to receive the data associated with the building spatial inventory prior to the start of construction. If this information is available, then contractor personnel will not need to recreate it. Data requirements for this exchange were discussed previously.

5 COBIE Pilot Implementation Standard

Implementation overview

The COBIE Pilot Implementation standard supports all the information exchange requirements that modify and finalize information eventually provided to facility operators by the construction contractor. As a result, users of the COBIE spreadsheet will need to consider which of these processes will need to be included in design and construction contract. Legacy software systems may also support some, or all, of the data exchange requirements identified by COBIE.

In many cases users of the COBIE data standard should be unaware that their software system is capturing data for COBIE. If, however, users are required to enter data into the COBIE spreadsheet directly, the COBIE data should be loaded in order of the processes that created the data. This process is directly reflected in the order of the worksheets. Groups of worksheets reference data created during design, procurement, installation, and commissioning processes. Loading the COBIE data in order from first to last worksheet will simplify the tracking of information about the facility that is required to be linked across multiple worksheets.

While replacing paper documents with COBIE formatted data is expected to reduce the cost of the production and use of COBIE data, a more holistic approach would be to require the capture of COBIE data throughout the project development. The use of commercial software systems for this purpose is recommended. It is possible, if commercial software systems are not in place, to manage such data directly through the COBIE spreadsheet. Development of contract language to support such exchanges will need to be crafted based on the specifics of the parties and required exchanges. For generic examples of contract language, see Chapter 8.

Introduction to the COBIE spreadsheet

COBIE has been designed based on an extensive review of literature, related past projects, and expert consultations. COBIE reflects a compromise among the following constraints: (1) data structures, entities, and property sets provided by IFC 2x3; (2) organization of information that reflects the ‘natural’ way practitioners use COBIE data; and alternative means of representing object-oriented data in the relational format provided by a

spreadsheet. A report on these activities is in preparation for publication in December 2007.

Several of the key design decisions made during the creation of the spreadsheet format are described in the following paragraphs. This information will be of interest to both software vendors and users of the COBIE spreadsheet.

Process-based representation

There are many ways to represent data, the most commonly used representation of data today is based on so-called normalized relational-database tables. The IFC model uses an object-oriented format for its representation of BIM data. COBIE data in the Pilot Implementation Standard is primarily represented by the order in which the data is created during the life-cycle of the project. The relational-database information is provided in the Pilot Implementation Standard, using foreign keys and lookup lists, however, process-orientation is the primary motivating factor for the COBIE Pilot Implementation Standard.

There are at least two implications of the process-based representation of the COBIE data found in the Pilot Implementation Standard. The first is for end users of the spreadsheet. Users that need to directly add data to the spreadsheet may go directly to those tables for which they are responsible and only add the data that they create. For example, in the list of spaces (rooms), the designer provides the room number and associated special measurements; having the contractor re-create that information at the end of construction duplicates work and may introduce errors.

The second implication of the process-based representation is that software implementers will need to look across multiple worksheets to find information that they would often include in a single table. For example, the designer specifies that Fan Coil Unit 01 is located in room 101. Later the contractor who installs the equipment provides the serial number for that equipment. Since the data is created at different times during the project, in the COBIE Pilot Implementation Standard, the data is provided on different worksheets. While the software issues around these issues are easily solved, it is important to understand this process-orientation prior to starting work on COBIE import/export modules.

Internal referencing

COBIE data are interrelated. This is key difficulty in capturing and tracking this data. To manage the relationships between data in the COBIE spreadsheet each row in a given worksheet is sequentially numbered. This Locally Unique Identifier (LUID) serves as the unique internal reference number for information on the spreadsheet. This number may be referenced, as in the case of a "foreign key," on other worksheets. The number may also be referenced on the same worksheet to identify aggregation or sequential relationships.

The relational nature of information in COBIE is easily supported by commercial automated systems that maintain relational database linkage using business rules. Some users providing information directly into the COBIE spreadsheet may experience difficulty since index values between tables must be manually selected. The COBIE spreadsheet is not meant as an alternative to commercial software, simply as a simple implementation standard of the COBIE exchange requirement.

There are two types of internal referencing in the COBIE Pilot Implementation Standard and found in the COBIE spreadsheet. The first is a compositional reference. This reference corresponds to the one-to-many relational database construct. In the table that contains the "many," a link to "one" item from that, or another, worksheet will be provided. These compositional references can be found throughout COBIE. For example: for a given building, there may be one or more floors; for a given floor, there may be several spaces; for a given system, there may be a set of equipment. To simplify the end-user's interaction with the spreadsheet, a calculated field has been added to the sample spreadsheet. This calculated field provides a lookup list on the "many" table including both the LUID number of the referenced data but also the name of that data. In processing the link that contains the calculated data only the first numeric value (corresponding to the foreign key value) should be used.

The other type of internal referencing in the COBIE Pilot Implementation Standard is that of many-to-many relational link. In this situation, the Integer List data type is provided. In the Integer List data type (e.g., *SpaceIDList*, *DocumentIDList*, etc.), a comma-delimited list of the ID numbers from the designated worksheet, will be provided. The integer list data fields that are required shall have one or more values identified.

External referencing

COBIE data is also related to information outside the specific instance of a given COBIE spreadsheet. Optional fields are provided in the COBIE spreadsheet to allow parties to include references to data systems beyond the scope of the COBIE data. Requirements for the specification of such external references are up to specific implementations developed for specific project teams or settings.

One example of such an external reference would occur when an owner has an accounting system that contains a property identifier. If, for example, an owner has a unique identifier for each facility that is managed and tracked in a corporate database, then that owner can require those providing COBIE data to list that external identifier within the needed external reference fields.

Tracking authorship

All data in COBIE is identified against the person who provided or created the data. The first worksheet in the COBIE spreadsheet identifies the list of all persons and firms referenced in all later sheets. Each record of COBIE data in all sheets refers back to the ID numbers of those users listed in the first worksheet. In addition to identifying who was responsible for providing or creating the COBIE data, the date and time that the data was entered is noted.

Ownership decomposition

Decomposition of data in the COBIE spreadsheet reflects the process of data ownership. For example, the name “AHU-1” name is tagged to specific piece of equipment in a given location during design. The serial number for “AHU-1” is provided by manufacturer and recorded by the installer. Keeping the name of “AHU-1” and the “serial number” in the same COBIE record makes sense from a data modeling efficiency point of view but requires field-based data locking that would be more difficult to explicitly manage.

In the COBIE spreadsheet, two separate records are provided for named equipment. The “Component” table identifies all named equipment or other building *components* identified during the design process. The “Installation” table identifies the contractor provided attributes of *installed* equipment.

Change history

The COBIE spreadsheet may, depending upon its implementation, be used to exchange information about the history of changes during the design or construction process. The "ReplacesID" column is the last column in every worksheet of the COBIE spreadsheet. The use of data in this column is to identify the earlier row of data on the same worksheet that is to be replaced by the current row. Once included in a COBIE spreadsheet records are not allowed to be updated. Replacement rows of data provide the record of incremental changes. Comparison of COBIE spreadsheets between two time periods (along with gaps in LUIDs) identify deleted rows.

Occasionally some data elements previously provided in a COBIE information exchange may need to be identified as no longer being active data — if a construction change order combines two rooms into a single room, for example. Once provided in the spreadsheet, the data cannot be removed. The following procedure is to be used to flag data that is "withdrawn" from the Building Information Model represented in COBIE. First, an updated row that matches the most recent related data is required to be added with the user ID, date, and time that the data was removed from the BIM. Second, this record will have the new column, "Withdrawn," set to "Yes."

The current data set is that set of records across all worksheets that has not been superseded or withdrawn.

Separation of value and units

COBIE is based upon the IFC model for many of its basic data type models. One of these models in IFC identifies the value of an item separately from the units associated with that item. Such a separation is reflected throughout the COBIE specification to ensure that there is no confusion about units of measure during information exchanges.

Unless otherwise noted, it is assumed that the default units of COBIE will be millimeters.

Facility management practice

Facility management experts specified that the presentation of COBIE data in any human-readable format needs to reflect the common organization of the material that is received at construction handover. For example, the records for "Manual" and "Instruction" are the same and would otherwise

be merged by a system analysis with some kind of category designation field. Facility Managers, however, found such a construction more difficult to understand than simply providing two separate worksheets.

In previous COBIE drafts, a single worksheet for task-related information was developed. A task category identified the nature of these tasks. Expert maintenance personnel, serving on the COBIE team, explicitly requested that this information be separated into the individual types of jobs that needed to be done. Thus there are now task lists for “PM,” “Safety,” “StartUp,” “ShutDown” etc...

Progressive implementation

Today, the electronic information provided by manufacturers in a non-document format is limited. For example exploded diagrams for spare parts lists are common. In other cases, job plans for different kinds of work are listed, again in documents. The COBIE standard is able to accept these documents, but will also accept full sets of data, if provided by manufacturers.

A designer’s maturity with BIM technology will also have an impact upon the data provided through COBIE. If the design team is not using BIM, then the “Coordinates” of rooms and spaces, relative to the origin point of the facility, would be difficult to identify. As a result, in the COBIE Pilot Implementation standard coordinates are listed as an optional worksheet. If the design team uses BIM-based software, then the production of space and equipment coordinates would simply be an export from the BIM.

Another area that will evolve over time, and is currently supported by the COBIE Pilot Implementation standard, is property sets. Property sets, for example, could define the type of finish to be installed in a given space or the performance specifications of individual materials or work products. As these property sets become standardized through the additional efforts of the NBIMS, they may be referenced in specific implementations of the COBIE standard.

COBIE pilot implementation spreadsheet

Overview

The COBIE Pilot Implementation standard spreadsheet is organized in seven sets of worksheets. These worksheets may be created using com-

monly used spreadsheet tools, through translation of Building Information Models, or commercial database or management systems. The value of the spreadsheet format is that the ubiquitous nature of the spreadsheet will allow the widest possible use of the COBIE standard including medium and even small commercial contractors.

The first set of worksheets needed for COBIE is the single contact worksheet shown in Table 5-1. The contact Worksheet contains all data needed for the capture of both data ownership and company references. The ID number of the individuals and firms listed in the Contact worksheet is used as a reference in through all later worksheets.

Table 5-1. Contact worksheet.

Worksheet		Purpose	Author
01	Contact	People/offices/companies referenced in this file.	All

At the start of a project the function and layout of horizontal and vertical spaces within a facility are defined. The design worksheet set, Table 5-2, describes the design features required by facility operators. Today, many contractors are required to recreate this information even though it is originally created by the designer. In COBIE, the designer is required to provide the list of spaces and their functions. Construction contractors are required to add records to these tables to reflect as-built conditions.

Table 5-2. Design worksheets.

Worksheet		Purpose	Author
02	Facility	Identification of facility(ies) referenced in a file	Designer
03	Floor	Description of vertical levels	Designer
04	Space	Spaces referenced in a project	Designer
05	System	Systems referenced in a project	Designer
06	Register	Material/equipment/etc. catalog (submittal register)	Designer
07	Component	Individually named materials and equipment	Designer
08	Attribute	Material/equipment/etc. properties	Designer
09	Coordinate	Location of spaces and components	Designer

Designers also select the performance requirements for equipment, components, and materials to be installed. The catalogue of items that describe materials, components, and equipment to be submitted by the construction contractor is the “submittal register.” This “Register” is provided as a COBIE worksheet. The list of individually named equipment is found in COBIE under the “Component” worksheet. At a minimum the Component

worksheet will contain the list of all individually named equipment, and items found in schedules such as door hardware.

Designers combine individual components to create systems providing services within buildings. The COBIE worksheet "System" allows the designer to provide the list of systems. Large projects will include multiple systems, such as zones, in different parts of a facility. The "System" worksheet enables such decisions to be captured by the designer instead of having to be recreated, as is current practice, by construction contractors.

