BIM and COBie for Facility Management

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ABSTRACT

A building which has been modeled by using Building Information Modeling (BIM) software, has a graphical information which is the 3D geometry, and non-graphical information which is the data of this geometry.

This data can be exported in many formats like Construction Operations Building Information Exchange (COBie) format to use it in Facility Management (FM) and Operation & Maintenance (O&M) during the building life cycle.

Key Words: BIM Building Information, BIM, Modeling, Construction Operations Building Information Exchange, COBie, IFC, 6D, Facility Management, FM, Operation and Maintenance, O&M, Facility Lifecycle, buildingSMART, Solibri, Revit

1. INTRODUCTION

Building Information Modeling (BIM) is the process of generating a parametric 3D model that contains data of all the created elements in this model such as dimension, material, thermal specification and its coordinate values (X , Y, Z) in the building.

This BIM model function as shared data resources for all the information about a facility creating a database that can be used during the life cycle of the project.

The building's phases from the beginning of the design until the end of the construction normally takes 2-6 years, whereas the building life span might be 30 years or more, that's way BIM play a significant role to produce an organized data that can be used in managing this building over the long term.

BIM models in contrast to CAD models when making modification in one view its update automatically all the geometry and data in all the views and schedules making sure that these data are always correct and up to date.

2. Facility Lifecycle

The amount of BIM graphical information and data varies from phase to phase during the facility lifecycle.

At the design phase, the graphical information is fundamental and takes the priority; afterwards it starts to decreases when the construction phase starts. During the construction and operation phases, the attribute data starts to increase and takes the priority.

The importance of the Data in BIM increases once a building becomes operational because owners need BIM data more than graphics.

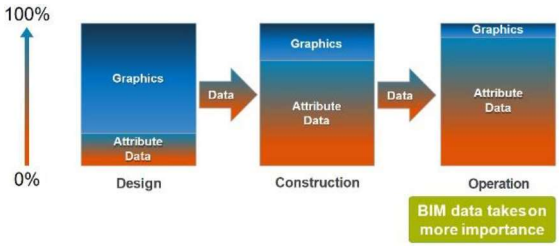


Figure 1: BIM Graphical Information and Attribute Data Importance over Facility Lifecycle

2.1 Facility Lifecycle Costs

The project owners typically focus on the initial costs of their buildings, but after the building is being constructed, they realize that the building operation and maintenance cost much more over the time.

According to Createmaster (2014), which is a company specialist in construction information handover management, and operation & maintenance in the United Kingdom., the construction costs take approximately 24% of the total building costs during its lifetime and the design costs are around 3% while the rest of the costs are taken by operation and maintenance by 73%.

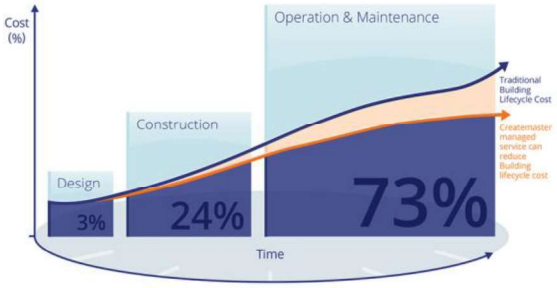


Figure 2: Building Life Cycle Cost Over Time
Source: Createmaster UK

This data would suggest that the facility owners should pay more attention to the Operation and Maintenance (O&M).

There is a long period of time for the owners to receive the design documents that represent the as-built drawing and this waiting period may takes 1 year.

Additionally, the owners should have all the information and specifications of all the equipment that are going to be installed in the project like doors, windows, curtain walls, lighting, and HVAC fixtures. This information come from different subcontractor and may change a lot during the construction which make it difficult sometimes to have the actual information for the installed equipment that reflect the as-built conditions.

In the 2004 National Institute for Standards and Technology (NIST) study analyzing cost of inadequate interoperability in the capital facilities industry found that 15.8 billion dollars each year was spent on interoperability costs in the facilities management industry (Gallaher, Connor, Dettbarn and Gilday, 2004).

The facility's operators and owners carried the majority of the estimated costs, which was around 10.6 billion in 2002. When comparing the costs between the life cycle phases, it has been noticed that higher costs are associated with the operation and maintenance phase than other phases. In Addition, the report also mentioned that postponed costs are mainly related to operators and owners of the facility.

Furthermore, most of the stakeholders pointed out that a unified exchange of electronic data format would reduce the construction and design time.

2.2 6D BIM (Project Lifecycle Information)

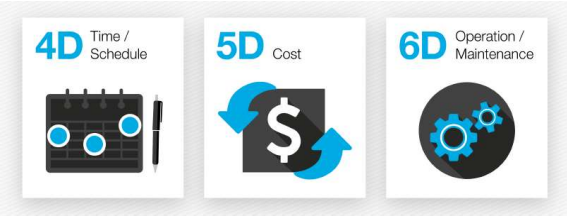


Figure 3: BIM Dimensions

The construction industry usually concentrate on the investment costs of construction. Changing this concentration to understand the cost of the building during its entire life and know where the most costs come from will lead to make better decisions in the long term and from here comes the importance of the 6D BIM.

