BIM Uses on test projects

A guide on understanding and selecting BIM uses
Sept. 2020
1 Background and purpose

BIMinfra has initiated a development project on defining BIM uses applicable to coming BIM projects in Banedanmark and Vejdirektoratet and in the industry in general. The purpose of this development project has been to investigate existing BIM uses in the industry, both abroad and locally in Denmark. Based on this analysis we have defined the best approach to BIM uses for BIM infra. This document is intended to be used on coming test projects in BIM infra and later updated to become a BIMinfra standard used on all projects in the two organizations.

For the BIM uses to be fully integrated in the organizations of Banedanmark and Vejdirektoratet, a more thorough investigation on existing business-processes should be conducted in order to establish an AS-IS picture of the existing process landscape and then analyse how to gradually develop this picture into a more BIM and digital integrated TO-BE landscape. An example could be existing requirements to review process, revision procedures and QA documentation requirements. All these requirements must eventually be integrated and/or supported by different BIM uses in this example design review and design authoring plus more. Along this process the organizations should consider updating their value chains and analogue documentation requirements, so that these are more up to date with a digital, automated setup and agile project execution. This would also require looking at a new IT target architecture, that could support the flow of information and documentation. The BIM uses can however be used on projects without revising internal existing processes, if potential conflicts are highlighted and handled on the specific projects within in the commercial requirements and legal framework associated with these projects. It is also recommended that a competence development strategy is established, in order to properly implement BIM uses in all departments affected by the new digital processes.

Figure 1: To fully integrate BIM uses the existing methods, requirements and procedures of an organization should be revised and integrated in all BIM uses.

Until now the infrastructure industry in Denmark, has not had a common standard on how to apply BIM uses within a project. It has been decided from involved parties, to
develop a common procedure for this. BIMinfra has been working on standardization of Banedanmark and Vejdirektoratet requirements to BIM Uses in a taskforce called “BIM uses and BIM Maturity”.

The first task was to define a common understanding of how to setup BIM uses in a structured way using BPMN visualization. This also included the understanding of process maps and current requirements to existing processes, their history and the impact of implementation in the organizations of Banedanmark and The Road Directorate.

The next task was to find and study existing standards concerning BIM uses, and then analyse the best match for the Danish infrastructure sector. A survey\(^1\) incl. 12 questions was conducted in the Danish infrastructure market to investigate whether Danish companies were working in any structured way in relation to BIM uses. The result concluded that the few companies working with BIM uses in Denmark, mostly referred to Penn State University and their material on BIM uses\(^2\). It was decided to use Penn States approach on BIM uses as basis for the BIM infra development project.

2 Introduction to BIM uses

BIMinfra has worked on a set of BIM uses (processes) that can be applied to projects and test projects in the organizations or in the industry in general. A BIM use is defined as a method of applying building information modelling during an asset’s lifecycle to achieve one or more specific objectives. The BIM Execution Plan or ICT process manual (BEP or ICT) should provide a structured method for planning the implementation of BIM uses on a project.

The procedure from Penn State University includes the following three steps:

1. Identify high-value BIM uses during the project planning, design, construction and operational phases.
2. Design the BIM execution process by creating process maps (layouts already in appendix to this document)
3. Define the BIM deliverables (BIM use output) in the form of information exchanges and formulate this into a delivery specification.

The Penn State BIM uses consists of 24 uses (processes) that can be applied in one or several phases of a project. Visualization has been added as a 25\(^{th}\) BIM use after discussion in the development team.

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\(^1\) [https://forms.office.com/Pages/ResponsePage.aspx?id=OBW-Edh5OUnmCulndgF2ZCW3QZ0EyvgFJphgubO6zaORUNVYwTjFLRGE2RTJaQTMzSFo2U0I0ODZIIVS4u](https://forms.office.com/Pages/ResponsePage.aspx?id=OBW-Edh5OUnmCulndgF2ZCW3QZ0EyvgFJphgubO6zaORUNVYwTjFLRGE2RTJaQTMzSFo2U0I0ODZIIVS4u)

