User Guide

Utilizing ASHRAE Online BIM Data Exchange Protocols

Prepared as part of Research Project 1801-RP for:

Manager of Research & Technical Services (MORTS)
Michael R. Vaughn
ASHRAE, Inc., Atlanta, GA
and the
1801-RP Project Monitoring Subcommittee

Prepared by:

Robert J. Hitchcock, Ph.D.
Hitchcock Consulting, Bend, OR

Elizabeth Ford-Wilkins, PE
John Butterfield, PE
Ken Cross
Hallam-ICS, South Burlington, VT USA

TABLE OF CONTENTS

TABLES AND FIGURES

1 EXECUTIVE SUMMARY

This User Guide outlines a procedure for utilizing the 1801-RP ASHRAE Online BIM Data Exchange Protocol documents to support the data collection and population of a computerized O&M asset management software tool. This User Guide provides direction on: downloading and reviewing the 1801 information exchange specification and example data content documents, creating an equivalent data structure in an example mechanical, electrical, and plumbing (MEP) design software, updating and exporting these asset data from the design software, and importing these data into an example computerized maintenance management system (CMMS).

A need exists in the heating, ventilating, air-conditioning, and refrigeration (HVAC&R) industry to implement effective and practical facilities asset management programs. Frequently, equipment information is delivered to the facility owner in a wide variety of non-standardized paper and electronic document formats which must be reorganized to implement a comprehensive asset management program. Personnel responsible for the operation and maintenance of the facility are challenged to accomplish this work. The end result is that facility asset management programs are often inaccurate, incomplete and ineffective.

The ASHRAE-funded research project 1801-RP *Standardizing and Utilizing ASHRAE Online BIM Data Exchange Protocols* has developed standardized information exchange specifications and example data content documents intended to facilitate the collection and organization of HVAC&R asset management data focused on improving operations and management (O&M) activities. ASHRAE has established a publicly accessible data portal that can be used to archive and share such information exchange specifications and data content documents with end users.

2 TERMINOLOGY DEFINITIONS

Asset Management Program: A comprehensive set of activities and information pertaining to managing and maintaining assets such as HVAC&R equipment contained in a facility.

Building Information Model (BIM): A data specification for representing building information for the purposes of interoperable data exchange. Also, a data model of a specific building or its systems, components, or other information elements based on that specification.

Building Information Modeling (BIM): The process of developing and managing a Building Information Model.

COBie: The Construction Operations Building information exchange open BIM standard.

Computerized Maintenance Management System (CMMS): A computer database of information about an organization's maintenance operations including maintenance activities, specifications, purchase date, expected lifetime, warranty information, service contracts, service history, spare parts and anything else that might be of help to management or maintenance workers. A CMMS is also capable of managing work orders including scheduling jobs, assigning personnel, reserving materials, recording costs, and tracking relevant information such as the cause of problems.

Data Element: A data item that is reasonably atomic, such as a single property (e.g., Serial Number) or simple data object (e.g., Polygon) that is contained within a Data Group.

Data Group: A collection or set of Data Elements required to accomplish Use Case Activities.

Data Instance: An instantiated set of data property-value pairs that adhere to a data structure specification.

Data Structure: A specification of Data Groups and Data Elements that define the information content and organization of a set of data. This specification can be used to define a relational database or object-oriented structure for storing and managing instances of these data.

HVAC&R Equipment: Equipment and systems installed in a facility to provide heating, ventilating, air-conditioning and refrigeration services.

Mechanical, Electrical, and Plumbing (MEP): Professional disciplines involved in HVAC&R equipment and systems design and specification.

3 INTRODUCTION

3.1 WHAT ARE ASHRAE ONLINE BIM DATA EXCHANGE PROTOCOLS

ASHRAE has established a publicly accessible data portal that can be used to archive and share data exchange specifications (e.g., XML and JSON schemas) and data content documents (e.g., XML and JSON files). There are ongoing ASHRAE efforts such as Standard Project Committee 205 *Representation of Performance Data for HVAC&R and Other Facility Equipment* that are developing both specifications and data content that will be posted to the ASHRAE data portal for public downloading. The ASHRAE data portal is located at data.ashrae.org.

The ASHRAE-funded research project 1801-RP *Standardizing and Utilizing ASHRAE Online BIM Data Exchange Protocols* has developed example XSD schema and XML data content documents intended to support heating, ventilating, air-conditioning, and refrigeration (HVAC&R) asset management activities focused on operations and management (O&M).

The 1801 XSD schema, available at http://data.ashrae.org/1801rp/1801RPAssetOMDocumentation.xsd, specifies standard data properties useful during O&M asset management for several HVAC&R equipment types, including: air handler, boiler, cooling coil, heating coil, energy recovery unit, fan, motor, packaged unit, and pump. A validated example XML content document based on the 1801 XML Schema (XSD) is available at http://data.ashrae.org/1801rp/AssetOMExample20190917.xml

The 1801 XSD and XML documents represent what are referred to in this User Guide as *ASHRAE Online BIM Data Exchange Protocols*. These documents are accessible to the public with no restrictions on log in credentials, and are available free of charge. This is a working example of enabling new ways of working using building information modeling (BIM) specifications.

Spreadsheet documentation of the 1801 data specification and example data content is also available from the ASHRAE data portal. These documents are meant for human consumption rather than automated computer access. These documents are discussed in more detail below.