Accomplishing better business outcomes come from involving the 6D BIM data in supporting facility operation and management.

This data contain all the information about equipment's specifications, how to install this equipment, maintenance schedule, life span and user manuals.

This data should be prepared in the design phase and keep it up to date during the construction then pass it to facility operators to achieve the best results.

An organized and easily accessible data prepared by the facilities operator well reduce the need of maintenance and reduce the cost over the lifetime of the building (Kensek 2015).

2.3 BIM Levels

BIM Levels have been defined within a range from 0 to 3.

COBie is an exchange format that have selected for non-graphical data at BIM level 2 according to the British Standards BS1192:4 COBie UK Implementation (2014).

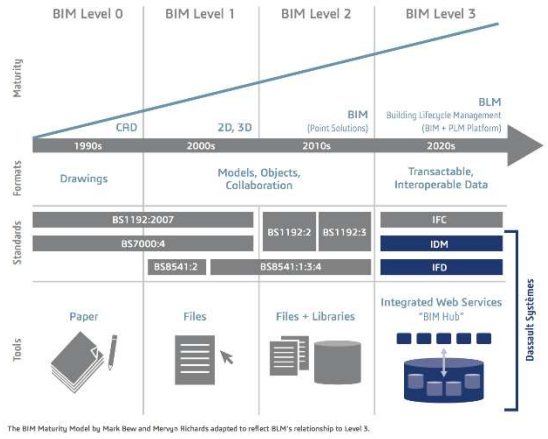


Figure 4: BIM Maturity Levels

In the BSI Little book of BIM (British Standards Institution, 2017) BIM Levels define as follows:

Level 0

Level 0 is the oldest form of drawings, it could be paper drawings or simple digital 2D CAD drawings, and it does not include any type of collaboration.
Most organizations now do not use this level.

Level 1

This level is the most common level nowadays. It is a combination between the 2D CAD and 3D CAD drawings that is shared in electronic format.

These CAD standards are handled by BS 1192:2007.

Level 2

Level 2 is well known by its collaborative form, but this form does not require working in one single shared model.
The collaborative come from the ability exchanged information between different formats.

A BIM model for example has a graphical information, which is the 3D geometry and non-graphical information, which is the data of this geometry that can, shared using the Construction Operations Building Information Exchange (COBie) format

In 2016, the government of the United Kingdom set this way of working as the minimum target to approve accepting any new project in the municipality.

Level 3

Level 3 define a full collaborative forum that require working in one single shared model.

3. COBie

Construction Operations Building Information Exchange (COBie) is an exchange format typically used to export data for manageable assets from Building Information Modeling (BIM) design software into a data format that can be easily imported into Facility Management (FM) and Operations and Maintenance (O&M) software

COBie aid to collect the important project data such as equipment specification lists, warranties, product data sheets, maintenance schedules and life span. This information is crucial to assist operation and maintenance of the facility (Becerik-Gerber, Jazizadeh, Li and Calis, 2012).

One of the biggest benefits of COBie is the growing support for its format after adopting it by the British government as Standards to submit any project in 2016.

3.1 The History of COBie

The United States Army Corps of Engineers developed it in 2007.

In 2011, the US-based National Institute of Building Sciences as part of its National Building Information Model (NBIMS-US) standard approved it.

In 2013, BuildingSMART was working on a lightweight XML format for COBie, COBieLite, which became available for review in April 2013

In 2014, a code of practice regarding COBie was issued as (BS 1192-4:2014 Collaborative production of information Part 4: Fulfilling employer's information exchange requirements using COBie – Code of practice, 2014).

In 2016, the United Kingdom government adopt copy to the minimum target to approve and accept any new project.

3.2 COBie VS Paper Documentation

In traditional projects the building information contained in drawings, and specifications.
These documentation normally handled by paper or in PDF format that are non-organized, difficult to use by facility mangers and sometimes do not reflect the building situation after being constructed.

An organized data format like COBie data which has been exported by BIM software contain up to date information that change automatically when making any change in the drawings, reflect the final as-built drawings and can be used easily by facility mangers (Wang, Bulbul and McCoy, 2015).

3.3 The Use of COBie

During the design phase COBie data can be Collected and captured in the schedules of the design software like Autodesk Revit.
BIM software like Revit make sure that COBie data matches the drawings when exporting.
Contractors consider COBie as an alternative way of construction submittals because of its organized data structure.

One of the most benefits of COBie is the ability to organize the data by using a classification system that provided by the Construction Specifications Institutes such as UniFormat, Omniclass and MasterFormat.

COBie can be handled to the facility mangers by importing it into Computerized Maintenance Management System (CMMS) software or by Microsoft Excel spreadsheet format, which is the most popular or by an IFC format (Lavy and Jawadekar, 2012).