\(^2\) [https://www.bim.psu.edu/](https://www.bim.psu.edu/)
<table>
<thead>
<tr>
<th>#1</th>
<th>Plan</th>
<th>Design</th>
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<th>Operations</th>
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<tr>
<td>#2</td>
<td>Existing Conditions Modeling</td>
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<td>#3</td>
<td>Scheduling (4D)</td>
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<td>#4</td>
<td>Programming</td>
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<td>#5</td>
<td>Site Analysis</td>
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<td>#13</td>
<td>3D Coordination</td>
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<td>#14</td>
<td>Site Utilization Planning</td>
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<td>#15</td>
<td>Construction System Design</td>
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<td>#16</td>
<td>Digital Fabrication</td>
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<td>#17</td>
<td>3D Control and Planning</td>
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<td>#18</td>
<td>Maintenance Scheduling (7D)</td>
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<td>#19</td>
<td>Record Model</td>
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<td></td>
<td>Building System Analysis</td>
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<td>#21</td>
<td>Space Mgmt/Tracking</td>
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<tr>
<td>#22</td>
<td>Disaster Planning</td>
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</tbody>
</table>

Figure 2: List of BIM uses and the phases where they can occur. Green colour indicates that the Use has been prioritized in the phase 1 of the development project and has been revised in some extend according to figure 1.

Building Information Modeling (BIM) has been defined as “the act of creating a digital model of an asset or a project for the purpose of visualization, engineering analysis, conflict analysis, code criteria checking, cost engineering, as-built product, budgeting and many other purposes”. To foster better communication within the industry, it is important to define a consistent language to describe the focused use of BIM on a project.

The Language of These BIM uses are visualized in the process maps incl. descriptions in the appendix to this document.

BIM infra has scrutinized at the material from Penn state and is in the process of revising these uses to match ISO19650 terms and infrastructure projects in Denmark and the two organizations. In the initial workshop of this project a prioritization was done, and 6 uses was selected for revision in face 1, marked in green in figure 2. It is
suggested to run a phase 2 where 8 more uses will be revised and examples on the first 6 uses will be created. And then a face 3 will include updating the remaining BIM uses and testing all uses prioritized as 1 or 2 (priority is marked in appendix frontpage) on actual infrastructure projects depending on projects available, technological development and the needs on the actual projects. The uses not revised at this state can still be selected as BIM uses on projects. This only means that the projects will have to use the generic tactical uses provided on the use by Penn state University as basis. All 25 uses are listed in the appendix.

Please note that all uses are currently on tactical or strategic level. It is intended that the individual projects update the tactical workflow into operational workflows matching the project setup. BIM Uses can be classified primarily based on their purpose in implementing BIM throughout the life of an asset. In addition to the purpose alone, several other characteristics can be defined to properly identify and communicate a BIM Use. These purposes and characteristics can be defined at varying levels depending upon the level of maturity and detail required for different applications of the Uses. The BIM Use Characteristics allow a user to further define the BIM Use based on common asset and project attributes (Project information requirements and asset information requirements, REF ISO19650) project element, project phase, discipline, and Level of Development (LOD)
Each BIM use has one or more deliverables (the output row)\(^3\) such as information models or documents that either act as input to other BIM uses or as a “physical” deliverable to the Appointing party or another party of the Project team always matching the information requirement specifications set in The BEP/ICT agreement.

Based on the projects overall BIM strategy including the mission, vision, goals and objectives for a project or organization, the planning team should identify the appropriate BIM Uses in an early phase.

Each BIM Use has an initial description, including identified potential values. These values can be used in the initial assessment on how to fulfil the goals of the project.

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\(^3\) See BPMN process maps in appendix
A challenge and opportunity faced early on by planning team is identifying the most appropriate uses for BIM on a project given the project characteristics. Many different traditional tasks and processes can benefit by being replaced or optimized by the implementation of BIM.

**Mission:** Defines the purpose of the project.

**Vision:** The picture of the project after BIM-integration.

**Goals:** Specific aims which the project wishes to accomplish.

**Objectives:** Specific results that, when accomplished, fulfils the goals.

It is recommended that the BIM strategy of a project is defined as early as possible in the project start-up phase. The strategy should be used on the BIM kick-off workshop on the project, where the entire BIM setup is framed.