3.2 MOTIVATION FOR DEVELOPING ASHRAE ONLINE BIM DATA EXCHANGE PROTOCOLS

The National Institute of Science and Technology (NIST) study “Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry” (NIST, 2004) shows that all stakeholders in the capital facilities industry – designers, contractors, product suppliers, and owners waste a huge amount

of money looking for, validating, and/or recreating facility information that should be readily available. The total cost of these activities within the capital facilities industries was conservatively estimated at $15.8 billion in 2002, **with two-thirds of that cost occurring during the facilities operations and maintenance phase**.

A pressing need exists in the HVAC&R industry to implement effective and practical facilities asset management programs. Frequently, equipment information is delivered to the facility owner in a wide variety of non-standardized paper and electronic document formats which must be reorganized to implement a comprehensive asset management program. Personnel responsible for the operation and maintenance of the facility are challenged to accomplish this task under current information management conditions. The end result is that facility asset management programs are often inaccurate, incomplete and ineffective.

Given the challenge and cost of properly organizing O&M data, facilities maintenance personnel are inclined to maintain and troubleshoot equipment and systems in response to occupant complaints rather than systematic preventative maintenance practice based on intended equipment operation. The result is that the HVAC&R equipment and systems no longer function as they were intended to by design, often leading to increased occupant complaints, higher operating costs, and lower reliability.

This User Guide provides a procedure for addressing this situation through implementation of a BIM-enabled asset management program utilizing the ASHRAE Online BIM Data Exchange Protocols introduced above.

3.3 WHAT THIS GUIDE CONTAINS

- This guide begins with step-by-step guidance for utilizing the 1801 spreadsheet and XML/XSD documents to enable new ways of working that better support O&M activities (Section 4 Step-By-Step Utilization Guidance).
- A set of videos illustrating individual steps in the Section 4 utilization process is included. An ordered playlist of these videos is available (1801-RP-c, 2020).
- Detailed explanations of the 1801 XSD schema and example data content documents are given (Section 5 The 1801 Data Specification and Example Content Documents).
- A set of Terminology Definitions for terms used consistently throughout this document are included (Section 2 Terminology Definitions).

4 STEP-BY-STEP UTILIZATION GUIDANCE

This section provides step-by-step instructions on utilizing the ASHRAE online BIM data exchange protocols. The basic steps required to do this are shown in Table 1 below. More detailed utilization guidance for each of these steps is given in the sub-sections below.

Table 1. Utilization Steps for ASHRAE Online BIM Data Exchange Protocols

Utilization Step		Project Stage When This Step Occurs	Activities Involved in This Step
1	Develop equipment specifications	Design	• Develop overall project design ○ Specify required equipment

			• **Input as-designed 1801 properties**
2	Collect equipment manufacturer submittals	Procurement	• Submit equipment specifications to manufacturers for quotes and submittals • Send selected submittals to the Architect/Engineer for approval • **Input as-procured 1801 properties**
3	Install and start up procured equipment	Construction	• Install and start up equipment • **Input as-built 1801 properties**
4	Deliver equipment O&M documentation	Facility Handover	• **Output 1801 asset O&M data** based on as-built installed conditions • **Populate asset O&M data in the facility CMMS**

During design, the MEP Engineer develops initial equipment specifications based on overall HVAC&R systems design requirements. This initial specification will likely be based on generic equipment types rather than specific manufacturer models, including minimal equipment properties, such as size (e.g., capacity) and intended operational set points (e.g., entering and leaving air temperatures). The resulting equipment properties should be included in the project *As-Designed* asset documentation.

During procurement, contractors will use the equipment design specifications to choose specific manufacturer equipment models that meet requirements. Contractors will receive manufacturer submittals for the selected/procured equipment. These submittals should contain additional equipment properties that can be used to update project data to *As-Procured* asset documentation. The additional information available at this stage may include manual information such as recommended maintenance tasks that could be added now rather than later.

During construction, contractors will install, start up, and test the equipment resulting in additional data properties that can be used to update project data to *As-Built* asset documentation.

During facility handover, the *As-Built* asset documentation can be supplemented with O&M manual information such as recommended maintenance tasks and frequencies for each equipment type and other properties relevant to long term O&M activities. Much of this information is currently available online from manufacturers' web sites. However, this information is presented in a wide variety of documents and formats, not only varying between manufacturers, but even from one equipment type to another from a given manufacturer.

This process of collecting, expanding, and updating asset documentation as information becomes available throughout design and construction is illustrated in Figure 1.