4. COBie and IFC

The COBie spreadsheet is a mapping of the FM Handover View Definition that is a subdivision of the Industry Foundation Classes (IFC) schema, which called Model View Definition (MVD), (NBS BIM Object Standard, Version 1, 2014).

4.1 FM Handover View

buildingSMART developed the FM Handover View to assist exchanging facility management data between building models .
The FM Handover View clarify the overall requirements for design implementations to allow transferring the information to facility management. These requirements have been associated in preceding buildingSMART schemes and were developed according to the latest data exchange requirements (buildingSMART).

4.2 Exchange Requirements (ER)

The Exchange Requirements (ER) clarify the general data requirements among two processes. The processes of the FM Handover are specified by planning, designing, and the beginning of the operation procedure (buildingSMART).

4.3 Model View Definition (MVD)

Model View Definition (MVD) is a subdivision of the Industry Foundation Classes (IFC) schema that is required to fulfill one or several Exchange Requirements (ER) of the Architecture,

Engineering and Construction (AEC) industry.

The Model View Definition transfer the Exchange Requirements (ER) into a specification for a specified exchange format (buildingSMART).

5. COBie

According to the British Standards BS 1192-4:2014, Collaborative production of information Part 4: Fulfilling employer's information exchange requirements using COBie – Code of practice (British Standards Institution, 2014); the COBie structure defines as follow:

5.1 Design

5.1.1 Component
It defines the independent organized physical objects and features, which may need management, like examination, maintenance, repairing and replacement, throughout the operational phase.

5.1.2 Facility
It defines a geographic benefit or different operative built, normally in a part of infrastructure or building in association with details and the geographic location scope of the project chronological.

5.1.3 Floor (region)
It defines a particular portion of space, containing separated horizontal regions, vertical levels, and subdivisions with allocated spaces.

5.1.4 Space (location)
It defines the area type like occupied space, service area and under maintenance area, including unoccupied spaces, but not necessarily isolated spaces.

5.1.5 System
It defines set of Components that can managed and arranged to provide a corporate functions.

5.1.6 Type
It defines the Component specifications such as materials, items and products.

5.1.7 Zone
It defines a group of Spaces, which have a particular Attribute in common, like condition, activity, entry and management.

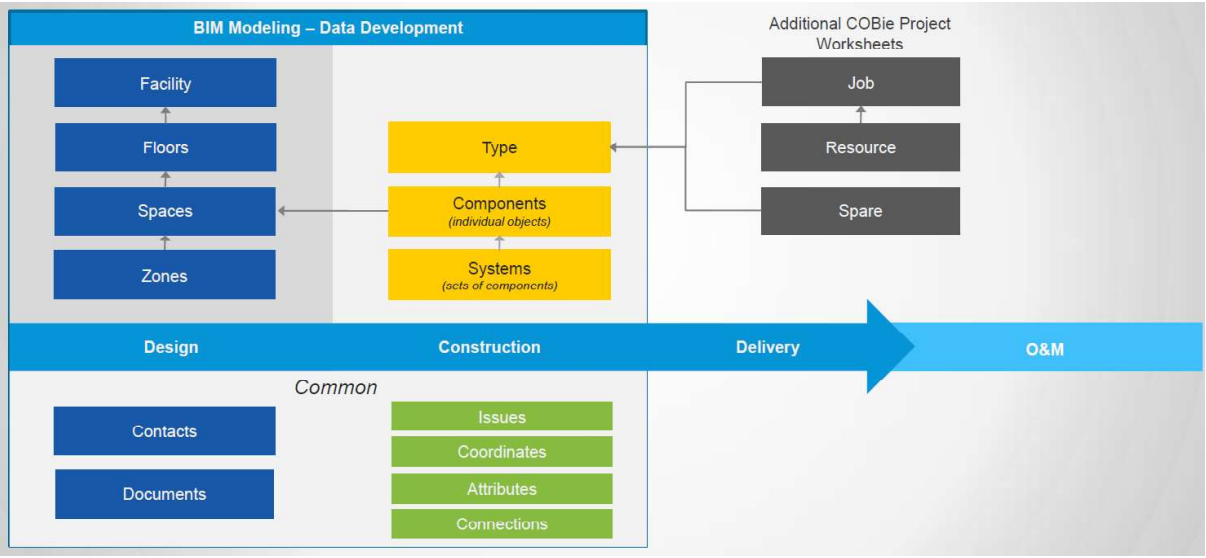


Figure 5: COBie Structure
Source: Autodesk

5.2 Common

5.2.1 Attribute
It defines a particular specification that related to an asset

5.2.2 Connection
It defines a common relationship between two components.

5.2.3 Contact
It defines a person or an association which responsible for the lifecycle of a Facility.

5.2.4 Coordinate
It defines a location related to Component, Space, Floor or Facility.

5.2.5 Document
It defines an external document related to an asset.

5.2.6 Issue
It defines the lake of information or hazard that related to the assets.

5.3 Build

5.3.1 Job
It defines a task that related to Type throughout the operational phase

5.3.2 Resource
It defines an ability or material that is necessary to accomplish a Job.

5.3.3 Spare
It defines a part that related to a Type and can be replaced with another part.

5.4 COBie Data Handover

In reality, not all COBie data are required and it may vary from one projects to another depending on the project requirement.