The next set of worksheets capture the interface between a construction contractor's supply chain management and the construction manager's quality assurance process. During this process documents describing the materials, components, equipment, and systems to be installed on the project are submitted and reviewed. The capture of this information as it is created by manufacturers and subcontractors will greatly simplify the creation of final project handover documents.

Construction contractors identify the schedule for the delivery of submittals. "Transmittals" provide the official delivery of the actual "Documents" that are ultimately "Approved" by the construction manager. Of critical concern to data later in the COBIE Pilot Implementation spreadsheet is the "Document" worksheet. The identifiers in the document worksheet allow those documents to be referenced where appropriate throughout the remainder of the COBIE spreadsheet.

A disk that provides the COBIE Pilot Implementation spreadsheet shall also contain the list of all individual files identified in the "Document" worksheet. A copy of all files identified in the "Document" worksheet must accompany each submission of the COBIE spreadsheet.

Table 5-3. Submittal worksheets.

Worksheet		Purpose	Author
10	Schedule	The planned and needed-by dates for submittals	Contractor
11	Document	Documents referenced in this file	Contr./Mfg
12	Transmittal	Transmittals for given submittal register item	Contractor
13	Action	The approval status of transmittals/submittals	Owner Rep.

As construction proceeds, materials, components, and equipment are installed (Table 5-4) on the project. To capture information about each specific piece of installed equipment and those materials or components that

may be specifically called out in construction documents, a set of installation worksheets is provided. The "Installation" worksheet is where installed equipment serial and tag numbers are listed.

Table 5-4. Installation worksheets.

Worksheet		Purpose	Author
14	Installation	Location and serial no. of installed components	Contr./Mfg
15	Manual	Instruction manuals for sets of/or components	Contr./Mfg
16	Warranty	Warranty information for sets of/or components	Contr./Mfg
17	Spare	Spare parts info provided for sets of/or components	Contr./Mfg

As building systems are completed, the systems are tested for compliance with contractual requirements. "Commissioning" worksheets, Table 5-5, identify the data needed to verify correct installation of those portions of a design that require "Test" or "Certification" results prior to acceptance by the owner. "Instructions" are system-oriented documents that may contain any number of different types of procedures for system operations.

Table 5-5. Commissioning worksheets.

Worksheet		Purpose	Author
18	Instruction	Installation/operating instructions	Contr./Mfg
19	Test	System/component test results	Contractor
20	Certification	Installation certifications	Contr./Mfg

The final two sets of information work together to identify the resources and tasks needed to complete manufacturer recommended procedures. Since resources may be applied on multiple tasks, the set of "Resource" worksheets, Table 5-6, appears in the COBIE standard prior to the job plan worksheet set. The three types of resources identified by expert facility maintenance personnel for inclusion in COBIE are "Materials", "Tools", and "Training."

Table 5-6. Resource worksheets.

Worksheet		Purpose	Author
21	Material	Special materials needed for a given Job Plan Task	Contr./Mfg
22	Tool	Special tools needed for a given Job Plan Task	Contr./Mfg
23	Training	Special training needed for a given Job Plan Task	Contr./Mfg

The final set of COBIE worksheets, Table 5-7, the procedures needed to maintain and operate the facility. The types of job plans identified below,

as well as the resource types required, were identified during meetings with COBIE stakeholders.

Table 5-7. Job plan worksheets.

Worksheet		Purpose	Author
24	PM	Identifies specific PM tasks and frequency	Contr./Mfg
25	Safety	Identifies required safety tasks	Contr./Mfg
26	Trouble	Maintenance trouble shooting procedures	Contr./Mfg
27	Start-Up	Start-up procedures	Contr./Mfg
28	Shut-Down	Shut-down procedures	Contr./Mfg
29	Emergency	Emergency operating procedures	Contr./Mfg

COBIE data types

To clearly identify the requirements of the COBIE Pilot Implementation Standard, information about the data types identified in the worksheets (Section 0) is provided. To the extent possible there is a direct mapping between the data types identified in this section and data types supported by the IFC model.

Reference data types

Reference data types are those that identify or reference individual records within COBIE worksheets.

Integer (LUID)

The LUID is a non-zero positive integer that for a given worksheet is required to be ascending by row number and non-repeating. In the COBIE Pilot Implementation Standard once a record has been saved the data associated with the LUID may not be changed by later users (Section 0, “Change history”).

Integer (local key)

The local key is a non-zero positive integer that for a given worksheet must be found in the list of worksheet LUIDs. The local key allows worksheet data to reference itself to identify “made-of” relationships among similar COBIE worksheet data.

Integer (foreign key)

The foreign key is a non-zero positive integer that for a given use must be found in the list of LUIDs of the referenced worksheet. The Foreign key

allows worksheet data on a given worksheet to refer to data on a different, or “foreign,” worksheet. The foreign key allows worksheet data to identify “part-of,” “created-by,” and other relationships among COBIE worksheet data.

Calculated references (foreign key)

While direct use of the COBIE spreadsheet for data entry may not be the optimal solution, until such time as software is provided to fully support the exchange of COBIE data many users, particularly at the construction site, may find it easier to directly use a blank sample spreadsheet rather than use full BIM software. In this case, selecting the integer ID number of the foreign key may prove difficult. In some cases errors can be expected as users refer back and forth between sheets. To assist in reductions of direct data entry errors and new field type, calculated references are provided.

Calculated reference fields combine the ID number, i.e., the foreign key, required by the Integer (foreign key) data type and the name of the data from the row referred to by the foreign key. For example, when selecting the floor on which a space is located, the calculated reference (foreign key) value will provide both the ID number of the floor and the name of the floor. A comma will separate the foreign key from the description. Users directly using the spreadsheet will, therefore, be able to select the correct floor without referring to the Floor worksheet.

The integer foreign key field requires that the field contain a single, positive integer. The selection of the integer foreign key selected by a calculated reference foreign key is accomplished by the selection of the number to the left of the comma. For example the calculated reference selection may result in a value of “101, Circuit, 13Amp”. A simple algorithm to test for the existence of a comma and only capture the information to the left of the comma, i.e., “101,” May be easily implemented to support this needed usability feature within the spreadsheet.

Calculated references are not allowed in the Integer List data type. This will ensure that the situation posed by the string "101, Circuit, 13Amp, 203, Damper, Fire" is not allowed. The correct presentation of the selected value is “101,203”. Note that in most cases Integer List data types are optional fields and would most likely only be generated directly from BIM or other software solutions.

Integer list (foreign keys)

The list of foreign keys is a comma-delimited list of non-zero positive integers that for a given use must be found in the list of LUIDs of the referenced worksheet. The List of Foreign Keys allows all appropriate records in the referenced worksheet to be linked to the current worksheet record. Calculated references are not allowed in the Integer List data type.

External references

All reference data types in COBIE worksheets are local references. If users of COBIE data need to pass external references to data within COBIE, then they may do so using the external reference fields provided on specific worksheets. It is possible that different authors may want to reference different internal systems. In all cases the referenced system name and the id from the reference system may be provided by the user creating the COBIE record.

An example where an external reference may be applied is in the case of multiple facilities being constructed under the same contract. In this case, the owner may have an existing unique property ID number for each facility. To assist in importing of the facility data, COBIE specifications may require the submitter of the COBIE data to include this unique identifier with the related facility record.

Standard data types

Standard data types are those that contain data defining the contents of the record identified by the LUID.

Text (50)

An alphanumeric field containing no more than 50 characters.

Text (255)

An alphanumeric field containing no more than 255 characters.

Positive decimal number

A numeric field containing positive numbers that may contain decimal portions. In many software systems such numbers would be represented by the non-zero positive real numbers.

A maximum of two decimal places will be provided for positive decimal number.

Date (dd-MMM-yyyy)

Date fields are provided in the format that has as example, “31-Dec-2006”. This format provides a complete unambiguous interpretation that may be imported into any locally required data format. All dates will be created based on the local clock of the user who created the data.

Time (local 24 hour clock)

Time fields are provided in the format that has as an example, “23:59” This example value translates into 11:59 PM. Use of twenty-four hour clock provides an unambiguous value for time. Seconds are not required to be transferred within COBIE. All times will be created based on the local clock of the user who created the data.

Classification data types

Classification data types are those whose values are bound by the values identified in the associated classification list. Classification data types in COBIE are listed below in alphabetical order.

Classification (ActionType)

The ActionType classification (Table 5-8) identifies the action taken when Quality Assurance personnel determine the status contractor quality control submittal.

Table 5-8. ActionType classification.

Approved
Approved, with comment
Approved, resubmittal required
Denied, resubmittal required
Receipt Acknowledged
Information Only

Classification (ApprovalType)

The ApprovalType classification (Table 5-9) identifies the level of approval required when submitting construction contactor submittals as part of a contractor quality control process.

Table 5-9. ApprovalType classification.

Owner Approval
Contractor Certified
Information Only

Classification (AreaUnit)

The AreaUnit classification (Table 5-10) identifies the units of area measurements to be allowed within the COBIE specification.

Table 5-10. AreaUnit classification.

Squareinches
Squarefeet
Squaremiles
Squaremillimeters
Squaremeters
Squarekilometers

Classification (AssetType)

The AssetType classification (Table 5-11) allows materials, products, and equipment identified by a project designer to be classified for asset managers into assets that are fixed parts of the project and those that may be moved following project handover.

Table 5-11. AssetType classification.

Fixed
Moveable

Classification (AttributeSetType)

The AttributeSetType classification allows an attribute set to be identified by category (Table 5-12). This set is consistent with property set types in the IFC model.

Table 5-12. AttributeSetType classification.

SingleValue
EnumeratedValue
BoundedValue
TableValue
ReferenceValue
ListValue
SetValue

Classification (CoordinateType)

The CoordinateType classification (Table 5-13) allows objects within COBIE to be physically located within a locally defined, three dimensional geometry according to one of three constructs: single point, two ends of a line, or bounding corners of a box. Box coordinates of "lowerleft" and "upperright" are determined in accordance with the local origin for information contained in the COBIE worksheet.

Table 5-13. CoordinateType classification.

point
line-end-one
line-end-two
box-lowerleft
box-upperright

Classification (CostUnit)

The CostUnit classification (Table 5-14) allows COBIE cost values to be identified with their appropriate currency. Additional currencies may be added for projects funded with local government, or a mix of different, currencies. These additional currency values must be identified in the contract language requiring COBIE data exchange.

Table 5-14. CostUnit classification.

Dollars
Euros

Classification (DurationUnit)

The DurationUnit classification (Table 5-15) allows COBIE planning data to be used to construct project and maintenance schedules.

Table 5-15. DurationUnit classification.

minute
hour
day
week
month
quarter
year

Classification (JobStatusType)

The Job Status Type classification (Table 5-16) allows the construction contractor to inform the facility operator if specific required maintenance items were completed prior to the handover of the building at beneficial occupancy.

Table 5-16. JobStatusType classification.

Not Yet Started
Started
Completed

Classification (LinearUnit)

The LinearUnit classification (Table 5-17) identifies the units of linear measurements to be allowed within the COBIE specification.

Table 5-17. LinearUnit classification.

inches
feet
miles
millimeters
meters
kilometers

Classification (RegisterType)

The RegisterType classification (Table 5-18) allows the designer to identify the type of contractor quality control submittal required.

Table 5-18. RegisterType classification.

Preconstruction Submittals
Shop Drawings
Product Data
Samples
Design Data
Test Reports
Certificates
Manufacturer Instructions
Manufacturer Field Reports
Operation and Maintenance
Closeout Submittals

Classification (SpareType)

The SpareType classification (Table 5-19) allows the construction contractor to identify the type of part that is required to maintain a given piece or set of equipment.