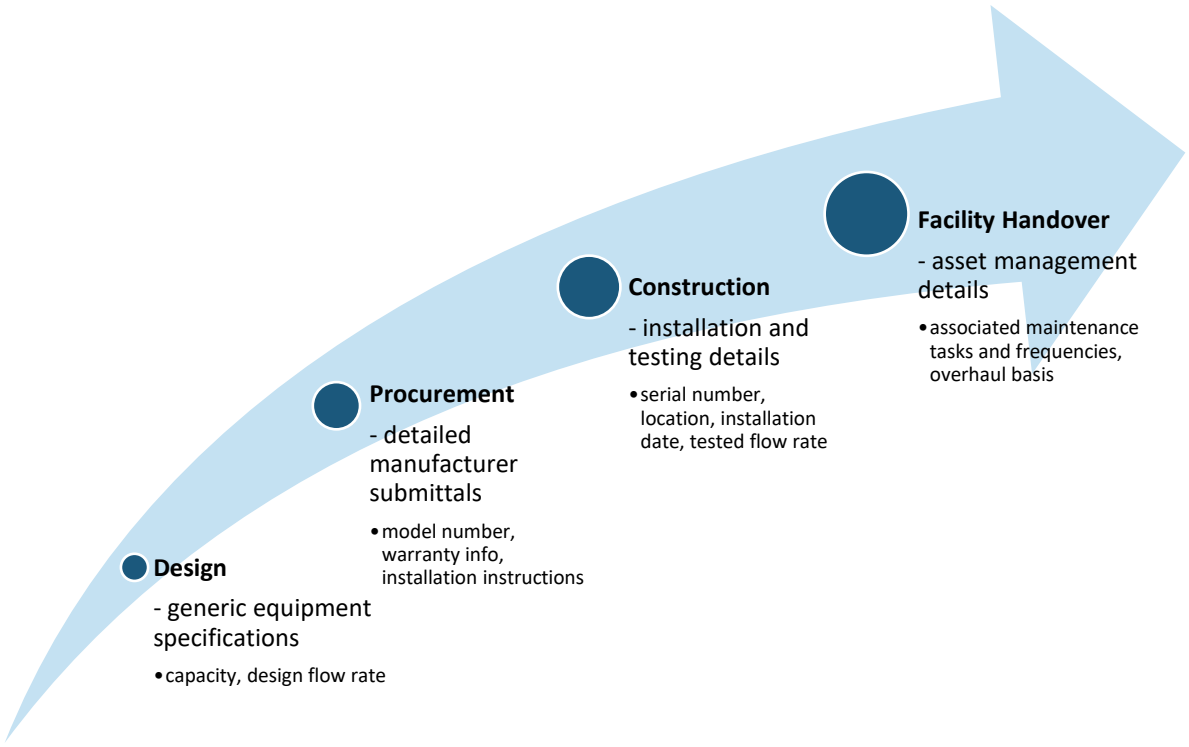

Figure 1. 1801 data set enhanced population from Design to Handover.

As manufacturers make more of their equipment catalog available online, in consistent formats, this situation of including only minimal generic equipment data during design may change to the point where the MEP Engineer can easily select specific equipment and include more complete data as part of their *As-Designed* documentation. This trend is already taking place in markets outside North America. To promote this trend and more fully establish a consistent set of data properties useful in operating and maintaining the selected equipment, the MEP Engineer can create 1801 data sets in the software of their choice.

These consistent 1801 data sets can then be more fully populated with as much data as is available at the design stage, and then updated as more and/or revised data becomes available downstream during procurement and construction. Having a defined set of properties like the 1801 data sets can greatly facilitate this process by making it clear to all project participants what properties are expected to be populated. A building information modeling (BIM) project execution plan can more fully elaborate this process by assigning project team members' responsibilities for collecting specific equipment properties and managing these data within the overall project documentation. This is the assumed process described in the steps below beginning in Section 4.1.

The step-by-step instructions for implementing this process are an illustrative example of some of the most commonly used commercially available software tools. This example can be adapted to other software tools of choice by end users. The overall sequence of process steps is shown in Table 2. A series of how-to videos were created to illustrate this process beginning with familiarizing the user to the ASHRAE 1801 Data Portal and proceeding through each step of the example procedure. A playlist is available (1801-RP-c, 2020) that guides viewing these videos in order.

Table 2. User Guide Step-by-Step Instruction Sequence

Life Cycle Stage	Utilization Instruction Step	Video
Design	1. Develop overall project design and specify required equipment 2. Input as-designed 1801 properties	• How-to download and review the 1801 example content documents • How-to create Revit MEP shared parameters and families based on the 1801 spreadsheet template • How-to save Revit MEP families for use in subsequent projects • How-to create and export equipment schedules based on the 1801 Revit MEP families
Procurement	3. Approve manufacturer equipment submittals 4. Input as-procured 1801 properties	
Construction	5. Install and start up procured equipment 6. Input as-built 1801 properties	
Facility Handover	7. Output 1801 asset O&M data 8. Populate asset O&M data in the facility CMMS	• How-to export COBie format data from Revit MEP • How-to import COBie format data into Maximo

4.1 Design Stage Equipment Specifications

4.1.1 Develop overall project design and specify required equipment

MEP design generally begins with the project architect handing building design information to the MEP Engineer to design the HVAC&R systems necessary to provide occupancy requirements. This process includes selecting appropriate system types and configurations, and the required equipment components for each system. System designs are developed and documented in the software chosen by project team members.

4.1.2 Input as-designed 1801 properties

MEP design software tools include various methods and data constructs for input, analysis, and output of HVAC&R equipment systems and components that support the process of selecting, sizing, and further specifying the required equipment. To illustrate the process of equipment data input and output utilizing the ASHRAE 1801 data sets, the 1801-RP project team used Revit (Revit, 2020) MEP as an example. This is only intended as an example and not an endorsement. Other MEP software tools will have analogous capabilities.

As a starting point, 1801 example data content documents are available from the ASHRAE data portal (http://data.ashrae.org/1801rp/). This documentation is available in both spreadsheet and XML formats and described in more detail in Section 4.1.2.1 and Section 5 below.