Furthermore, in order to create a suitable COBie data, the facility owners, designers, engineers, contractors, and facility operators during the pre-design phase, should define their COBie data handover requirements and criteria (National BIM Standard, United States, Version 3, 2015). Like:

1. Who is going to use the data?
   (for example):
   i. Maintenance Personnel.
   ii. Asset Manager.

2. What types of data will be collected?
   (for example):
   i. BIM Project Execution Plan.
   ii. QA/QC Data (Quality Assurance/Quality Control Data).

3. How is data maintained?
   (for example):
   i. The Data will be transferred into Computerized Maintenance Management (CMMS) or Computer-Aided Facility Management (CAFM) software like IBM Maximo.
   ii. The Data will be transferred into Integrated Workplace Management System (IWMS) like IBM TRIRIGA.

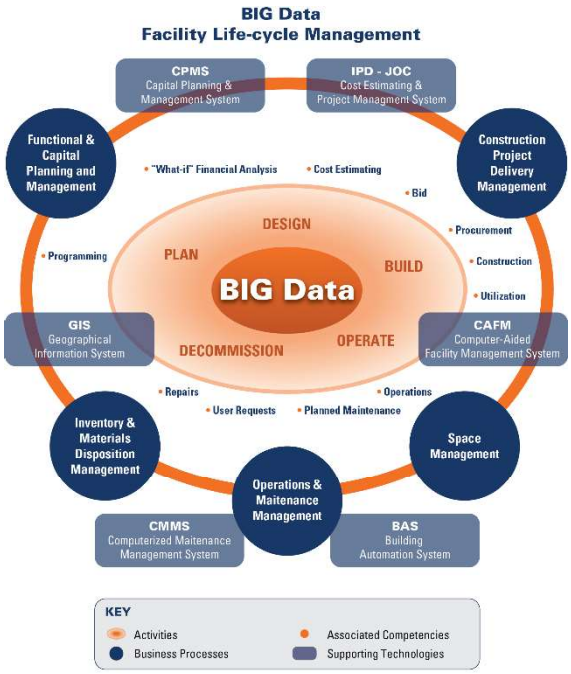


Figure 6: Facility Lifecycle Data Management

6. COBie Extension for Revit

The Autodesk COBie Extension for Revit is an add-in for Autodesk Revit.
It Works on Revit 2013 and later versions.
It configures Revit model to be able to hold and export data in the COBie standard format.
It utilizes shared parameters to hold the data in the model.
These parameters can be customized using the "Custom Parameter Mapping" feature.

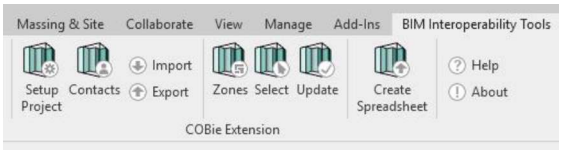


Figure 7: COBie Extension for Revit from the BIM Interoperability Tools Toolbar Menu

6.1 Contacts

Clicking on the Contacts modify button from the BIM Interoperability Tools toolbar menu will open a new window which allow the user to add, edit or delete COBie contacts.

The user will assign the required and optional fields for the Contacts, any missing or incomplete data for the required fields will not be created by the COBie extension.

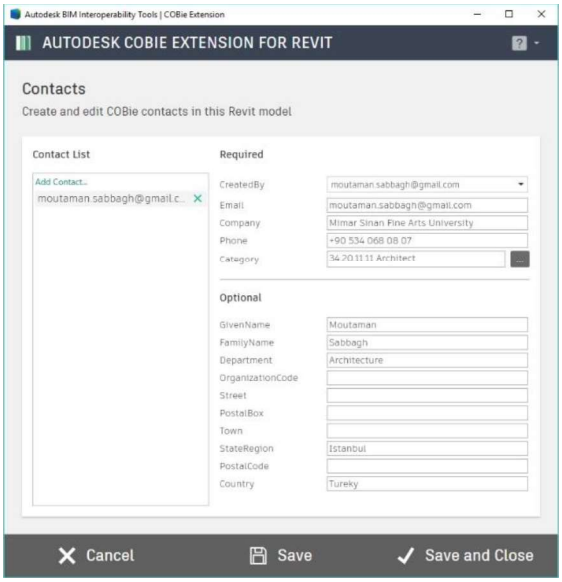


Figure 8: COBie Contacts Window

6.2 Setup Project

The Setup Project will generate the required COBie parameters in the Revit model and apply those parameters to the appropriate elements with the proper data.
Clicking on the Setup Project button from the BIM Interoperability Tools toolbar menu will open a new window, which allows the user to:

- Define the COBie settings.
- Specify properties for the COBie spaces, types, components, systems, attributes, coordinates and schedules for the spreadsheet in the Revit model.
- Define parameter mappings and values for the fields.