3 The structure of the proposed BIM uses

The appendix lists the 25 BIM uses where several are still under construction at this moment. Each BIM use consists of

1. A description, on what, when and why.
2. A description on the BIM use
3. Required competencies within the delivery team to execute the BIM use
4. Required applications to execute the BIM use
5. A workflow diagram containing:
   a. Input row (data input necessary to carry out the BIM use, not processed in previous BIM Uses. This data is provided either by appointing party or appointed party (should be agreed in information assignment matrix and information protocol ref. ISO19650)
   b. A workflow for the executing party. including responsibilities for each step in the workflow along with a description for each step
   c. An output row describing the outcome of the BIM use as actual deliveries. The output of a BIM use is measurable and subject to a checklist. the output should always be documented by the executing party. An output either acts as input in other BIM uses or as required data handover to appointing party or third party e.g. contractor.
For better understanding on how to work with and implement BIM uses, it is recommended that the reader studies the framework on this topic provided by Penn State University at https://www.bim.psu.edu/ (some of this framework is described and summarized in section 4 and 5)

### 4 BIM execution plan or ICT process manual

When setting up your BIM project it is important that you have a plan for when to implement different BIM uses and who is responsible for executing the uses, in which phases of the project these will be applied and exactly what output you expect.

1st a BIM kickoff workshop/meeting should be prepared. See section 6. The purpose is to find relevant BIM uses supporting the goals of the project. Next it is decided when to introduce the individual uses to the project.
When this is done it is possible to set up the process maps and detailed data/information delivery plan for each BIM use. and finally, the exchange requirements in the information models should be set. The output either works as delivery to other parties of the project team or as a specific contractual delivery.

**BIM USES – Standardized processes**

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify high-value BIM uses during the project planning, design, construction and operational phases.</td>
<td>Design the BIM execution process by creating process maps (already as defaults in BIM wheel tab).</td>
<td>Define the BIM deliverables in the form of information exchanges.</td>
</tr>
</tbody>
</table>

*Figure 5: Three overall phases when choosing, defining and executing your BIM uses*

The goal for developing this structured procedure is to stimulate planning and direct communication by the project team during the early phases of a project. The team leading the planning process should include members from all the organizations with a significant role in the project. Since there is no single best method for BIM implementation on every project, each team must effectively design a tailored execution strategy by understanding the project goals, the project characteristics, and the capabilities of the team members.

A closer look at phase 1: This is where a value list is created, provided for each BIM use, select the uses that add most value in the specific project. After your organization has defined overall BIM uses you should make a list describing pros and cons for each BIM use so that project managers and BIM managers have a valid basis for selecting the correct uses. Potential values but also team requirements are listed in each BIM use of the appendix to make this task easier.
**BIM USES – Phase 1**

**Phase 1**

Identify high-value BIM uses during the project planning, design, construction and operational phases.

**Figure 6: Phase 1, mapping value to use**

A closer look at phase 2: This is where the processes are defined for the use. Remember these must be supplemented with software specific guides that supports the execution (operationalized)

**BIM USES – Phase 2**

**Phase 2**

Design the BIM execution process by creating process maps (already as defaults in BIM wheel tab).

**Figure 7: Phase 2, Here an example of how 3D coordination could look like in practical use**

A closer look at phase 3: This is where the output and delivery associated with each BIM use is defined. The output—the information model is either a delivery to another party in the project or a delivery to another BIM use that needs the data as basis for its own execution.
BIM USES – Phase 3

Phase 3

Define the BIM deliverables in the form of information exchanges.

Figure 8: Phase 3, defining the output from the BIM uses. This is part of delivery specification or scope of service on the project.

A detailed execution process can be found on Pennstate along with templates supporting the selection, evaluation and analysis of different BIM uses. Additional BIM uses can always be developed to serve a specific goal in the project. A method of doing so is explained in BIM planning execution guide also developed by Penn State. The essential 4 step process of developing, implementing and supporting new BIM uses are outlined in below section

5 BIM implementation plan

This plan outlines a four-step procedure to develop a detailed BIM implementation Plan. The procedure is designed to steer owners, program managers, and early project participants through a structured process to develop detailed, consistent plan for the project. This procedure is later mapped to relevant sections and appendices of the framework of the BEP/ICT and used for both planning and competence development. The four steps, consist of:

1. Identifying the appropriate BIM goals and uses on a project,
2. Designing the BIM execution process,
3. Defining the BIM deliverables,
4. And identifying the supporting infrastructure to successfully implement the plan.