The spreadsheet format documents are separate data sheets that include: Equipment Type, Equipment Component, and the extended property sets for each type of equipment covered by this project. These documents are listed under the “Example Content Data Spreadsheet Files” section of the data portal.

The XML format document is listed under the “XML Example Data Content Document (XML)” section of the data portal. This single XML document contains example data values for all specified properties for each equipment type addressed by the 1801 research project.

While the 1801 example content documents can be easily downloaded, Revit MEP does not support direct import of either spreadsheet or XML documents based on the ASHRAE 1801 specifications. Instead, Revit families based on the 1801 data property sets must first be created using either manual methods or third-party import utilities. MEP design project specific data values for each property can then be input into the appropriate family. Once example families have been created, they can be saved for easier use in subsequent projects.

How-to videos have been created to illustrate this process and are available for viewing at the indicated locations. A playlist is available (1801-RP-c, 2020) that guides viewing these videos in order.

4.1.2.1 How-to download and review the 1801 example content documents.

The following video discusses the ASHRAE 1801-RP data portal and the resources available for downloading.

- ASHRAE1801-RPDataPortalVideo1.mp4 (MP4, 10.9MB, 3:42 Minutes) (https://youtu.be/Vq7KOraqMDM)

The following video discusses the ASHRAE 1801-RP work process use case spreadsheet documentation.

- ASHRAE1801-UseCaseSpreadsheetVideo.mp4 (MP4, 11.6MB, 5:00 Minutes) (https://youtu.be/Sxs9QuI6fLU)

The following video discusses the ASHRAE 1801-RP Example Content Data Spreadsheet Files.

- ASHRAE1801-ExampleDataSheets.mp4 (MP4, 11.4MB, 5:23 Minutes) (https://youtu.be/IKRVpCWAOCM)

4.1.2.2 How-to create Revit MEP shared parameters and families based on the 1801 spreadsheet template.

The following videos discuss the ASHRAE 1801 spreadsheets and how to use them as the basis for inputting shared parameters and creating families in Revit MEP.

- 01-Ashrae Spreadsheets.mp4 (MP4, 8.3MB, 3:32 Minutes) (https://youtu.be/ywtvKiO2SCY)
- 02-Parameters and Families.mp4 (MP4, 25.7MB, 12:33 Minutes) (https://youtu.be/QwPb6XBHhFA)

4.1.2.3 How-to save Revit MEP families for use in subsequent projects.

The following video discusses how to save the families created in the previous section so that they can be more easily used in subsequent projects without having to recreate them. Note that other MEP software tools may also support the import of Revit MEP families; saving the effort of having to manually create these data structures in other software environments.

The example Revit families created by the 1801 research project team are available for download at data.ashrae.org/1801rp under the *Illustrative Example Equipment Families and Schedules* section.

- 03-Saving Families.mp4 (MP4, 7.2MB, 7:45 Minutes) (https://youtu.be/2LGlJG1FlvA)

4.1.2.4 How-to create and export equipment schedules based on the 1801 Revit MEP families.

Once families have been created, they can be used to make and export schedules from the software. Schedules are tables of building elements and their properties that can be used to display these properties in drawings produced by MEP software.

The following videos discuss the process of making schedules based on the families created in a previous section and exporting these properties.

The example Revit families created by the 1801 research project team are available for download at data.ashrae.org/1801rp under the *Illustrative Example Equipment Families and Schedules* section.

- 04-Making Schedules.mp4 (MP4, 17.2MB, 7:12 Minutes) (https://youtu.be/eWyMZQulW8I)
- 05-Exporting Schedules.mp4 (MP4, 11.6MB, 3:58 Minutes) (https://youtu.be/nM7Lnmo_J7c)

4.2 Procurement Stage Manufacturer Equipment Submittals

4.2.1 Approve manufacturer equipment submittals

Based on as-designed equipment specifications, project contractors will collect manufacturer submittals for equipment that meets design requirements. Selected submittals will be sent to project engineers for approval, and approved equipment will be procured.

4.2.2 Input as-procured 1801 properties

Manufacturer equipment submittals contain significant additional properties for each equipment type that can be used to more fully populate the 1801 data sets in the project software. The 1801 XML example data content document was populated using data from actual submittals for a real project. As mentioned above, manufacturer submittals currently are available online on many manufacturer websites. However, these online documents come in a wide variety of formats with no consistent set of data properties. For this reason, this step of manually extracting data from online documentation for populating the 1801 data sets is a tedious process that could be greatly facilitated if manufacturers directly provided 1801 data sets online.

4.3 Construction Stage Contractor Equipment Installation

4.3.1 Install and start up procured equipment

During construction, contractors will install procured equipment and perform start up and testing procedures as appropriate. This process will generate additional data properties for various equipment types, such as installation dates and verified flow rates.

4.3.2 Input as-built 1801 properties

Additional equipment data properties generated during installation and start up can be used to more fully and accurately populate the 1801 data sets in the project software.

4.4 Facility Handover Stage O&M Documentation Delivery

4.4.1 Output 1801 asset O&M data

At the completion of construction, the project team should review 1801 data sets to assure that all available data properties have been populated and updated to as-built status.

The 1801 equipment data sets now become facility handover asset documentation that can be used by the owner and facility management team to populate a computerized maintenance management system (CMMS) for managing O&M activities throughout occupancy. At facility handover, the project team should output project data, including the 1801 asset data.