Table 5-19. SpareType classification.

Part
PartSet
Lubricant
Other
Spare
SpareSet

Classification (OmniClass13, Space Function)

The OmniClass Table 13, Space Function, classification allows the designer to identify the primary purpose of a given space.

Aggregation of space measurement and asset information against the Space Function classification scheme provides information required by asset managers at construction handover.

Classification (OmniClass21, System Function)

The OmniClass Table 21, System Function, classification allows the designer to identify the primary purpose of a given system of parts within a given building. This classification allows the facility manager to map the

data within COBIE to their own internal classification of resources used for facility operations and maintenance.

Aggregation of installed equipment associated with individual system function classifications provides information required by asset managers at construction handover.

Classification (OmniClass23, Product)

The OmniClass Table 23, Product, classification allows the designer to identify the primary purpose of a given product within a given building. This classification allows the facility manager to map the data within COBIE to their own internal classification of products used for facility operations and maintenance.

Classification (OmniClass34, Actor)

The OmniClass Table 34, Actor, classification allows the construction manager to identify the role that all the persons identified throughout the COBIE database played in the given project. It may also be possible to use this information in future software implementation to limit write access to certain COBIE data based on the user's role.

COBIE worksheet definitions

There are 29 individual worksheets in every COBIE file. Table 5-20 – Table 5-48 list the data fields required for each worksheet.

Each table definition begins with header information describing the name of the worksheet and the required content. Header information identifies if data is required, or optional. If optional, requirements under which the data may be required are identified.

In the case where COBIE data is required to be submitted at construction handover, the author of all COBIE data will be the person collating COBIE data for the prime contractor. However, in cases where COBIE data is to be submitted during the design and construction process the author of the COBIE data may not be the prime construction contractor. Header information identifies the expected authors of the COBIE information, if collected during the process of design and construction.

The header section for each worksheet concludes with a listing of any options that are relevant to assist in the description of the worksheet.

Following the general information provided in the header, a listing of each of the columns to be created in a COBIE spreadsheet is provided. Requirements for column, column name, format, and the data are provided. The definitions for all formats for each COBIE data column were described above in Section 0. Notes to software vendors implementing the COBIE spreadsheet are found in Section 0.

Table 5-20. Worksheet 01: Contact (Required).

WORKSHEET NAME	Contact
CONTENT	People/offices/companies referenced in this file.
REQUIRED	Yes
PRIMARY AUTHOR	Anyone that provides or creates COBIE data
ALTERNATE AUTHOR	n/a
OPTIONS	n/a

Column	Column Name	Data Type	Reqd
A	ContactID	Integer (LUID)	Yes
B	ContactRole	Classification (OmniClass34)	Yes
C	ExternalSystemName	Text (50)	If Needed
D	ExternalNameID	Text (50)	If Needed
E	ExternalOfficeID	Text (50)	If Needed
F	GivenName	Text (50)	Yes
G	FamilyName	Text (50)	Yes
H	OfficeName	Text (255)	Yes
I	OfficeDepartment	Text (50)	Opt
J	OfficeOrganizationCode	Text (50)	Opt
K	AddressStreet	Text (255)	Yes
L	AddressPostalBox	Text (50)	Opt
M	AddressTown	Text (50)	Yes
N	AddressStateRegion	Text (50)	Yes
O	AddressPostalCode	Text (50)	Yes
P	AddressCountry	Text (50)	Opt
Q	ContactPhone	Text (50)	Yes
R	ContactFax	Text (50)	Opt
S	ContactEmail	Text (255)	Yes
T	CreatedBy	Integer (Local Key)	Yes
U	CreatedDate	Date (dd-MMM-yyyy)	Yes
V	CreatedTime	Time (local 24-hr clock)	Yes
W	ReplacesID	Integer (Local Key)	If Needed
X	Withdrawn	Yes/No	Yes
Y	ContactIDPick	Calculated Ref. A,E,F,H	Automatic

Table 5-21. Worksheet 02: Facility (Required).

WORKSHEET NAME	Facility
CONTENT	Identification of facility(ies) referenced in a file
REQUIRED	Yes
PRIMARY AUTHOR	Designer
ALTERNATE AUTHOR	Construction Contractor (updates with as-built data)
OPTIONS	Links to existing asset management systems occurs through data provided Columns B & C. All references to facilities information in COBIE information exchanges are local.

Column	Column Name	Data Type	Reqd
A	FacilityID	Integer (LUID)	Yes
B	ExternalSystemName	Text (50)	If Needed
C	ExternalNameID	Text (50)	If Needed
D	FacilityName	Text (50)	Yes
E	FacilityDescription	Text (255)	Opt
F	CreatedBy	Integer (Foreign Key)	Yes
G	CreatedDate	Date (dd-MMM-yyyy)	Yes
H	CreatedTime	Time (local 24-hr clock)	Yes
I	ReplacesID	Integer (Local Key)	If Needed
J	Withdrawn	Yes/No	Yes
K	FacilityIDPick	Calculated Ref. A,D	Automatic

Table 5-22. Worksheet 03: Floor (Required).

WORKSHEET NAME	Floor
CONTENT	Description of vertical levels
REQUIRED	Yes
PRIMARY AUTHOR	Designer
ALTERNATE AUTHOR	Construction Contractor (updates with as-built data)

Column	Column Name	Data Type	Reqd
A	FloorID	Integer (LUID)	Yes
B	FacilityID	Integer (Foreign Key)	Yes
C	ReferenceFloorID	Integer (Local Key)	If Needed
D	ExternalSystemName	Text (50)	If Needed
E	ExternalNameID	Text (50)	If Needed
F	FloorName	Text (50)	Yes
G	FloorDescription	Text (255)	Opt
H	FloorElevation	Positive Decimal Number	Opt
I	FloorElevationUnits	Classification (Linear Unit)	Opt
J	FloorTotalHeight	Positive Decimal Number	Opt
K	FloorTotalHeightUnits	Classification (Linear Unit)	Opt
L	ExteriorGrossArea	Positive Decimal Number	Opt
M	ExteriorGrossAreaUnit	Classification (AreaUnit)	Opt
N	InteriorGrossArea	Positive Decimal Number	Opt
O	InteriorGrossAreaUnit	Classification (AreaUnit)	Opt
P	PlannableGrossArea	Positive Decimal Number	Opt
Q	PlannableGrossAreaUnit	Classification (AreaUnit)	Opt
R	RentableAreaUsableArea	Positive Decimal Number	Opt
S	RentableAreaUsableAreaUnits	Classification (AreaUnit)	Opt
T	InteriorPlannableArea	Positive Decimal Number	Opt
U	InteriorPlannableAreaUnits	Classification (AreaUnit)	Opt
V	CalculationMethod	Text (50)	Opt
W	CreatedBy	Integer (Foreign Key)	Yes
X	CreatedDate	Date (dd-MMM-yyyy)	Yes
Y	CreatedTime	Time (local 24-hr clock)	Yes
Z	ReplacesID	Integer (Local Key)	If Needed
AA	Withdrawn	Yes/No	Yes
AB	FloorIDPick	Calculated Ref. A,D	Automatic

Table 5-23. Worksheet 04: Space (Required).

WORKSHEET NAME	Space
CONTENT	Spaces identified within a given floor
REQUIRED	Yes
PRIMARY AUTHOR	Designer
ALTERNATE AUTHOR	Construction Contractor (updates with as-built data)

Column	Column Title	Data Type	Reqd
A	SpaceID	Integer (LUID)	Yes
B	FloorID	Integer (Foreign Key)	Yes
C	SpaceFunction	Classification(OmniClass13)	Yes
D	SpaceReferenceID	Integer (Local Key)	If Needed
E	ExternalSystemName	Text (50)	If Needed
F	ExternalNameID	Text (50)	If Needed
G	SpaceNumber	Text (50)	Yes
H	SpaceName	Text (50)	Opt
I	SpaceDescription	Text (255)	Opt
J	SpaceUsableHeight	Positive Decimal Number	Opt
K	SpaceUsableHeightUnits	Classification (LinearUnit)	Opt
L	ExteriorGrossArea	Positive Decimal Number	Opt
M	ExteriorGrossAreaUnit	Classification (AreaUnit)	Opt
N	InteriorGrossArea	Positive Decimal Number	Opt
O	InteriorGrossAreaUnit	Classification (AreaUnit)	Opt
P	PlannableGrossArea	Positive Decimal Number	Opt
Q	PlannableGrossAreaUnit	Classification (AreaUnit)	Opt
R	RentableAreaUsableArea	Positive Decimal Number	Opt
S	RentableAreaUsableAreaUnits	Classification (AreaUnit)	Opt
T	InteriorPlannableArea	Positive Decimal Number	Opt
U	InteriorPlannableAreaUnits	Classification (AreaUnit)	Opt
V	CalculationMethod	Text (50)	Opt
W	CreatedBy	Integer (Foreign Key)	Yes
X	CreatedDate	Date (dd-MMM-yyyy)	Yes
Y	CreatedTime	Time (local 24-hr clock)	Yes
Z	ReplacesID	Integer (Local Key)	If Needed
AA	Withdrawn	Yes/No	Yes
AB	SpaceIDPick	Calculated Ref. A,E	Automatic

Table 5-24. Worksheet 05: System (Required).

WORKSHEET NAME	System		
CONTENT	Systems referenced in a project		
REQUIRED	Yes		
PRIMARY AUTHOR	Designer		
ALTERNATE AUTHOR	Construction Contractor (updates with as-built data)		
OPTIONS	Sub systems and zones may be identified through System-ReferenceID		
Column	**Column Title**	**Data Type**	**Reqd**
A	SystemID	Integer (LUID)	Yes
B	FacilityID	Integer (Foreign Key)	Yes
C	SystemFunction	Classification (OmniClass21)	Yes
D	SystemReferenceID	Integer (Local Key)	If Needed
E	ExternalSystemName	Text (50)	If Needed
F	ExternalNameID	Text (50)	If Needed
G	SystemName	Text (50)	Yes
H	SystemDescription	Text (255)	Opt
I	CreatedBy	Integer (Foreign Key)	Yes
J	CreatedDate	Date (dd-MMM-yyyy)	Yes
K	CreatedTime	Time (local 24-hr clock)	Yes
L	ReplacesID	Integer (Local Key)	If Needed
M	Withdrawn	Yes/No	Yes
N	FacilityIDPick	Calculated Ref. A,E	Automatic

Table 5-25. Worksheet 06: Register (Required).

WORKSHEET NAME	Register
CONTENT	Material/equipment/etc. catalog
REQUIRED	Yes
PRIMARY AUTHOR	Designer
ALTERNATE AUTHOR	Construction Contractor (updates with as-built data)
OPTIONS	This is equivalent to the submittal register created as part of the construction documents.

Column	Column Title	Data Type	Reqd
A	RegisterID	Integer (LUID)	Yes
B	ProductType	Classification (OmniClass23)	Yes
C	RegisterType	Classification (Register)	Yes
D	AssetType	Classification (AssetType)	Yes
E	RegisterApprovalBy	Classification (Approval)	Yes
F	SystemIDList	Integer List (Foreign Key)	If Needed
G	SpaceIDList	Integer List (Foreign Keys)	If Needed
H	ExternalSystemName	Text (50)	If Needed
I	ExternalNameID	Text (50)	If Needed
J	RegisterName	Text (50)	Yes
K	RegisterReference	Text (255)	Opt
L	ReplacementCost	Positive Decimal Number	Opt
M	ReplacementCostUnit	Classification (CostUnit)	Opt
N	ExpectedLife	Positive Decimal Number	Opt
O	ExpectedLifeUnit	Classification (DurationUnit)	Opt
P	CreatedBy	Integer (Foreign Key)	Yes
Q	CreatedDate	Date (dd-MMM-yyyy)	Yes
R	CreatedTime	Time (local 24-hr clock)	Yes
S	ReplacesID	Integer (Local Key)	If Needed
T	Withdrawn	Yes/No	Yes
U	RegisterIDPick	Calculated Ref. A,H	Automatic

Table 5-26. Worksheet 07: Component (Required).