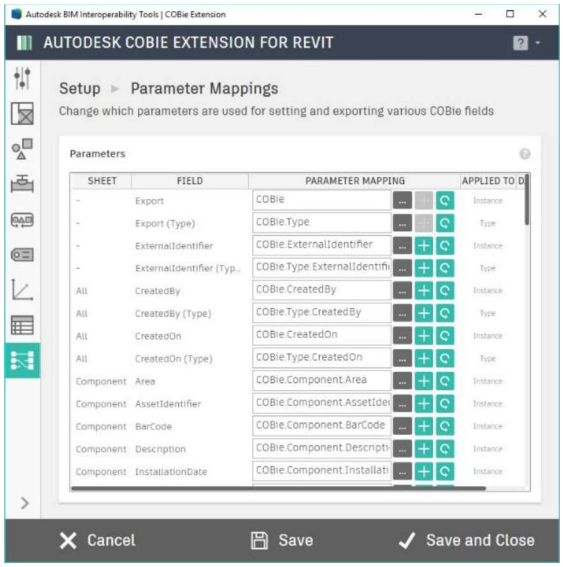


Figure 9: COBie Setup Window, Parameter Mappings

6.3 Zone Manager

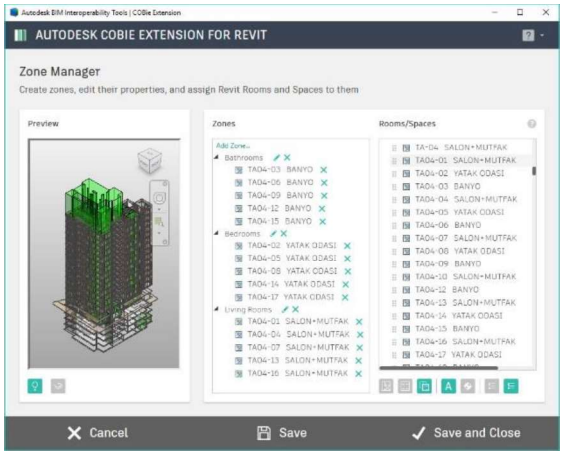


Figure 10: Zone Manager Window

The Zone Manager is based on the classification of Revit elements.
COBie Zones are defined by Revit Rooms and Spaces.

The Zone Manager creates COBie Zones in a hierarchical manner.

6.3 Select

Select allow the user to choose which elements will be exported by preparing a list for the available Revit families, types and elements in the Revit model in order to export them.

When pressing Apply button the tool will check the COBie parameters for the selected families, types and elements.

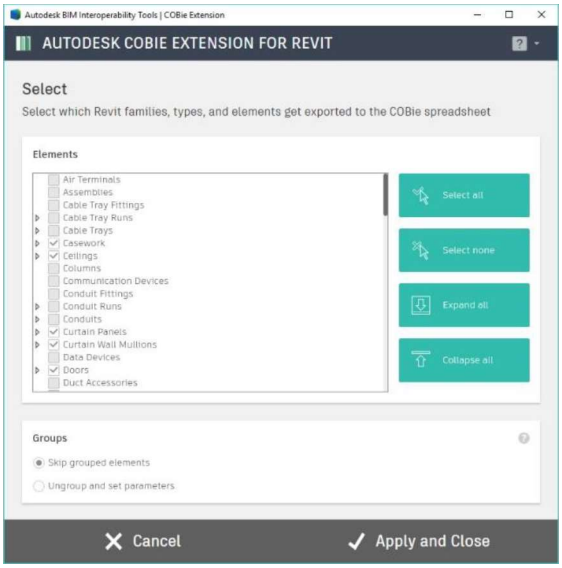


Figure 11: Select Window

6.4 Update

The Update will batch modify values in the COBie fields and create the suitable data by using the settings specified in the setup to assign that data to the COBie Extension parameter or any appropriate mapped parameter.

The user can choose to update all parameter, only blank parameters or skip them.

The elements inside the groups do not allow the customized data to be written at their mapped parameters accurately, that is way the extension give the user two options to fix this issue.
The first option is to skip grouped elements and the second option is to ungroup the elements in order to allow the data to be written correctly.

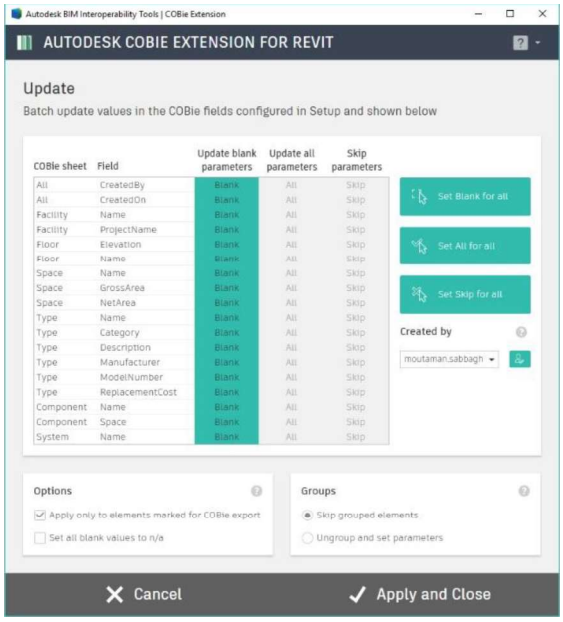


Figure 12: Update Window

6.5 Create Spreadsheet

Clicking on the COBie Create Spreadsheet button from the BIM Interoperability Tools toolbar menu will open a new window that allows the user to export the COBie spreadsheet as a Microsoft Excel document according to the settings configured in the previous steps.