The COBie (Construction Operations Building information exchange) data format (COBie, 2020), as its name implies, is targeted at exchange of O&M facility data. Several software vendors have implemented data exchange utilities (export/import) based on the COBie data format. COBie is an international standard available through free licensing.

Outputting 1801 equipment data sets in COBie format can facilitate the handover of these data sets from design and construction software tools such as Revit MEP to CMMS software tools. Revit can export project data in COBie format.

4.4.1.1 How-to export COBie format data from Revit MEP

The Autodesk COBie Extension for Revit is a free tool that supports setting up Revit models to capture COBie data and then export those data to a COBie compliant spreadsheet. This first video walks through the necessary initial step of using the Parameter Mapping feature to use Revit parameters for collecting COBie data. COBie mapping of 1801 data elements is discussed in more detail below in Section 5.7.

- COBie Extension for Revit - Parameter Mappings (3:43 minutes) (https://www.youtube.com/watch?v=lBZp5iJ_G2c)

The following video discusses how to export COBie data from a Revit model to a COBie compliant spreadsheet.

- COBie Extension for Revit - Create Spreadsheet (6:50 minutes) (https://www.youtube.com/watch?v=fCF4vuYRqC8)

4.4.2 Populate asset O&M data in the facility CMMS

Currently, the process of structuring and populating CMMS systems is generally done manually either in-house or by a third-party contractor. Since each facility is unique, it is assumed that each CMMS configuration will be unique and must be customized to accommodate this. However, for equipment types that have predefined data property sets such as those developed by the 1801 research project, this process can become more automated.

As an illustrative example, the CMMS software tool Maximo (Maximo, 2020) can import data in COBie format. As with Revit MEP, Maximo is discussed here only as an example and not an endorsement. Other CMMS software tools may have analogous capabilities.

4.4.2.1 How-to import COBie format data into Maximo

The following video discusses importing COBie data into Maximo.

- BIM MAXIMO DEMO Part1 (4:43 minutes) (https://www.youtube.com/watch?v=142WRvF7R0k)

5 THE 1801 DATA SPECIFICATION AND EXAMPLE CONTENT DOCUMENTS

In order to facilitate the data exchanges and management of information needed to support a BIM Asset Management Program, a detailed specification of all Data Elements that comprise this information is

required. This type of data specification is at the heart of Building Information Modeling. Unambiguously documenting this specification requires knowledge of how data is defined and structured in the world of computer software applications.

The 1801-RP ASHRAE Online BIM Data Exchange Protocols have been documented in both spreadsheet and XML/XSD formats. This section describes these documents.

5.1 1801 XML/XSD Conceptual Data Organization

The organization diagram in Figure 2 illustrates the structure of the primary data groups contained in the 1801 XML schema (XSD). Data content contained in an XML document based on the 1801 XSD will conceptually follow this structure, although with slightly different details as discussed below.

Note that this XSD structure is not the only manner in which this equipment data can be organized. Relational data properties have been included that can be used to infer a topological data structure that defines the physical or logical layout of equipment components that make up an HVAC&R equipment system. This topological data structure is illustrated in Figure 3 and described in Section 5.2.

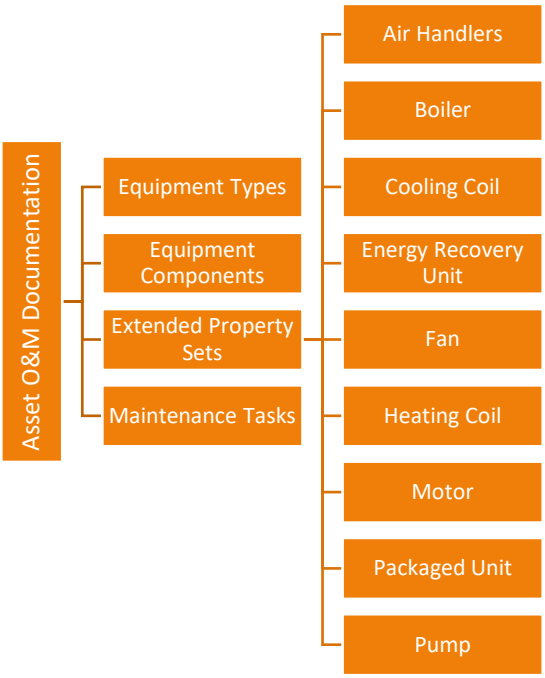

Figure 2. Data organization diagram for 1801 spreadsheet and XML/XSD Data Groups

5.2 1801 Data Groups and Data Elements

Data Elements (properties, see Section 5.4) are collected into Data Groups within the *OM-10 Manage Asset O&M Documentation* spreadsheet (1801-RP-a, 2020) and the *1801-RP Asset O&M Documentation Schema* (1801-RP-b, 2020). In BIM object-oriented terms, Data Groups correspond to Objects, while Data Elements correspond to Properties. This provides structure to the overall data set that can be easily mapped to object-oriented, relational database, or other data structures such as XML schemas.

The primary Data Groups that make up the information content illustrated in Figure 2 above are shown in the table below.