WORKSHEET NAME	Component
CONTENT	Individually named materials and equipment
REQUIRED	Yes
PRIMARY AUTHOR	Designer
ALTERNATE AUTHOR	Construction Contractor (updates with as-built data)
OPTIONS	All named items including, but not limited to, mechanical equipment such as “AHU-1,” must appear in this worksheet.

Column	Column Title	Data Type	Reqd
A	ComponentID	Integer (LUID)	Yes
B	SpaceID	Integer (Foreign Key)	Yes
C	RegisterID	Integer (Foreign Key)	Yes
D	ExternalSystemName	Text (50)	If Needed
E	ExternalNameID	Text (50)	If Needed
F	ComponentName	Text (50)	Yes
G	ComponentDescription	Text (255)	Opt
H	CreatedBy	Integer (Foreign Key)	Yes
I	CreatedDate	Date (dd-MMM-yyyy)	Yes
J	CreatedTime	Time (local 24-hr clock)	Yes
K	ReplacesID	Integer (Local Key)	If Needed
L	Withdrawn	Yes/No	Yes
M	IDPick	Calculated Ref. A,D	Automatic

Table 5-27. Worksheet 08: Attribute (Optional).

WORKSHEET NAME	Attribute
CONTENT	Material/equipment/etc. properties
REQUIRED	Optional
PRIMARY AUTHOR	Designer
ALTERNATE AUTHOR	Construction Contractor (updates with as-built data)
OPTIONS	If specific attributes are defined by the enabling contract documents, these attributes shall be provided in this work-sheet.

Column	Column Title	Data Type	Reqd
A	AttributeID	Integer (LUID)	Yes
B	AttributeSetType	Classification (PropertyType)	Yes
C	AttributeReferenceID	Integer (Local Key)	If Needed
D	SystemID	Integer (Foreign Key)	If Needed
E	RegisterID	Integer (Foreign Key)	If Needed
F	TransmittalID	Integer (Foreign Key)	If Needed
G	InstallationID	Integer (Foreign Key)	If Needed
H	SpaceIDList	Integer List (Foreign Keys)	If Needed
I	AttributeName	Text (50)	Yes
J	AttributeDescription	Text (255)	Opt
K	AttributeValue	Text (50)	Yes
L	AttributeUnit	Text (50)	Yes
M	AttributeReference	Text (50)	Opt
N	AttributePriority	Text (50)	Opt
O	CreatedBy	Integer (Foreign Key)	Yes
P	CreatedDate	Date (dd-MMM-yyyy)	Yes
Q	CreatedTime	Time (local 24-hr clock)	Yes
R	ReplacesID	Integer (Local Key)	If Needed
S	Withdrawn	Yes/No	Yes
T	IDPick	Calculated Ref. A,I	Automatic

Table 5-28. Worksheet 09: Coordinate (Optional).

WORKSHEET NAME	Coordinate
CONTENT	Location of spaces and components
REQUIRED	Optional
PRIMARY AUTHOR	Designer
ALTERNATE AUTHOR	Construction Contractor (updates with as-built data)
OPTIONS	If coordinates for specific parts of the facility are required by the enabling contract documents, those coordinates shall be provided in this worksheet.

Column	Column Title	Data Type	Reqd
A	CoordinateID	Integer (LUID)	Yes
B	CoordinateType	Classification (Coord. Type)	Yes
C	FacilityID	Integer (Foreign Key)	If Needed
D	FloorID	Integer (Foreign Key)	If Needed
E	SpaceID	Integer (Foreign Key)	If Needed
F	ComponentID	Integer (Foreign Key)	If Needed
G	InstallationID	Integer (Foreign Key)	If Needed
H	CoordinateXAxis	Positive Decimal Number	Yes
I	CoordinateXAxisUnit	Classification (LinearUnit)	Yes
J	CoordinateYAxis	Positive Decimal Number	Yes
K	CoordinateYAxisUnit	Classification (LinearUnit)	Yes
L	CoordinateZAxis	Positive Decimal Number	Yes
M	CoordinateZAxisUnit	Classification (LinearUnit)	Yes
N	CreatedBy	Integer (Foreign Key)	Yes
O	CreatedDate	Date (dd-MMM-yyyy)	Yes
P	CreatedTime	Time (local 24-hr clock)	Yes
Q	ReplacesID	Integer (Local Key)	If Needed
R	Withdrawn	Yes/No	Yes

Table 5-29. Worksheet 10: Schedule (Optional).

WORKSHEET NAME	Schedule
CONTENT	The planned and needed-by dates for construction submittals
REQUIRED	Not required, unless specified
PRIMARY AUTHOR	Construction Contractor
ALTERNATE AUTHOR	Subcontractor(s)
OPTIONS	References to CPM schedules occurs through ExternalScheduleActivity field.

Column	Column Title	Data Type	Reqd
A	ScheduleID	Integer (LUID)	Yes
B	RegisterID	Integer (Foreign Key)	Yes
C	SubmitBy	Date (dd-MMM-yyyy)	Yes
D	ApproveBy	Date (dd-MMM-yyyy)	Yes
E	DeliverBy	Date (dd-MMM-yyyy)	Yes
F	ExternalScheduleActivity	Text (50)	Opt
G	CreatedBy	Integer (Foreign Key)	Yes
H	CreatedDate	Date (dd-MMM-yyyy)	Yes
I	CreatedTime	Time (local 24-hr clock)	Yes
J	ReplacesID	Integer (Local Key)	If Needed
K	Withdrawn	Yes/No	Yes

Table 5-30. Worksheet 11: Document (Required).

WORKSHEET NAME	Document
CONTENT	References to every document provided through the COBIE data format.
REQUIRED	Yes
PRIMARY AUTHOR	Construction Contractor
ALTERNATE AUTHOR	Manufacturers, Subcontractor(s)
OPTIONS	All documents referenced shall be submitted with the COBIE data. Default format for documents, unless otherwise notified, should be Portable Document Format (PDF). Documents identified here are referenced through the remainder of the COBIE format, where appropriate.

Column	Column Title	Data Type	Reqd
A	DocumentID	Integer (LUID)	Yes
B	ExternalSystemName	Text (50)	If Needed
C	ExternalSystemID	Text (50)	If Needed
D	DocumentName	Text (255)	Yes
E	DocumentDirectoryName	Text (255)	Yes
F	DocumentFileName	Text (255)	Yes
G	DocumentType	Text (50)	Yes
H	CreatedBy	Integer (Foreign Key)	Yes
I	CreatedDate	Date (dd-MMM-yyyy)	Yes
J	CreatedTime	Time (local 24-hr clock)	Yes
K	ReplacesID	Integer (Local Key)	If Needed
L	Withdrawn	Yes/No	Yes
M	IDPick	Calculated Ref. A,E	Automatic

Table 5-31. Worksheet 12: Transmittal (Optional).

WORKSHEET NAME	Transmittal		
CONTENT	Record of transmitting documents from Construction Contractor to Quality Assurance staff.		
REQUIRED	Not required, unless specified		
PRIMARY AUTHOR	Construction Contractor		
ALTERNATE AUTHOR	n/a		
Column	**Column Title**	**Data Type**	**Reqd**
A	TransmittalID	Integer (LUID)	Yes
B	RegisterID	Integer (Foreign Key)	Yes
C	DocumentID	Integer (Foreign Key)	Yes
D	TransmittalNumber	Text (50)	Yes
E	TransmittalRevision	Text (50)	Yes
F	TransmittalDeviation	Text (50)	Yes
G	TransmittalName	Text (255)	Yes
H	TransmittalDescription	Text (255)	Opt
I	CreatedBy	Integer (Foreign Key)	Yes
J	CreatedDate	Date (dd-MMM-yyyy)	Yes
K	CreatedTime	Time (local 24-hr clock)	Yes
L	ReplacesID	Integer (Local Key)	If Needed
M	Withdrawn	Yes/No	Yes
N	IDPick	Calculated Ref. A,G	Automatic

Table 5-32. Worksheet 13: Action (Optional).

WORKSHEET NAME	Action		
CONTENT	Record of action by the Quality Assurance staff on individual transmittals and/or entire submittal packages		
REQUIRED	Not required, unless specified		
PRIMARY AUTHOR	Quality Assurance Staff		
ALTERNATE AUTHOR	n/a		
Column	**Column Title**	**Data Type**	**Reqd**
A	ActionID	Integer (LUID)	Yes
B	RegisterID	Integer (Foreign Key)	Yes
C	ActionCode	Classification (Action Type)	Yes
D	TransmittalID	Integer (Foreign Key)	Opt
E	ActionDescription	Text (255)	Opt
F	CreatedBy	Integer (Foreign Key)	Yes
G	CreatedDate	Date (dd-MMM-yyyy)	Yes
H	CreatedTime	Time (local 24-hr clock)	Yes
I	ReplacesID	Integer (Local Key)	If Needed
J	Withdrawn	Yes/No	Yes

Table 5-33. Worksheet 14: Installation (Required).

WORKSHEET NAME	Installation
CONTENT	The as-built tag and serial numbers for all installed equipment. The space IDs where the equipment is installed.
REQUIRED	Yes
PRIMARY AUTHOR	Construction Contractor
ALTERNATE AUTHOR	Subcontractor
OPTIONS	If identified by contact, this worksheet shall also contain information about the installation finishes that apply to multiple rooms.

Column	Column Title	Data Type	Reqd
A	InstallationID	Integer (LUID)	Yes
B	RegisterID	Integer (Foreign Key)	Yes
C	ComponentID	Integer (Foreign Key)	If Needed
D	TransmittalID	Integer (Foreign Key)	If Needed
E	SpaceIDList	Integer List (Foreign Keys)	If Needed
F	DocumentIDList	Integer List (Foreign Keys)	If Needed
G	InstallationName	Text (255)	Yes
H	InstallationManufacturer	Text (255)	Yes
I	InstallationModel	Text (50)	Yes
J	InstallationSerialNumber	Text (50)	Yes
K	InstallationTagNumber	Text (50)	Opt
L	InstallationDescription	Text (255)	Opt
M	CreatedBy	Integer (Foreign Key)	Yes
N	CreatedDate	Date (dd-MMM-yyyy)	Yes
O	CreatedTime	Time (local 24-hr clock)	Yes
P	ReplacesID	Integer (Local Key)	If Needed
Q	Withdrawn	Yes/No	Yes
R	InstallationIDPick	Calculated Ref. A,H,I	Automatic

Table 5-34. Worksheet 15: Manual (Required).

WORKSHEET NAME	Manual
CONTENT	Link between installation and operations manuals (contained in Document worksheet) for related equipment.
REQUIRED	Yes
PRIMARY AUTHOR	Construction Contractor
ALTERNATE AUTHOR	Manufacturer
OPTIONS	Installation and operations manuals shall be linked at the highest relevant level. For example, if there are three pumps of the same type, then the link here will be between the DocumentID and the RegisterID.

Column	Column Title	Data Type	Reqd
A	ManualID	Integer (LUID)	Yes
B	DocumentIDList	Integer List (Foreign Keys)	Yes
C	RegisterIDList	Integer List (Foreign Keys)	Yes
D	TransmittalIDList	Integer List (Foreign Keys)	If Needed
E	InstallationIDList	Integer List (Foreign Keys)	If Needed
F	SystemIDList	Integer List (Foreign Keys)	If Needed
G	ManualName	Text (255)	Yes
H	ManualDescription	Text (255)	Opt
I	CreatedBy	Integer (Foreign Key)	Yes
J	CreatedDate	Date (dd-MMM-yyyy)	Yes
K	CreatedTime	Time (local 24-hr clock)	Yes
L	ReplacesID	Integer (Local Key)	If Needed
M	Withdrawn	Yes/No	Yes

Table 5-35. Worksheet 16: Warranty (Required).