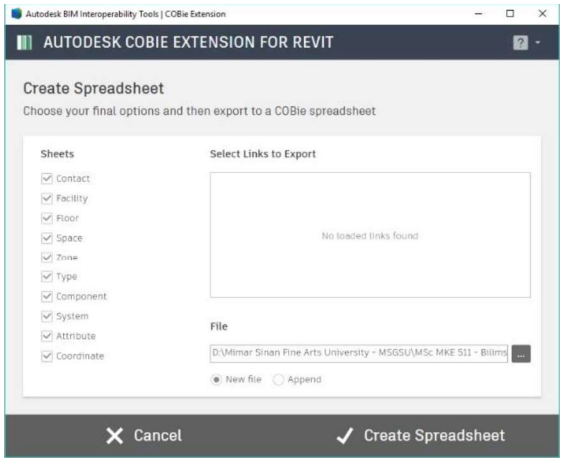
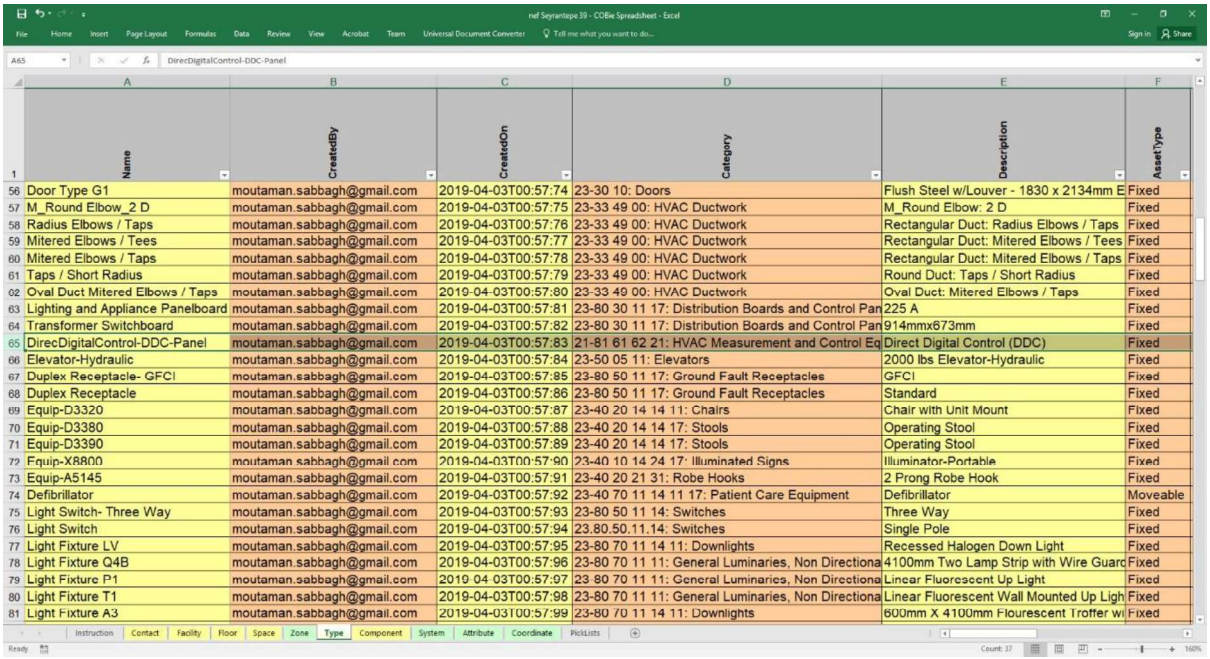