Table 3. Primary Data Groups for 1801 Asset O&M Documentation

Data Group Name	Definition
Asset O&M Documentation	Asset O&M documentation for an entire facility. This is an umbrella Data Group for other 1801 Data Groups
Equipment Type	Properties for unique types of equipment installed in a facility. These properties are common to all instances of each type of equipment installed in a facility.
Equipment Component	Properties for each instance of a type of equipment installed in a facility. These properties are unique to each component instance in the facility.
Extended Property Sets	Properties for each instance of an equipment component of a particular type installed in a facility. These properties are unique to the type of equipment, and so there is a different extended property set for each 1801 equipment type: air handler, boiler, cooling coil, energy recovery unit, fan, heating coil, motor, packaged unit, and pump.
Maintenance Task	Routine maintenance task description that applies to a given equipment type.

5.3 Topological Structure of Data Groups

Figure 3 below illustrates the potential topological (relational) data structure of 1801 Data Groups. It is not critical to fully understand this data structure unless you are the person tasked with implementing it in a data repository such as a relational database or CMMS. However, it may be helpful to understand how HVAC&R systems can be represented as a topology of equipment components.

The overall Asset O&M Documentation data set is contained within the *Asset O&M Documentation* Data Group similarly to the data organization in Figure 2. So called c*ontainment* relationships are shown in Figure 3 using black single line arrow connectors.

Another type of relationship is one created by *association. Association* relationships are shown in Figure 3 using blue double line arrow connectors. An example of an association relationship is one between *Equipment Component* and *Equipment Type*. *Equipment Type* defines properties that are common to all pieces of equipment of a certain type, for example, that have the same *Manufacturer* and *Model Number*. *Equipment Component* defines properties that are unique to each individual piece of equipment, such as *Serial Number* and *Installation Date*. To avoid having to repeat *Manufacturer* and *Model Number* for each *Equipment Component* in a facility, a database would have one *Equipment Type* database entry (record) for an air handler manufactured by "***AirFlow Inc.***" with *Model Number* "***XYZ123***," while each air handler instance of that type in the facility would have its own *Equipment Component* database entry with unique *Serial Number* and *Installation Date* property values. Each of those air handlers would have an association relationship with its *Equipment Type*. The association relationship can also be used to associate an Extended Property Set containing properties unique to each instance of the Air Handler equipment type.

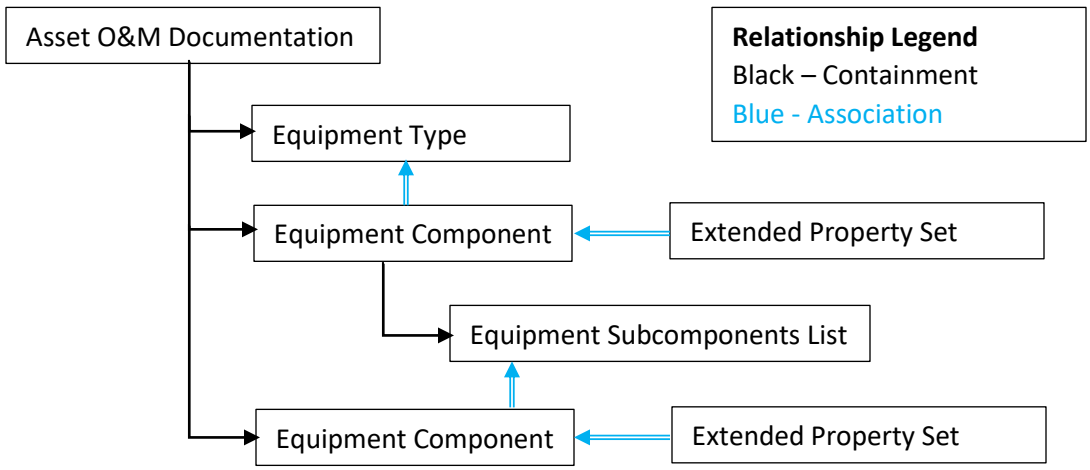

Figure 3. Relational structure of Data Groups

5.4 1801 Relationship Data Elements

Properties of each of the above Data Groups are referred to as Data Elements. For a detailed listing and description of all 1801 Data Elements, see the *OM-10 Manage Asset O&M Documentation* spreadsheet, specifically the *Data Elements* worksheet tab. Examples of these overall Data Elements are discussed in more detail in Section 5.5.

Structuring groups of Data Elements into a coherent set of information requires data modeling concepts that relate groups to each other. There are two important types of Data Elements that are used for this purpose and warrant further explanation: *Unique ID*, and *Key Reference* relationships.

5.4.1 Unique ID Data Elements

The first Data Element (property) in each Data Group in the OM-10 spreadsheet is named *Unique ID*. These properties are used to uniquely identify each instance of a given Data Group. That is, when a user creates (instantiates) a new instance of the *Equipment Type* Data Group, its *Unique ID* property is assigned an appropriately unique identification number. Ideally, unique identification numbers are algorithmically generated so that they are indeed unique. Using a simple text string value such as “My Pump Type” is not recommended since it is not guaranteed to be unique across all instances of the *Equipment Type* Data Group.

5.4.2 Key Reference Relationship Data Elements

Unique IDs are then used to create *association* relationships between Data Group instances through key references. For example, an instance of *Maintenance Task* can be *associated* with the instance of *Equipment Type* on which it is to be performed, by using the *Maintenance Task: Equipment Type Unique ID Reference* property. This key reference supports what is known as a many-to-one relationship; so that multiple *Maintenance Tasks* can be associated with a given *Equipment Type*.