WORKSHEET NAME	Warranty
CONTENT	Link between warranty certificates (contained in Document worksheet) for related equipment. Warranty data also provided.
REQUIRED	Yes
PRIMARY AUTHOR	Construction Contractor
ALTERNATE AUTHOR	Manufacturer
OPTIONS	Warranty guarantor list shall reference companies identified in the Contact worksheet.

Column	Column Title	Data Type	Reqd
A	WarrantyID	Integer (LUID)	Yes
B	DocumentIDList	Integer List (Foreign Key)	Yes
C	RegisterIDList	Integer List (Foreign Keys)	Yes
D	GuarantorIDList	Integer List (Foreign Keys)	Yes
E	TransmittalIDList	Integer List (Foreign Keys)	If Needed
F	InstallationIDList	Integer List (Foreign Keys)	If Needed
G	SystemIDList	Integer List (Foreign Keys)	If Needed
H	WarrantyName	Text (255)	Yes
I	WarrantyDescription	Text (255)	Opt
J	WarrantyStart	Date (dd-MMM-yyyy)	Yes
K	WarrantyEnd	Date (dd-MMM-yyyy)	Yes
L	CreatedBy	Integer (Foreign Key)	Yes
M	CreatedDate	Date (dd-MMM-yyyy)	Yes
N	CreatedTime	Time (local 24-hr clock)	Yes
O	ReplacesID	Integer (Local Key)	If Needed
P	Withdrawn	Yes/No	Yes

Table 5-36. Worksheet 17: Spare (Required).

WORKSHEET NAME	Spare
CONTENT	Link between spare parts sets (contained in Document worksheet) for related equipment. Part data also provided. If possible, specific part data should be provided by Manufacturers.
REQUIRED	Yes
PRIMARY AUTHOR	Construction Contractor
ALTERNATE AUTHOR	Manufacturer
OPTIONS	Part supplier list shall reference companies identified in the Contact worksheet.

Column	Column Title	Data Type	Reqd
A	SpareID	Integer (LUID)	Yes
B	SpareType	Classification (Parts Type)	Yes
C	DocumentIDList	Integer List (Foreign Keys)	Yes
D	RegisterIDList	Integer List (Foreign Keys)	Yes
E	SpareProviderIDList	Integer List (Foreign Keys)	Yes
F	SpareSetID	Integer (Local Key)	If Needed
G	TransmittalIDList	Integer List (Foreign Keys)	If Needed
H	InstallationIDList	Integer List (Foreign Keys)	If Needed
I	SystemIDList	Integer List (Foreign Keys)	If Needed
J	SpareNumber	Text (50)	Yes
K	SpareName	Text (255)	Opt
L	SpareDescription	Text (255)	Opt
M	CreatedBy	Integer (Foreign Key)	Yes
N	CreatedDate	Date (dd-MMM-yyyy)	Yes
O	CreatedTime	Time (local 24-hr clock)	Yes
P	ReplacesID	Integer (Local Key)	If Needed
Q	Withdrawn	Yes/No	Yes
R	IDPick	Calculated Ref. A,J	Automatic

Table 5-37. Worksheet 18: Instructions (Required).

WORKSHEET NAME	Instructions
CONTENT	Link between Operating Instructions (contained in Document worksheet) to related equipment. If possible, instructions should be provided by Manufacturers.
REQUIRED	Yes
PRIMARY AUTHOR	Construction Contractor
ALTERNATE AUTHOR	Manufacturer
OPTIONS	Instructions shall be linked between the DocumentID and the RegisterID. Additional links are provided to overall systems or specific installed equipment if appropriate.

Column	Column Title	Data Type	Reqd
A	InstructionID	Integer (LUID)	Yes
B	DocumentIDList	Integer List (Foreign Keys)	Yes
C	RegisterIDList	Integer List (Foreign Keys)	Yes
D	TransmittalIDList	Integer List (Foreign Keys)	If Needed
E	InstallationIDList	Integer List (Foreign Keys)	If Needed
F	SystemIDList	Integer List (Foreign Keys)	If Needed
G	InstructionName	Text (255)	Yes
H	InstructionDescription	Text (255)	Opt
I	CreatedBy	Integer (Foreign Key)	Yes
J	CreatedDate	Date (dd-MMM-yyyy)	Yes
K	CreatedTime	Time (local 24-hr clock)	Yes
L	ReplacesID	Integer (Local Key)	If Needed
M	Withdrawn	Yes/No	Yes

Table 5-38. Worksheet 19: Test (Required).

WORKSHEET NAME	Test
CONTENT	Link between Test results (contained in Document worksheet) to related equipment.
REQUIRED	Yes
PRIMARY AUTHOR	Construction Contractor
ALTERNATE AUTHOR	Testing agent
OPTIONS	Tests shall be linked between the DocumentID and the RegisterID. Additional links are provided to overall systems or specific installed equipment if appropriate.

Column	Column Title	Data Type	Reqd
A	TestID	Integer (LUID)	Yes
B	DocumentIDList	Integer List (Foreign Keys)	Yes
C	RegisterIDList	Integer List (Foreign Keys)	Yes
D	TransmittalIDList	Integer List (Foreign Keys)	If Needed
E	InstallationIDList	Integer List (Foreign Keys)	If Needed
F	SystemIDList	Integer List (Foreign Keys)	If Needed
G	TestName	Text (255)	Yes
H	TestDescription	Text (255)	Opt
I	CreatedBy	Integer (Foreign Key)	Yes
J	CreatedDate	Date (dd-MMM-yyyy)	Yes
K	CreatedTime	Time (local 24-hr clock)	Yes
L	ReplacesID	Integer (Local Key)	If Needed
M	Withdrawn	Yes/No	Yes

Table 5-39. Worksheet 20: Certification (Required).

WORKSHEET NAME	Certification
CONTENT	Link between Certifications (contained in Document worksheet) to related equipment or systems.
REQUIRED	Yes
PRIMARY AUTHOR	Construction Contractor
ALTERNATE AUTHOR	Certifying agent
OPTIONS	Certifications shall be linked between the DocumentID and the RegisterID. Additional links are provided to overall systems or specific installed equipment if appropriate.

Column	Column Title	Data Type	Reqd
A	CertificationID	Integer (LUID)	Yes
B	DocumentIDList	Integer List (Foreign Keys)	Yes
C	RegisterIDList	Integer List (Foreign Keys)	Yes
D	TransmittalIDList	Integer List (Foreign Keys)	If Needed
E	InstallationIDList	Integer List (Foreign Keys)	If Needed
F	SystemIDList	Integer List (Foreign Keys)	If Needed
G	CertificationName	Text (255)	Yes
H	CertificationDescription	Text (255)	Opt
I	CreatedBy	Integer (Foreign Key)	Yes
J	CreatedDate	Date (dd-MMM-yyyy)	Yes
K	CreatedTime	Time (local 24-hr clock)	Yes
L	ReplacesID	Integer (Local Key)	If Needed
M	Withdrawn	Yes/No	Yes

Table 5-40. Worksheet 21: Material (Required).

WORKSHEET NAME	Material		
CONTENT	Identification of a material resource need during the operations and maintenance phase of a project.		
REQUIRED	Yes		
PRIMARY AUTHOR	Construction Contractor		
ALTERNATE AUTHOR	Subcontractor, Manufacturer		
OPTIONS	The ID of this resource will be used in the job plan worksheets.		
Column	**Column Title**	**Data Type**	**Reqd**
A	MaterialID	Integer (LUID)	Yes
B	DocumentIDList	Integer List (Foreign Keys)	If Needed
C	RegisterIDList	Integer List (Foreign Keys)	If Needed
D	TransmittalIDList	Integer List (Foreign Keys)	If Needed
E	InstallationIDList	Integer List (Foreign Keys)	If Needed
F	SystemIDList	Integer List (Foreign Keys)	If Needed
G	MaterialName	Text (255)	Yes
H	MaterialDescription	Text (255)	Opt
I	CreatedBy	Integer (Foreign Key)	Yes
J	CreatedDate	Date (dd-MMM-yyyy)	Yes
K	CreatedTime	Time (local 24-hr clock)	Yes
L	ReplacesID	Integer (Local Key)	If Needed
M	Withdrawn	Yes/No	Yes

Table 5-41. Worksheet 22: Tool (Required).

WORKSHEET NAME	Tool		
CONTENT	Identification of a tool resource need during the operations and maintenance phase of a project.		
REQUIRED	Yes		
PRIMARY AUTHOR	Construction Contractor		
ALTERNATE AUTHOR	Subcontractor, Manufacturer		
OPTIONS	The ID of this resource will be used in the job plan worksheets.		
Column	**Column Title**	**Data Type**	**Reqd**
A	ToolID	Integer (LUID)	Yes
B	DocumentIDList	Integer List (Foreign Keys)	If Needed
C	RegisterIDList	Integer List (Foreign Keys)	If Needed
D	TransmittalIDList	Integer List (Foreign Keys)	If Needed
E	InstallationIDList	Integer List (Foreign Keys)	If Needed
F	SystemIDList	Integer List (Foreign Keys)	If Needed
G	ToolName	Text (255)	Yes
H	ToolDescription	Text (255)	Opt
I	CreatedBy	Integer (Foreign Key)	Yes
J	CreatedDate	Date (dd-MMM-yyyy)	Yes
K	CreatedTime	Time (local 24-hr clock)	Yes
L	ReplacesID	Integer (Local Key)	If Needed
M	Withdrawn	Yes/No	Yes

Table 5-42. Worksheet 23: Training (Required).

WORKSHEET NAME	Training
CONTENT	Identification of a training resource need during the operations and maintenance phase of a project.
REQUIRED	Yes
PRIMARY AUTHOR	Construction Contractor
ALTERNATE AUTHOR	Subcontractor, Manufacturer
OPTIONS	The ID of this resource will be used in the job plan worksheets.

Column	Column Title	Data Type	Reqd
A	TrainingID	Integer (LUID)	Yes
B	DocumentIDList	Integer List (Foreign Keys)	If Needed
C	RegisterIDList	Integer List (Foreign Keys)	If Needed
D	TransmittalIDList	Integer List (Foreign Keys)	If Needed
E	InstallationIDList	Integer List (Foreign Keys)	If Needed
F	SystemIDList	Integer List (Foreign Keys)	If Needed
G	TrainingName	Text (255)	Yes
H	TrainingDescription	Text (255)	Opt
I	CreatedBy	Integer (Foreign Key)	Yes
J	CreatedDate	Date (dd-MMM-yyyy)	Yes
K	CreatedTime	Time (local 24-hr clock)	Yes
L	ReplacesID	Integer (Local Key)	If Needed
M	Withdrawn	Yes/No	Yes

Table 5-43. Worksheet 24: PM (Required).

WORKSHEET NAME	PM
CONTENT	Identification of sets of sequenced tasks needed to accomplish preventative maintenance functions. If possible the specific tasks shall be identified in this worksheet. Linking to a file containing tasks, unless created by manufacturers, should be discouraged.
REQUIRED	Yes
PRIMARY AUTHOR	Construction Contractor
ALTERNATE AUTHOR	Subcontractor, Manufacturer
OPTIONS	Material, Tool, and Training resources are identified by reference.