Figure 13: Create Spreadsheet



	Name	CreatedBy	CreatedOn	Category	Description	AssetType
56	Door Type G1	moutaman.sabbagh@gmail.com	2019-04-03T00:57:74	23-30 10: Doors	Flush Steel w/Louver - 1830 x 2134mm E	Fixed
57	M_Round Elbow_2 D	moutaman.sabbagh@gmail.com	2019-04-03T00:57:75	23-33 49 00: HVAC Ductwork	M_Round Elbow: 2 D	Fixed
58	Radius Elbows / Taps	moutaman.sabbagh@gmail.com	2019-04-03T00:57:76	23-33 49 00: HVAC Ductwork	Rectangular Duct: Radius Elbows / Taps	Fixed
59	Mitered Elbows / Tees	moutaman.sabbagh@gmail.com	2019-04-03T00:57:77	23-33 49 00: HVAC Ductwork	Rectangular Duct: Mitered Elbows / Tees	Fixed
60	Mitered Elbows / Taps	moutaman.sabbagh@gmail.com	2019-04-03T00:57:78	23-33 49 00: HVAC Ductwork	Rectangular Duct: Mitered Elbows / Taps	Fixed
61	Taps / Short Radius	moutaman.sabbagh@gmail.com	2019-04-03T00:57:79	23-33 49 00: HVAC Ductwork	Round Duct: Taps / Short Radius	Fixed
62	Oval Duct Mitered Elbows / Taps	moutaman.sabbagh@gmail.com	2019-04-03T00:57:80	23-33 49 00: HVAC Ductwork	Oval Duct: Mitered Elbows / Taps	Fixed
63	Lighting and Appliance Panelboard	moutaman.sabbagh@gmail.com	2019-04-03T00:57:81	23-80 30 11 17: Distribution Boards and Control Pan	225 A	Fixed
64	Transformer Switchboard	moutaman.sabbagh@gmail.com	2019-04-03T00:57:82	23-80 30 11 17: Distribution Boards and Control Pan	914mmx673mm	Fixed
65	DirecDigitalControl-DDC-Panel	moutaman.sabbagh@gmail.com	2019-04-03T00:57:83	21-81 61 62 21: HVAC Measurement and Control Eq	Direct Digital Control (DDC)	Fixed
66	Elevator-Hydraulic	moutaman.sabbagh@gmail.com	2019-04-03T00:57:84	23-50 05 11: Elevators	2000 lbs Elevator-Hydraulic	Fixed
67	Duplex Receptacle- GFCI	moutaman.sabbagh@gmail.com	2019-04-03T00:57:85	23-80 50 11 17: Ground Fault Receptacles	GFCI	Fixed
68	Duplex Receptacle	moutaman.sabbagh@gmail.com	2019-04-03T00:57:86	23-80 50 11 17: Ground Fault Receptacles	Standard	Fixed
69	Equip-D3320	moutaman.sabbagh@gmail.com	2019-04-03T00:57:87	23-40 20 14 14 11: Chairs	Chair with Unit Mount	Fixed
70	Equip-D3380	moutaman.sabbagh@gmail.com	2019-04-03T00:57:88	23-40 20 14 14 17: Stools	Operating Stool	Fixed
71	Equip-D3390	moutaman.sabbagh@gmail.com	2019-04-03T00:57:89	23-40 20 14 14 17: Stools	Operating Stool	Fixed
72	Equip-X8800	moutaman.sabbagh@gmail.com	2019-04-03T00:57:90	23-40 10 14 24 17: Illuminated Signs	Illuminator-Portable	Fixed
73	Equip-A5145	moutaman.sabbagh@gmail.com	2019-04-03T00:57:91	23-40 20 21 31: Robe Hooks	2 Prong Robe Hook	Fixed
74	Defibrillator	moutaman.sabbagh@gmail.com	2019-04-03T00:57:92	23-40 70 11 14 11 17: Patient Care Equipment	Defibrillator	Moveable
75	Light Switch- Three Way	moutaman.sabbagh@gmail.com	2019-04-03T00:57:93	23-80 50 11 14: Switches	Three Way	Fixed
76	Light Switch	moutaman.sabbagh@gmail.com	2019-04-03T00:57:94	23.80.50.11.14: Switches	Single Pole	Fixed
77	Light Fixture LV	moutaman.sabbagh@gmail.com	2019-04-03T00:57:95	23-80 70 11 14 11: Downlights	Recessed Halogen Down Light	Fixed
78	Light Fixture Q4B	moutaman.sabbagh@gmail.com	2019-04-03T00:57:96	23-80 70 11 11: General Luminaries, Non Directiona	4100mm Two Lamp Strip with Wire Guard	Fixed
79	Light Fixture P1	moutaman.sabbagh@gmail.com	2019-04-03T00:57:97	23-80 70 11 11: General Luminaries, Non Directiona	Linear Fluorescent Up Light	Fixed
80	Light Fixture T1	moutaman.sabbagh@gmail.com	2019-04-03T00:57:98	23-80 70 11 11: General Luminaries, Non Directiona	Linear Fluorescent Wall Mounted Up Ligh	Fixed
81	Light Fixture A3	moutaman.sabbagh@gmail.com	2019-04-03T00:57:99	23-80 70 11 14 11: Downlights	600mm X 4100mm Flourescent Trotter wi	Fixed

Figure 14: COBie Excel Spreedsheet after Exporting

6.6 Export COBie Data as an IFC format

The COBie spreadsheet is a mapping of the IFC FM Handover View, that enable the handover of facility management information (BSI Little book of BIM, 2017)

The COBie data can be exported as IFC format by using the Revit IFC export feature and select the IFC2×3 COBie 2.4 Design Deliverable View.