Key references can also be used to represent *containment* relationships. The *Asset O&M Documentation: Equipment Type List* property is an example of this, whereby all instances of *Equipment Type* are contained in *Asset O&M Documentation* through a list of their *Unique ID*s.

All key reference relationship Data Elements are highlighted in the OM-10 spreadsheet using a light-green color for easy identification. Figure 3 illustrates the relationships between Data Groups created by various key reference relationships.

5.5 1801 Data Elements Specification Example

A partial example of Data Elements that make up the Equipment Type Data Group are shown in Figure 4. Each data element has a name, description, data type, and unit of measure. If applicable, the data mapping to the COBie information exchange specification is also show for each data element. This mapping facilitates transforming data in the 1801 format to the COBie format.

Data Group	Data Element Name	Description	Data Type	Units	COBie Mapping
Equipment Type		Properties for unique types of equipment installed in a facility. These properties are common to all instances of each type of equipment installed in a facility.			COBie.Type
	Unique ID	Unique identifier	UUID	N/A	COBie.Type.Name
	Equipment Type Name	1801-RP type of equipment	Enumeration		COBie.Type.Description
	Manufacturer	Manufacturer of the equipment type	String	N/A	COBie.Type.Manufacturer
	Model Number	Model number of the equipment type	String	N/A	COBie.Type.ModelNumber
	Voltage	Voltage of the equipment type	Real	Volts	COBie.Attribute.Voltage

Figure 4. Equipment Type Data Element Example

A partial example of Data Elements that make up the Equipment Component Data Group are shown in Figure 5. Note that the Equipment Type Unique ID Reference data element is used to associate an instance of Equipment Component with its corresponding Equipment Type instance by referencing the Equipment Type Unique ID.

Equipment Component		Properties for each instance of a type of equipment installed in a facility. These properties are unique to each component instance in the facility.			COBie.Component
	Unique ID	Unique identifier	UUID	N/A	COBie.Component.Name
	Equipment Component Name	Name of a component of equipment that is installed in a system (pump1, chiller2, cooling tower7, etc.)	String	N/A	COBie.Component.Description
	Equipment Type Unique ID Reference	Referenced Unique ID of the type of equipment for this component.	UUID	N/A	COBie.Component.TypeName
	Space	Unique ID of the building Space within which this component is located	String	N/A	COBie.Component.Space

Figure 5. Equipment Component Data Element Example

Lastly, a partial example of Data Elements that make up the Air Handler Extended Property Set is shown in Figure 6. Note that the Equipment Component Unique ID Reference data element is used to associate an instance of Air Handler with its corresponding Equipment Component instance by referencing the Equipment Component Unique ID.

Air Handler Component Property Set		Extended properties unique to each air handler instance in the facility.			COBie.Component Also see COBie.Attribute

	Unique ID	Unique identifier	UUID	N/A	COBie.Component.Name
	Equipment Component Unique ID Reference	Referenced Unique ID of the associated component instance.	UUID	N/A	COBie.Attribute
	Heating Medium	Heating medium	Enumeration		COBie.Attribute Coil Heating Medium
	Total Heating Capacity	Total Heating Capacity	Real	MBTU/hr	COBie.Attribute Coil Capacity W

Figure 6. Air Handler Extended Property Set Data Element Example

By associating the three data groups illustrated above using Unique ID references, a complete set of data elements for an instance of Air Handler includes Equipment Type, Equipment Component, and Extended Property Set properties that fully document the Air Handler.

This same Data Group and Data Element structure has been created in the *1801-RP Asset O&M Documentation Schema* XML Schema (1801-RP-b, 2020) available for download from the ASHRAE data portal.

5.6 1801 Data Content Example

An important distinction needs to be understood between a *data structure specification* and a *data content instance*. The OM-10 spreadsheet and the 1801-RP Asset O&M Documentation Schema define the *data structure* for asset documentation; defining for example that *Manufacturer* and *Model Number* are properties of *Equipment Type*. When a user creates (instantiates) a data set for a given building, this data set is referred to as a *data content instance*. In a data content instance, each property is assigned a value. So, for example, *Manufacturer* may be assigned the value "AirFlow Inc." and *Model Number* assigned "XYZ123". This distinction is true whether the data structure is documented in a spreadsheet such as the OM-10 spreadsheet, and an instance is created in spreadsheet format, or the data structure is formalized in an XML schema such as the 1801-RP Asset O&M Documentation Schema and instances are created in XML format.

Data Content instance examples are also available for download from the ASHRAE data portal. A partial example of the data content spreadsheets that correspond to the data structure spreadsheets in Section 5.5 figures are shown below.