Column	Column Name	Data Type	Reqd
A	PMTaskID	Integer (LUID)	Yes
B	RegisterIDList	Integer List (Foreign Keys)	Yes
C	TaskStatus	Classification (Task Status)	Yes
D	DocumentIDList	Integer List (Foreign Keys)	If Needed
E	TransmittalIDList	Integer List (Foreign Keys)	If Needed
F	InstallationIDList	Integer List (Foreign Keys)	If Needed
G	SystemIDList	Integer List (Foreign Keys)	If Needed
H	MaterialIDList	Integer List (Foreign Keys)	If Needed
I	ToolIDList	Integer List (Foreign Keys)	If Needed
J	TrainingIDList	Integer List (Foreign Keys)	If Needed
K	PriorTaskList	Integer List (Foreign Keys)	If Needed
L	Task Number	Text (50)	Yes
M	TaskName	Text (50)	Yes
N	TaskDescription	Text (255)	Opt
O	TaskDurationValue	Positive Decimal Number	Yes
P	TaskDurationUnit	Classification (Duration Unit)	Yes
Q	TaskStartValue	Positive Decimal Number	Yes
R	TaskStartUnit	Classification (Duration Unit)	Yes
S	TaskFrequencyValue	Positive Decimal Number	Yes
T	TaskFrequencyUnit	Classification (Duration Unit)	Yes
U	CreatedBy	Integer (Foreign Key)	Yes
V	CreatedDate	Date (dd-MMM-yyyy)	Yes
W	CreatedTime	Time (local 24-hr clock)	Yes
X	ReplacesID	Integer (Local Key)	If Needed
Y	Withdrawn	Yes/No	Yes

Table 5-44. Worksheet 25: Safety.

WORKSHEET NAME	Safety
CONTENT	Identification of sets of sequenced tasks needed to safely operate referenced equipment or systems. If possible the specific tasks shall be identified in this worksheet. Linking to a file containing tasks, unless created by manufacturers, should be discouraged.
REQUIRED	Yes
PRIMARY AUTHOR	Construction Contractor
ALTERNATE AUTHOR	Subcontractor, Manufacturer
OPTIONS	Material, Tool, and Training resources are identified by reference.

Column	Column Name	Data Type	Reqd
A	SafetyTaskID	Integer (LUID)	Yes
B	RegisterIDList	Integer List (Foreign Keys)	Yes
C	TaskStatus	Classification (Task Status)	Yes
D	DocumentIDList	Integer List (Foreign Keys)	If Needed
E	TransmittalIDList	Integer List (Foreign Keys)	If Needed
F	InstallationIDList	Integer List (Foreign Keys)	If Needed
G	SystemIDList	Integer List (Foreign Keys)	If Needed
H	MaterialIDList	Integer List (Foreign Keys)	If Needed
I	ToolIDList	Integer List (Foreign Keys)	If Needed
J	TrainingIDList	Integer List (Foreign Keys)	If Needed
K	PriorTaskList	Integer List (Foreign Keys)	If Needed
L	Task Number	Text (50)	Yes
M	TaskName	Text (50)	Yes
N	TaskDescription	Text (255)	Opt
O	TaskDurationValue	Positive Decimal Number	Yes
P	TaskDurationUnit	Classification (Duration Unit)	Yes
Q	TaskStartValue	Positive Decimal Number	Yes
R	TaskStartUnit	Classification (Duration Unit)	Yes
S	TaskFrequencyValue	Positive Decimal Number	Yes
T	TaskFrequencyUnit	Classification (Duration Unit)	Yes
U	CreatedBy	Integer (Foreign Key)	Yes
V	CreatedDate	Date (dd-MMM-yyyy)	Yes
W	CreatedTime	Time (local 24-hr clock)	Yes
X	ReplacesID	Integer (Local Key)	If Needed
Y	Withdrawn	Yes/No	Yes

Table 5-45. Worksheet 26: Trouble (Required).

WORKSHEET NAME	Trouble
CONTENT	Identification of sets of sequenced tasks needed to trouble-shoot referenced equipment or systems. If possible the specific tasks shall be identified in this worksheet. Linking to a file containing tasks, unless created by manufacturers, should be discouraged.
REQUIRED	Yes
PRIMARY AUTHOR	Construction Contractor
ALTERNATE AUTHOR	Subcontractor, Manufacturer
OPTIONS	Material, Tool, and Training resources are identified by reference.

Column	Column Name	Data Type	Reqd
A	TroubleTaskID	Integer (LUID)	Yes
B	RegisterIDList	Integer List (Foreign Keys)	Yes
C	TaskStatus	Classification (Task Status)	Yes
D	DocumentIDList	Integer List (Foreign Keys)	If Needed
E	TransmittalIDList	Integer List (Foreign Keys)	If Needed
F	InstallationIDList	Integer List (Foreign Keys)	If Needed
G	SystemIDList	Integer List (Foreign Keys)	If Needed
H	MaterialIDList	Integer List (Foreign Keys)	If Needed
I	ToolIDList	Integer List (Foreign Keys)	If Needed
J	TrainingIDList	Integer List (Foreign Keys)	If Needed
K	PriorTaskList	Integer List (Foreign Keys)	If Needed
L	Task Number	Text (50)	Yes
M	TaskName	Text (50)	Yes
N	TaskDescription	Text (255)	Opt
O	TaskDurationValue	Positive Decimal Number	Yes
P	TaskDurationUnit	Classification (Duration Unit)	Yes
Q	TaskStartValue	Positive Decimal Number	Yes
R	TaskStartUnit	Classification (Duration Unit)	Yes
S	TaskFrequencyValue	Positive Decimal Number	Yes
T	TaskFrequencyUnit	Classification (Duration Unit)	Yes
U	CreatedBy	Integer (Foreign Key)	Yes
V	CreatedDate	Date (dd-MMM-yyyy)	Yes
W	CreatedTime	Time (local 24-hr clock)	Yes
X	ReplacesID	Integer (Local Key)	If Needed
Y	Withdrawn	Yes/No	Yes

Table 5-46. Worksheet 27: StartUp (Required).

WORKSHEET NAME	StartUP
CONTENT	Identification of sets of sequenced tasks needed to start referenced equipment or systems. If possible the specific tasks shall be identified in this worksheet. Linking to a file containing tasks, unless created by manufacturers, should be discouraged.
REQUIRED	Yes
PRIMARY AUTHOR	Construction Contractor
ALTERNATE AUTHOR	Subcontractor, Manufacturer
OPTIONS	Material, Tool, and Training resources are identified by reference.

Column	Column Name	Data Type	Reqd
A	StartUpTaskID	Integer (LUID)	Yes
B	RegisterIDList	Integer List (Foreign Keys)	Yes
C	TaskStatus	Classification (Task Status)	Yes
D	DocumentIDList	Integer List (Foreign Keys)	If Needed
E	TransmittalIDList	Integer List (Foreign Keys)	If Needed
F	InstallationIDList	Integer List (Foreign Keys)	If Needed
G	SystemIDList	Integer List (Foreign Keys)	If Needed
H	MaterialIDList	Integer List (Foreign Keys)	If Needed
I	ToolIDList	Integer List (Foreign Keys)	If Needed
J	TrainingIDList	Integer List (Foreign Keys)	If Needed
K	PriorTaskList	Integer List (Foreign Keys)	If Needed
L	Task Number	Text (50)	Yes
M	TaskName	Text (50)	Yes
N	TaskDescription	Text (255)	Opt
O	TaskDurationValue	Positive Decimal Number	Yes
P	TaskDurationUnit	Classification (Duration Unit)	Yes
Q	TaskStartValue	Positive Decimal Number	Yes
R	TaskStartUnit	Classification (Duration Unit)	Yes
S	TaskFrequencyValue	Positive Decimal Number	Yes
T	TaskFrequencyUnit	Classification (Duration Unit)	Yes
U	CreatedBy	Integer (Foreign Key)	Yes
V	CreatedDate	Date (dd-MMM-yyyy)	Yes
W	CreatedTime	Time (local 24-hr clock)	Yes
X	ReplacesID	Integer (Local Key)	If Needed
Y	Withdrawn	Yes/No	Yes

Table 5-47. Worksheet 28: ShutDown (Required).

WORKSHEET NAME	StartUP
CONTENT	Identification of sets of sequenced tasks needed to shut down referenced equipment or systems. If possible the specific tasks shall be identified in this worksheet. Linking to a file containing tasks, unless created by manufacturers, should be discouraged.
REQUIRED	Yes
PRIMARY AUTHOR	Construction Contractor
ALTERNATE AUTHOR	Subcontractor, Manufacturer
OPTIONS	Material, Tool, and Training resources are identified by reference.

Column	Column Name	Data Type	Reqd
A	ShutDownTaskID	Integer (LUID)	Yes
B	RegisterIDList	Integer List (Foreign Keys)	Yes
C	TaskStatus	Classification (Task Status)	Yes
D	DocumentIDList	Integer List (Foreign Keys)	If Needed
E	TransmittalIDList	Integer List (Foreign Keys)	If Needed
F	InstallationIDList	Integer List (Foreign Keys)	If Needed
G	SystemIDList	Integer List (Foreign Keys)	If Needed
H	MaterialIDList	Integer List (Foreign Keys)	If Needed
I	ToolIDList	Integer List (Foreign Keys)	If Needed
J	TrainingIDList	Integer List (Foreign Keys)	If Needed
K	PriorTaskList	Integer List (Foreign Keys)	If Needed
L	Task Number	Text (50)	Yes
M	TaskName	Text (50)	Yes
N	TaskDescription	Text (255)	Opt
O	TaskDurationValue	Positive Decimal Number	Yes
P	TaskDurationUnit	Classification (Duration Unit)	Yes
Q	TaskStartValue	Positive Decimal Number	Yes
R	TaskStartUnit	Classification (Duration Unit)	Yes
S	TaskFrequencyValue	Positive Decimal Number	Yes
T	TaskFrequencyUnit	Classification (Duration Unit)	Yes
U	CreatedBy	Integer (Foreign Key)	Yes
V	CreatedDate	Date (dd-MMM-yyyy)	Yes
W	CreatedTime	Time (local 24-hr clock)	Yes
X	ReplacesID	Integer (Local Key)	If Needed
Y	Withdrawn	Yes/No	Yes

Table 5-48. Worksheet 29: Emergency (Required).

WORKSHEET NAME	Emergency
CONTENT	Identification of sets of sequenced tasks needed to complete emergency operations on referenced equipment or systems. If possible the specific tasks shall be identified in this worksheet. Linking to a file containing tasks, unless created by manufacturers, should be discouraged.
REQUIRED	Yes
PRIMARY AUTHOR	Construction Contractor
ALTERNATE AUTHOR	Subcontractor, Manufacturer
OPTIONS	Material, Tool, and Training resources are identified by reference.

Column	Column Name	Data Type	Reqd
A	EmergencyTaskID	Integer (LUID)	Yes
B	RegisterIDList	Integer List (Foreign Keys)	Yes
C	TaskStatus	Classification (Task Status)	Yes
D	DocumentIDList	Integer List (Foreign Keys)	If Needed
E	TransmittalIDList	Integer List (Foreign Keys)	If Needed
F	InstallationIDList	Integer List (Foreign Keys)	If Needed
G	SystemIDList	Integer List (Foreign Keys)	If Needed
H	MaterialIDList	Integer List (Foreign Keys)	If Needed
I	ToolIDList	Integer List (Foreign Keys)	If Needed
J	TrainingIDList	Integer List (Foreign Keys)	If Needed
K	PriorTaskList	Integer List (Foreign Keys)	If Needed
L	Task Number	Text (50)	Yes
M	TaskName	Text (50)	Yes
N	TaskDescription	Text (255)	Opt
O	TaskDurationValue	Positive Decimal Number	Yes
P	TaskDurationUnit	Classification (Duration Unit)	Yes
DELETED	TaskStartValue	Positive Decimal Number	Yes
DELETED	TaskStartUnit	Classification (Duration Unit)	Yes
DELETED	TaskFrequencyValue	Positive Decimal Number	Yes
DELETED	TaskFrequencyUnit	Classification (Duration Unit)	Yes
Q	CreatedBy	Integer (Foreign Key)	Yes
R	CreatedDate	Date (dd-MMM-yyyy)	Yes
S	CreatedTime	Time (local 24-hr clock)	Yes
T	ReplacesID	Integer (Local Key)	If Needed
U	Withdrawn	Yes/No	Yes

Implementer's guide

This section provides notes for those using the COBIE spreadsheet as part of automated import/export routines. Information related to the manual loading of COBIE data into a spreadsheet is provided in the next section.