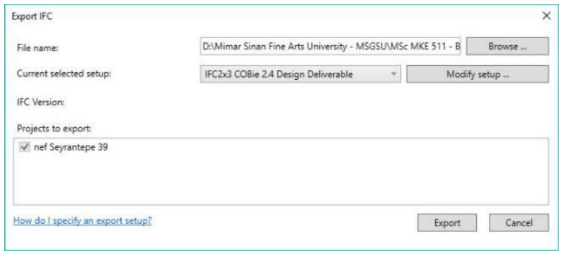


Figure 15: Revit IFC2×3 COBie 2.4 Design Deliverable View Exporter

To make sure that the COBie data was exported correctly as an IFC format, IFC and COBie data validation was made by importing the IFC file that has been exported by Revit into Solibri Model Checker (SMC), which is BIM-based software for checking the BIM and IFC models.

The validation results showed that COBie parameters and their fields' values had been exported correctly (see the Figure 19 below).

However, the fields that has been left blank without adding any value has not been exported.

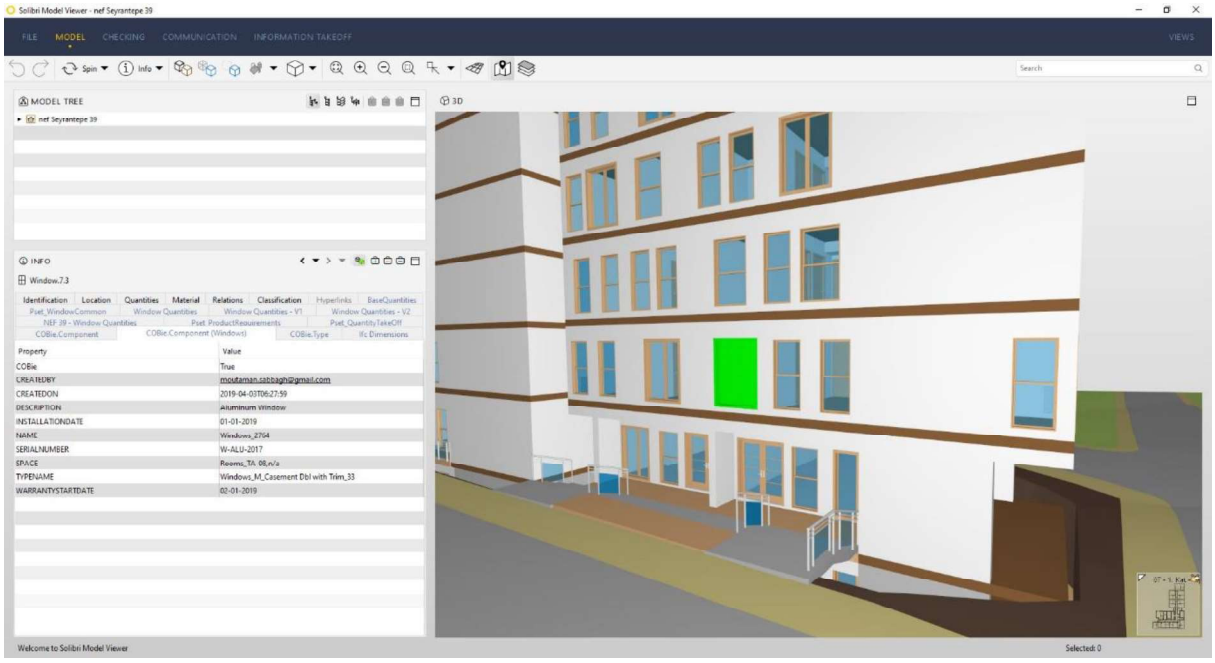


Figure 16: IFC and COBie data validation using Solibri

7. Conclusion

The use of Building Information Modeling (BIM) for database source and Construction Operations Building Information Exchange (COBie) as a data format proved to be a beneficial for the Facility Management (FM) Operations & Maintenance (O&M).

COBie helps to capture and record the project data such as equipment specifications, warranties, product data sheets, and maintenance schedules during the building design and construction phase in organized form, which help to reduce the cost of maintenance and save cost during the building life cycle.

However, to get the maximum benefits of COBie, the facility owners, designers, engineers, contractors, and facility operators should define their COBie data handover requirements during the pre-design phase.

In addition, it is important to start creating and organizing the COBie data from the early stages of design phase and keep it up to date in the construction phase until it is delivered to the facility operators.

COBie data can be organized by using a classification system that provided by the Construction Specifications Institutes such as UniFormat, Omniclass and MasterFormat.

Furthermore, COBie data can be easly captured and generated by using BIM software like Revit. This insure that the COBie data will be up to date because it automatically remodified when making any changes.

Finally, COBie data can be exported in two formats, the first one as Microsoft Excel spreadsheet format, which is the most popular and the second one as IFC format under FM Handover View Definition, that enable the handover of facility management information, then it can be imported into FM and O&M software.

8. References

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