By following the chapters in this document along with the detailed planning guide from Pennstate, it is expected that the goals and supporting BIM uses can be
defined, including the overall success criteria for implementing BIM on any given project

**Figure 9: 4 Step process of selecting implementing and supporting BIM Uses**

**5.1 Identifying the appropriate BIM goals and uses on a project**

One of the most important steps in the planning process is to clearly define the potential value of BIM on the project and for project team members through defining the overall goals for BIM implementation. These goals could be based on project performance and include items such as reducing the schedule duration, achieving higher field productivity, increasing quality, reducing cost of change orders, or obtaining important operational data for the facility. Goals may also relate to advancing the capabilities of the project team members, for example, the owner may wish to use the project as a pilot project to illustrate information exchanges between design, construction and operations or a design team may seek to gain experience in the efficient use of digital design applications. Once the team has defined measurable goals, both from a project perspective and company perspective, then the specific BIM uses on the project can be identified.
<table>
<thead>
<tr>
<th>Priority (1-3)</th>
<th>Goal Description</th>
<th>Potential BIM Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1- Most Important</td>
<td>Value added objectives</td>
<td>Design Reviews, 3D Coordination</td>
</tr>
<tr>
<td>2</td>
<td>Increase Field Productivity</td>
<td>Design Authoring, Design Reviews, 3D Coordination</td>
</tr>
<tr>
<td>1</td>
<td>Increase effectiveness of Design</td>
<td>Record Model, 3D Coordination</td>
</tr>
<tr>
<td>3</td>
<td>Accurate 3D Record Model for O&amp;M</td>
<td>Engineering Analysis, LEED Evaluation</td>
</tr>
<tr>
<td>2</td>
<td>Increase effectiveness of Sustainable Goals</td>
<td>Design Reviews, 3D Coordination</td>
</tr>
<tr>
<td>2</td>
<td>Track project during construction</td>
<td>4D Modeling</td>
</tr>
<tr>
<td>1</td>
<td>Identify issues associated with phasing on campus</td>
<td>4D Modeling</td>
</tr>
<tr>
<td>3</td>
<td>Review Design progress</td>
<td>Design Reviews</td>
</tr>
<tr>
<td>3</td>
<td>Quickly Assess cost associated with design changes</td>
<td>Cost Estimation</td>
</tr>
<tr>
<td>2</td>
<td>Eliminate field conflicts</td>
<td>3D Coordination</td>
</tr>
</tbody>
</table>

*Figure 10: project specific prioritization based on values*

All potential values for each BIM use are listed in the appendix containing BIM uses. The uses are originally developed by Pennsylvania University and are part of the American national building standards (NBIMS).

Once the goals are defined, the project team should identify the appropriate tasks that the team would like to perform using BIM. This analysis of BIM Uses should initially focus on the desired outcomes for the overall process. Therefore, the team should begin with the Operations phase, and identify the value for each of the BIM Uses as it specifically relates to the project by providing a High, Medium or Low priority to each use. The team can then progress to each preceding project phase.

To help facilitate this BIM Use review process, a BIM Selection Worksheet has been developed. This template includes a list of the potential BIM Uses, along with fields to review the value, responsible party, capabilities, additional notes, and the decision from the team on whether to implement the BIM Use. Below is an example only containing 4 uses.
5.2 Designing the BIM execution process (also explained in section 4)

Once the team has identified the BIM Uses, a process mapping procedure for planning the BIM implementation needs to be performed. Initially, a high-level map showing the sequencing and interaction between the primary BIM Uses on the project is developed (see next figure as an example). This allows all team members to clearly understand how their work processes interact with the processes performed by other team members.