The mapping between IFC and specific COBIE worksheets is being completed and will be provided under separate cover through the IDM Wiki [http://idm.buildingsmart.no/confluence/display/IDM/North+America].

General notes

The COBIE Pilot Implementation Standard is a Microsoft Excel formatted spreadsheet. This spreadsheet is comprised of 29 worksheets identified in this report. All worksheets are required to be provided in every COBIE file exchange. Worksheets are required to be submitted in the order identified in this document. All worksheets will contain the column headers as noted in Section 0. Worksheets not required by a specific set of construction specifications, or whose data is not available given the context of a specific information exchange will be blank.

The first worksheet, "Instructions," and the last, "Addl. Pick Lists," should be provided with every file. For files produced by software systems, however, these worksheets may be blank.

Linear and area units of measure are found throughout the spreadsheet. It is assumed that these units of measure will be set to the same value. Translation to a common unit of measure used throughout the spreadsheet is required.

The goal of the COBIE spreadsheet is to help remove people from data transcription activities. Until a full set of software tools is provided for this data life cycle, it is likely that some users will directly update the spreadsheet itself, using the sample spreadsheet as a starting point.

To improve the usability of the spreadsheet, for those users who need to manually enter data into the spreadsheet, a calculated foreign key lookup field has been included as the last column in many worksheets of the blank sample worksheet. This calculated lookup list column is not required to be imported or exported but does have a minor implication for software implementers. The user selection of a foreign key may (or may not) result in a comma-delimited list that contains the ID number of the referenced re-

cord as well as the name (or other 'human readable' text) for the record. Vendors should test all foreign key integer fields during import and only import the first value in the list, i.e., the foreign key.

Vendors exporting COBIE data do not need to include the ID Pick columns and may provide only the ID number of the foreign key.

In all cases the ID lists will be only comma-delimited lists of foreign keys.

Notes on change history

Section 0 identifies the method that is required to track changes within the COBIE spreadsheet. If COBIE data is being updated, new full data records must be provided that reference the replaced ID of the original records are required. The user entering the information into the COBIE spreadsheet shall also be recorded with every record. To the extent practical the user identified should be the actual person creating the information, not someone who may have assisted in data transcription into the COBIE spreadsheet. If the original author is not known, then the data transcriber or person preparing the COBIE spreadsheet will be identified as the author of the record.

During the process of creating COBIE data during design and construction, records may not be removed from later submissions of a COBIE spreadsheet once the spreadsheet has begun to be used (or has been submitted to the owner). Records may either be replaced or withdrawn. Withdrawing requires the addition of a replacement record, that date-stamps the time and author of the withdraw action. This new replacement record will have the "Withdrawn" column set to "Yes."

Implementers should note that only non-superseded, non-withdrawn rows contain the current data set.

Manufacturer-provided information

Current industry practice is for manufacturers to provide their data in paper or electronic paper formats (such as PDF). COBIE can support this method of data transfer, even though this is not the most helpful method of transfer for such data.

When provided by the manufacturers' spare parts, resources, and job plans should be individually provided. It is likely that, in the short term,

such information will continue to have to be manually extracted out of these documents rather than used as a direct import. Vendors should check the validity of the spare part, resource, and job plan data prior to directly importing COBIE data.

Worksheet 01: Contact notes

All persons and organizations referenced in the COBIE spreadsheet must be identified in the Contact worksheet. The minimum set of persons and organizations listed in the Contact worksheet would occur when a single individual from a construction contractor is identified to compile the entire COBIE data at project handover. In this case, the person compiling the information, warranty guarantors, and spare parts providers would be the only records identified in the spreadsheet.

All records in all worksheets are required to be identified by the ContactID of the user who entered the data in the COBIE spreadsheet. The date and time for this information is provided. Additional discussion of this requirement is found in Section 0.

Worksheet 02: Facility notes

A minimum of one record is required in the Facility worksheet. In most cases this will represent the name of the project whose data is contained in the COBIE spreadsheet. In cases where multiple buildings or projects are contained in a single contract, the Facility worksheet may contain multiple records.

The use of owner-based real property identifiers may be accomplished through the external reference fields in the Contact, Facility, and other worksheets.

Worksheet 03: Floor notes

A minimum of one record is required in the Floor worksheet. The Floor worksheet is typically used to define vertical spaces within a given project. The Floor worksheet may also be used to define site or geographically-oriented volumes related to civil works, highway or other horizontal projects.

Worksheet 04: Space notes

The Space worksheet is, for a typical building simply the list of rooms in the building. Later information about the location of equipment is linked to the space worksheet to create the list of installed equipment.

Spaces may include zones, such as circulation zones, by nesting spaces. Spaces may also be grouped to identify physical building areas such as "wings".

Worksheet 05: System notes

Systems may include zoning to identify differences in fire protection, alarm systems, or HVAC coverage.

Worksheet 06: Register notes

The register worksheet is the catalog of all materials, products, and equipment types that are included in the facility. This information must be identified by selecting a RegisterType value of "ProductData". Items in this table identified as "Product Data" may be used to create product types or classes.

In addition the register contains the set of all submittals identified by the designer that are required of the construction contractor.

The standard "submittal register, from the point of view of a BIM, is a catalog of all the materials, products, and equipment and information about these items. The submittal register is the key point of integration between the designers' requirements contained in specifications and the construction contractors' supply chain. COBIE employs this critical interface to capture manufacturer provided data as it is provided (or becomes available).

Worksheet 07: Component notes

The component worksheet allows the designer to identify the location of named equipment, e.g., "AHU-1", within the building. The Installation worksheet allows the construction contractor to identify the serial number for that named equipment. If the construction contractor is creating the equipment list at construction handover the Installation worksheet may used alone, as it reflects the as-built conditions of the building.

Worksheet 08: Attribute notes

Spare parts, instructions, and other documents often are prepared by manufacturers as part of the same document. It is expected that the construction contractor will not provide a single PDF file with all information. The construction contractor should break the document into constituent parts, as identified in COBIE, where possible.

Worksheet 08: Attribute notes

A minimum of one value for Columns C – H must be selected for a record to be valid.

Worksheet 09: Coordinate notes

A minimum of one value for Columns C – G must be selected for a record to be valid. All coordinates are provided relative to the building's local origin 0,0,0 point.

Worksheets 10, 12, 13: Quality assurance notes

Worksheets 10, 12, and 13 are included to describe the data needed to process and/or approve documents submitted against Register requirements. This data is optional. If available, such information may be provided in COBIE as documentation of technical issues that may have arisen on specific submittals.

Worksheet 16: Warranty notes

In addition to the name and dates associated with a warranty, identification of warranties requires a reference to the original warranty certificate(s) (DocumentIDList), the equipment type(s) covered by the warranty (RegisterIDList), and the point(s) of contact responsible for the warranty call (GuarantorIDList).

Worksheet 17: Spare notes

This worksheet includes spare parts on site, replacement parts that require ordering, and lubricants that are needed for equipment operation. The Spare Type field allows users to distinguish between these two types of parts.

As with warranty data, replacement part data must include a reference to the original parts diagram(s) (DocumentIDList), the equipment type(s) covered by the s diagram(s) (RegisterIDList), and one or more suppliers who can indicate who is able to supply replacement parts (GuarantorIDList).

Worksheets 21 – 23: Resource notes

Data contained in the material, tool, and training worksheets must be referenced at least once in the job plan worksheets (i.e., 24 – 29).

Worksheets 21 – 23: Job Plan notes

Manufacturers often specify that equipment should be greased, checked, or adjusted "periodically." Such requirements should be reviewed by experienced O&M staff to ensure that a reasonable period between such adjustments is defined in the COBIE data file prior to CMMS import.

User's guide

The objective of the COBIE standard is to enable software vendors to provide direct import/export support for COBIE based on the parts of the building process on which those software systems are focused. Until a full suite of tools are developed and widely available, it is expected that users may need to directly input data into the spreadsheet. This section provides some key insights based on early pilot testing of the standard.

The user guide contained in the following paragraphs is a general, more technical discussion of the documents that may be directly obtained from the Whole Building Design Guide at http://www.wbdg.org. A WBDG "Resource Page" will provide links to a template spreadsheet, a step-by-step guide to manually completing the spreadsheet, a COBIE overview document, a COBIE briefing, and a copy of this technical report. The information provided below provides a more abstract description that, for technical readers, can supplement the step-by-step guide.

Template spreadsheet

The order and naming of the worksheets shall not be changed. The order and naming of column headings within each spreadsheet shall not be changed. Color coding of the blank spreadsheet should be maintained, in the new records, to allow users who are entering data by hand, or checking data to spot-check for required data fields.

As records are added to the blank spreadsheet the formulas in the spreadsheet will need to be copied to the new records. Someone with experience in using Excel formulas, and lookup lists, should be responsible for expanding the spreadsheet for the total number of rows.

Records that are not filled out in the blank spreadsheet should be removed prior to submission of the spreadsheet. Required data that is not available at the time when the file is submitted should be left blank.

In some cases, users may wish to track additional information in the spreadsheet. This is permitted. User defined information columns shall be placed within the appropriate worksheet to the right of all COBIE data columns.

Process orientation

COBIE worksheets are organized based on when the data is created, therefore, data loading should begin with worksheet one and proceed through the project. Data in later worksheets references data in earlier worksheets. As a result, you must begin to load data starting with the design worksheets then and follow through to the construction, installation, and commissioning worksheets.

Authorship

The person entering the data into the COBIE spreadsheet should be identified as the first data row in the Contact Worksheet. This user will be identified with all other data in the spreadsheet under the “CreatedBy” column.

Designer data

Starting with the Facility Worksheet, the user should begin to enter the data about the building in order Facility, Floor, and Space. Note that the area measurements for the Floors and Spaces are not mandated (unless required by contract). If direct data transfer or room lists do not already exist this information can be quickly identified directly from contract drawings. Ask the facility owner if they have a “facility id” or other numbers they would like added to the external reference columns to assist them to load COBIE data following construction.

The Register worksheet is used in the COBIE (which is really a simplified BIM) to identify all the types of materials, products, and equipment in the

building. Often the submittal register is already provided in electronic format and can be manipulated to be copy and pasted into COBIE. Once the data is pasted into COBIE, links between all items identified as "Product Data" and their respective systems, and room numbers is required.

The Component worksheet identifies specifically named items that are specific instances of items found in the Register. For example the Register would include a requirement for a pump with specified capacity. The Component worksheet would identify that there are three of these pumps in the facility with names "Pump-1", "Pump-2", and "Pump-3". Items may also be identified by tag numbers as noted in the design drawings.

If data is being created in the absence of a submittal register, in the case of COBIE data being created by those not directly involved in the original construction project, the data commissioning consultant should begin by listing each named and tagged item found on the as-built construction drawings and add those to the Component Worksheet. From there, the consultant can "back-into" the register by identifying the standard product types two which these products belong.

Note that attribute and coordinate data are not required worksheets. If the data set is being created by hand these worksheets will typically not be required. Users should consult their specific contract to determine if these worksheets are explicitly required.