Unique ID	Equipment Type Name	Manufacturer	Model Number	Voltage
UUID	Enumeration	String	String	Real
N/A		N/A	N/A	Volts
c3e652c2-b310-11e9-a2a3-2a2ae2dbcce4	AirHandler	MAFNA Air Technologies	15.2202-CGH-AHU-1	120.0

Figure 7. Air Handler Equipment Type Data Content Example

Unique ID	Equipment Component Name	Equipment Type Unique ID Reference	Space
UUID	String	UUID	String
N/A	N/A	N/A	N/A
9ba8eede-ae68-11e9-a2a3-2a2ae2dbcce4	AirHandler-1	c3e652c2-b310-11e9-a2a3-2a2ae2dbcce4	Mechanical Room

Figure 8. Air Handler Equipment Component Data Content Example

Unique ID	Equipment Component Unique ID Reference	Heating Medium	Total Heating Capacity
UUID	UUID	Enumeration	Real
N/A	N/A		MBTU/hr
68a89d04-ae68-11e9-a2a3-2a2ae2dbcce4	9ba8eede-ae68-11e9-a2a3-2a2ae2dbcce4	steam	2608

Figure 9. Air Handler Extended Property Set Data Content Example

Note that the Unique ID reference values in the above examples associate the AirHandler-1 component to its corresponding AirHandler equipment type, and the extended property set to the AirHandler-1 component. In this same fashion, if multiple air handler instances of the same type were installed in a facility, there would be multiple rows of data in the Equipment Component and Extended Property Set tables referencing the same Equipment Type Unique ID.

Matching data content examples in XML format that validate against the *1801-RP Asset O&M Documentation Schema* XML Schema are also available for download from the ASHRAE data portal.

5.7 MAPPING TO COBIE

There are existing BIM Standards that address facility asset management program information. The principal open standard for this purpose in use today is the Construction Operations Building information exchange (COBie, 2020). The following information is given to facilitate transforming data from the 1801 data specification to COBie.

The *OM-10 Manage Asset O&M Documentation* spreadsheet contains a preliminary mapping to the COBie spreadsheet format as illustrated in the figures in Section 5.5. This COBie Mapping is contained in the 9th column (Column I) of the Data Elements worksheet. The corresponding COBie worksheet is shown for each Data Group. For example, the *Equipment Type* Data Group maps to the COBie.Type worksheet, while the *Equipment Component* Data Group maps to the COBie.Component worksheet.

Note that COBie uses the Name property as the "primary key" identifier for each instance on a COBie worksheet. This Name property is then used to represent relationships between worksheets such as COBie.Component.TypeName to COBie.Type.Name relationships. This requires that the Name entry be unique for each instance on a worksheet. The *OM-10 Manage Asset O&M Documentation* spreadsheet instead uses the *Unique ID* Data Element in each Data Group for this purpose, and generally does not include a Name Data Element. Therefore, to map OM-10 Data Groups to COBie worksheet objects, you should map the COBie Name property with the OM-10 *Unique ID* value for each instance. This will assure that the relationships in an OM-10 data set are consistent with a COBie mapping.

There is also a COBie ExtIdentifier (External Identifier) property on each COBie worksheet. This external identifier is commonly the Unique ID that has been assigned by a creating software application to each instance (record/row) on that worksheet. You should populate this COBie property with the same value used to populate the OM-10 *Name* property to provide consistency when mapping data between applications.

Note that COBie also uses email addresses from the COBie.Contact worksheet as unique identifiers of contacts like Manufacturer and Warrantor. If you are planning to use mappings between your data and

COBie, you need to also populate a Contact list with email addresses that can be used for these key reference Data Elements.

Mappings are also shown in the OM-10 spreadsheet for those Data Elements that correspond directly to a matching COBie property. For example, the *Model Number* Data Element in the *Equipment Type* Data Group maps to COBie.Type.ModelNumber.

Many Data Elements in the *OM-10 Manage Asset O&M Documentation* spreadsheet do not map directly to COBie properties. For these cases, COBie provides an approach to capturing extended properties in the COBie Attribute worksheet. Relationship references are made on the COBie Attribute worksheet to support linking any Attribute with entries on other COBie worksheets. For example, to map an *Equipment Type Vendor Agent* Data Element to COBie, create a record in the COBie.Attribute worksheet with COBie.Attribute.Name = "Vendor Agent", COBie.Attribute.SheetName = "Type", COBie.Attribute.RowName = *Unique ID* for the correct *Equipment Type*, and COBie.Attribute.Value = *Vendor Agent* for the correct *Equipment Type*.

Obviously, this type of mapping between data sets in two different data structures should be automated for ease and accuracy of data transfer. This type of automation can be encoded programmatically (e.g., spreadsheet macros or standalone program code) or using BIM technologies like XSLT (eXtensible Stylesheet Language Transformations). The details of such transformation encoding are beyond the scope of this guide.

6 REFERENCES

1801-RP-a, 2020. *OM-10 Manage Asset O&M Documentation*, http://data.ashrae.org/1801rp/OM-10%20Manage%20Asset%20O&M%20Documentation%2020190917.xlsx

1801-RP-b, 2020. *1801-RP Asset O&M Documentation Schema*, http://data.ashrae.org/1801rp/1801RPAssetOMDocumentation.xsd

1801-RP-c, 2020. *1801-RP User Guide Video Playlist*, https://www.youtube.com/watch?v=Vq7KOraqMDM&list=PL9CNkb2HmnFZyPT7EcjHv-8fyApRzXUHu

COBie, 2020. Construction Operations Building Information Exchange, https://www.nibs.org/page/bsa_cobie

Maximo, 2020. IBM Maximo Asset Management Software, https://en.wikipedia.org/wiki/Maximo_(software)

NIST, 2004. Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry, https://www.nist.gov/publications/cost-analysis-inadequate-interoperability-us-capital-facilities-industry

Revit, 2020. Autodesk Revit Software, https://en.wikipedia.org/wiki/Autodesk_Revit