Quality control/assurance data

If an electronic submittal process is being used to support COBIE, little additional effort, beyond that required to execute the submittal and review/approval process will be needed to capture documents for COBIE. Unfortunately, many users do not have access to a fully-electronic submittal review process and, today, hand manipulation of manufacturers' data will be required.

If COBIE data is being recreated manually, the contractors' submission process is not expected to be recreated in the QC/QA worksheets (10, 12, and 13). Documents in Worksheet 11 shall be provided. The documents listed in Worksheet 11 are those provided directly by a single manufacturer for a single product. If the manufacturers' document exceeds 25 pages, then the document will likely pertain to many different references of COBIE data found later in the spreadsheet. In general, COBIE data should

be decomposed into specific parts that allow the document to be linked to a single referenced item appearing in later spreadsheets.

Installing equipment

When equipment is installed the user entering data into COBIE will select the specific named item from the class of item from the Register ID list.

If the item installed is also listed in the Component worksheet, then the Component ID value must also be selected.

Warranty information

Warranty information found in worksheet 16 must include the warranty certificate(s) referenced in the DocumentIDList, the submittal Register to identify the product class in the RegisterIDList, and the list of companies that are assigned to complete warranty work – GuarantorIDList. To be listed in these columns data must have already been entered in the Document, Register, and Contact worksheets. Warranties records in COBIE shall also identify the name, start date, and end date for the warranty.

Spare and replacement parts information

The Spare worksheet contains information on spare parts, ordering information for replacement parts and required lubricants. The SpareType field allows the user to distinguish between these different types of parts related data.

As with warranty data each record must include the document containing spare parts diagrams, DocumentIDList, the submittal Register to identify the product class in the RegisterIDList, and the list of companies from whom parts may be ordered or re-ordered – SpareProviderIDList. To be listed in these columns data must have already been entered in the Document, Register, and Contact worksheets.

Change management

Requests for changes to COBIE and this document may be submitted directly to the author of this document. Comments will be evaluated and incorporated by the NBIMS Consensus Committee and released as the COBIE Consensus Implementation Standard.

The July 2007 release contains input from project stakeholders representing Computerized Maintenance Management System (CMMS), data commissioning consultants, and members of the IFC Model Support Group.

6 COBIE Data Compatibility with IFC

The previous chapters identified the process maps, described the required information exchanges needed for COBIE, and defined a spreadsheet that may be created to explain the data being exchanged in COBIE. To map those information exchanges to the IFC model, the Information Delivery Manual (IDM) process [Wix 2007] was also used. The detailed definition of Exchange Requirements and Functional Parts required by the IDM process that describe COBIE may be found at IDMWiki 2007 [http://idm.buildingsmart.no/confluence/display/IDM/North+America].

Efforts are currently under way to create several sets of COBIE data from real projects, based on the pilot implementation standard. Translators between the COBIE data and the IfcXML format have already been developed. Use of this IfcXML file is seen as an intermediate format to allow the transmission of BIM data from designers for the purpose of kick-starting the COBIE data. The results of these current efforts will be published upon their completion.

7 COBIE Pilot Testing Specification

Specifications for the use of COBIE on design-build projects for the Corps of Engineers Louisville and Seattle District offices were developed by specification writers at the Louisville District. There are three types of inclusions to the design-build request for proposal. The first relates to submittals and is shown below:

```
SD-03 Product Data

COBIE Standard Tables

Three data sets of the completed COBIE tables containing
all as-built, approved and final information. The data sets
shall include both the COBIE spreadsheet and all indexed,
entered, referenced or linked information. The spreadsheets
shall be fully functional and in compliance with the Con-
struction Operations Building Information Exchange (COBIE)
Format Specification. Each data set shall be provided on
compact disk(s) with proper instructions and labeling so
that individuals not familiar with the process can utilize
the provided information.
```

The second area where Corps of Engineers design-build requests for proposals were updated relates to several places including “Equipment In-Place,” as shown in the paragraph below.

```
1.3.  EQUIPMENT DATA

1.3.1.      Real Property Equipment

Provide an electronic version (compliant with the COBIE
format specification) of the Equipment-in-Place list and
all information included; enter and/or index the data into
the COBIE Standard spreadsheet in compliance with the Con-
struction Operations Building Information Exchange (COBIE)
Format Specification.
```

The final place where USACE design-build requests for proposals were updated relates to a meeting held 60 days prior to facility handoff. This "Red Zone Meeting" includes the following bullet item that must be addressed:

```
"Provide COBIE Standard Tables to Customer"
```

A generic sample of contract language for construction contractors to submit handover data in COBIE format in lieu of existing paper documents is provided in the paragraphs below:

> The Contractor shall have the option of providing two (2) electronic copies of handover documents in lieu of the standard requirement to provide binders of paper documents.
>
> The National Building Information Model Standard (NBIMS) COBIE format shall be required for this electronic exchange. The COBIE standard specifies requirement for the indexing and submission of Portable Document Format (PDF) and other appropriate file formats that would otherwise be printed and submitted in compliance with project handover requirements. In 2007 and 2008 the COBIE index shall be a Microsoft Excel Spreadsheet as provided by the NBIMS organization through their web site: www.nbims.org.
>
> The Construction Contractor is responsible to provide data for all COBIE worksheets with the following exceptions:
>
> (1) Unless otherwise noted, the Designer of Record shall be required to provide information identified in the COBIE Pilot Implementation Standard "Design" worksheets. These include worksheet 2 "Facility," worksheet 3 "Floor", worksheet 4 "Space", worksheet 5 "System", worksheet 6 "Register", worksheet 7 "Component", worksheet 8 "Attribute", and worksheet 9 "Coordinate." The Construction Contractor shall add additional information to this set of Design work-

sheets to reflect as built conditions of the facility in accordance with the change management instructions provided in the COBIE Pilot Implementation Standard.

(2) If data is not provided by the Designer of Record, the Construction Contractor shall be required to document the as-built facility by completing worksheet 2 “Facility,” worksheet 3 “Floor”, worksheet 4 “Space”, worksheet 5 “System”, and worksheet 6 “Register”.

(3) If data is not provided by the Designer of Record, the Construction Contractor shall document as-built locations of installed and/or tagged equipment and building components by completing worksheet 14 “Installation”.

(3) If submittal processing information is to be exchanged using COBIE, the Construction Contactor shall document this process by completing worksheets 10 “Schedule”, 12 “Transmit”. The Construction Manager or Owner’s Representative will use worksheet 13 “Approve” to document the results of their reviews.

Requests for information on the COBIE data exchange standard may be provided by email request to bill.east@us.army.mil. Telephonic requests will not be accepted. Those making direct email inquiry should expect replies to take between fourteen (14) and thirty (30) days. Inquiries containing contractual queries will be returned to the sender with a note that such issues must be addressed to contracting personnel for resolution.

The two (2) copies of COBIE shall be submitted on Compact Disk (CD) and checked for read errors prior to submittal. One (1) copy shall be labeled as the “File Copy”. The other copy shall be labeled as the “Working Copy.” The name of the project, contract number, and contact information for the person creating the

disk will also be included on the disk label. In case the facility operator is unable to retrieve information from the CDs, the Contractor is responsible to provide one additional a copy of the electronic data available during the warranty period of the contract (identified elsewhere in the specifications).

8 Conclusions

Adoption follows practice

During the course of developing this standard it has become clear that standards development will not succeed unless the standard follows the practices used in industry. Forward-looking standards that attempt to *lead* an industry, such as those developed by the IAI, cannot be implemented until common practice in the industry "catches up." Fortunately for the COBIE project, large construction firms and facility operators are increasingly becoming interested in capturing facility data. The means for capturing the data, during the construction quality assurance process, are well established; and the primary medium for documenting it, the PDF file, is ubiquitous. The use of forms, spreadsheets, and/or XML files to exchange data is also well understood by larger public and private A/E/C/O organizations.

Business process software

For business process software tools to succeed, owner-oriented implementations of the COBIE exchange requirements must go beyond the standard model of submittal registers provided by owner agencies. Owner-based software tools must provide means for transaction-based information exchange in the context of the complete, complex supply chains. In these systems, prime contractors are able to receive information from manufacturers, suppliers, and subcontractors needed to submit in compliance with the COBIE specification.

Multiple models and standards

Many organizations are working on developing standards related to the A/E/C/O space. Each standard contains information that the standards developer considers critical to its constituents. Those developing other portions of the National Building Information Modeling Standard will, undoubtedly, come across a similarly complex space of standards and standards bodies.

It is useful to recall what the statistician George Box said: "All models are wrong, some are useful" [Box 1979]. The implication of his statement is that there is room for multiple, overlapping models of the A/E/C/O space because different constituents focus on different useful aspects. These dif-

ferences will even be evident as owners begin to require COBIE data. For example, owners who require their own space function taxonomy should specify that scheme in place of the default OmniClass space function. Other changes that may be relevant for owner-specific applications of COBIE are area-calculation methods and asset management definitions. Adoption of any BIM standard must be accomplished within the context of the project team.

Evaluating implementations

During the course of this project participants have debated the role of testing and product certification. There are many non-intersecting concepts and approaches to standards and compliance. From the author's point of view, the most authoritative definition of standards compliance is provided by the Open Source Initiative. The open standards definition [OSI 2006] describes two different levels of interaction with open standards: (1) the *compatible* level allows a vendor to self-certify its use of the standard; (2) the *conformant* level requires that an independent party certify the vendor's successful adoption of the standard. The COBIE Pilot standard was developed with the goal of open source *compatibility*.

9 Recommendations

Begin COBIE pilot testing

The NBIMS organization is currently working toward establishing a formal process for establishing NBIMS-branded, IFC-compliant standards. The current lack of a formal process, however, does not prohibit early adopters who require COBIE data from implementing their own pilot tests of the COBIE specification. The construction contractors on the COBIE team have determined that their time and cost will be reduced if owners implement COBIE. As one member of the team stated, "It is easier to make one PDF file than it is to make and track 12 paper copies of a submittal."

Adopt COBIE pilot standard

COBIE and the phased release of updated specifications, based on the plan identified in this report, should be adopted by the NBIMS as a pilot information exchange standard. Following adoption, the Consensus and Operational Standards phase of NBIMS efforts will begin. Given the owners' need for COBIE, vendors should begin early adoption efforts using the IFC2x3 coordination view as the starting point for a facility management view definition.

Adopt open standards definition

In order to effectively communicate the requirements of NBIMS to create open standards, a formal definition of those standards should be adopted. The essential components of that definition have already been evaluated and are provided through the Open Source Initiative [OSI 2006].

Create an open-standards repository

As individual NBIMS standards are developed, there are pieces of those standards that will result in similar exchange requirements and individual functional parts. A national database of those requirements and parts should be adopted by NBIMS to ensure that standards are reused to the greatest extent possible. Through the compilation of these individual exchange requirements, future standards could even be constructed on an ad-hoc basis. The best current example of such a repository is maintained by the government of Norway [Norwegian buildingSMART Project 2007].

Open standards dictionary participation

To coordinate the multiple semantics associated with various information exchange requirements, an open-source international dictionary is required. Such an effort is currently under way in Europe. It is recommended that the NBIMS participate in and adopt this international lexicon.

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14. ABSTRACT

The Construction Operations Building Information Exchange (COBIE) specification denotes how information may be captured during design and construction and provided to facility operators. COBIE eliminates the current process of transferring massive amounts of paper documents to facility operators after construction has been completed. COBIE eliminates the need for post-hoc as-built data capture and helps to reduce operational costs. This report describes the background and process used to create and implement COBIE. An international panel of experts, facility operators, construction managers, and asset managers participated in this project under the auspices of the Development Team of the National Building Information Modeling Standard (NBIMS). This report documents the requirements analysis that led to a pilot implementation standard, specifications for the pilot implementation standard, and the creation of an Information Delivery Manual with process maps used to link user requirements into the Industry Foundation Class model.

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