![Figure 11: BIM use analysis worksheet](image-url)
After the high-level map is developed, then more detailed process maps should be selected or designed by the team members responsible for each detailed BIM Use. For example, the high-level map will show how the BIM authoring, Design Review, cost estimating, and 4D modeling are sequenced and interrelated. A detailed map will show the detailed process that will be performed executing party. These detailed maps are provided already by BIMintra on tactical level.

5.3 Defining the BIM deliverables

Once the appropriate process maps have been developed, the information exchanges which occur between the project participants should be clearly identified. It is important for the team members, in particular the author and receiver for each information exchange transaction, to clearly understand the information content. This information content for the exchange can be defined in the Information Exchange protocol. It is also possible to use Penn State's information exchange sheet if a standard protocol is not set up on the project itself.
Figure 13: Example on information exchange sheet.

Keep in mind that above sheet must be revised to match Danish terminology discipline definition and the project phases of the specific project. The Current ICT specification from BIM Infra gives the possibility of describing the delivery information exchange through section 2. It is recommended that a table showing the output from each BIM use is integrated to section 2 along with responsible party, receiving party and format of the information delivery. See more on ICT specification through reference list in the end.

5.4 Identifying the supporting infrastructure

After the BIM uses for the project have been identified, the project process maps are customized, and the BIM deliverables are defined, the team must develop the infrastructure needed on the project to support the planned BIM process. This will include the definition of the delivery structure and contract language; defining the communication procedures; defining the technology infrastructure; and identifying quality control procedures to ensure high quality information models. All this should be explained in the Projects BIM execution plan (BEP) or ICT specifications. See reference list in chapter 11 for more info on these.

6 BIM kick off Meeting and other meetings:

The development of the BEP is a collaborative process. Some portions of the procedure, e.g., discussing the overall project goals, are collaborative tasks, while other portions, e.g., defining the required file structure or a detailed information
exchange, do not necessarily require collaboration. The key to successfully developing the plan is to ensure that meetings are scheduled for the collaborative tasks when needed, and that the non-collaborative tasks are completed in a timely manner, in preparation for these meetings. The BIM Plan can be developed through a series of collaborative meetings, followed by work tasks which take place between the meetings. A series of four meeting have been defined to develop the BEP or ICT incl. the BIM uses. The goal of presenting this four-meeting series is to illustrate one structure that the team can use to effectively develop the plan. For some projects, the team may be able to reduce the number of meetings through effective collaboration between meetings.

Meeting 1: Identify BIM Goals and Uses

The first meeting should focus on the discussion of the overall goals for implementing BIM, along with identifying the BIM Uses. A draft agenda for this meeting would include:

1. Introduce and Discuss BIM Experiences (both individual and organizational)
2. Develop BIM goals (reference BIM Goal template document found in reference list)
3. Identify which BIM Uses to pursue (reference the BIM Uses worksheet found in reference list)
4. Develop the frequency and sequencing for the BIM Uses and identify a responsible party to develop the high level (Level One) BIM Overview process map
5. Identify the responsible parties to develop detailed BIM Use process maps, e.g., the level two maps (some uses are defined on level 2 in appendix)
6. Organize the schedule for future meetings
7. Agree on the tasks ahead and who is responsible for each

This meeting should be attended by senior management personnel and BIM management staff for all involved participants including the owner, designers, contractors and key subcontractors (depending on stage and contract form).

Tasks Prior to Meeting 2
After the initial kick-off meeting, the organizations should clearly understand who will be responsible for the defined tasks, and in what sequences the BIM Uses will be executed. The responsible party for the Level One map should clearly document and distribute it to the project team for review prior to the following meeting. Each responsible party for the specified BIM Uses should also draft their workflow prior to the Design BIM Execution Process meeting (Meeting 2).

Meeting 2: Design BIM Project Execution Process
The Project Specific BIM Use Process Maps shall contain a detailed process plan that clearly defines the different activities to be performed, who will perform them, and what information will be created and shared with future processes. The agenda for this meeting will include:
1. Review the initial BIM Goals and Uses
2. Review the high-level BIM Overview Process Map
3. Review the more detailed workflows from the various parties and identify areas of overlap or gaps between the various modeling tasks
4. Review the process to address opportunities and concerns
5. Identify the primary information exchanges within the process
6. Identify responsible parties for coordinating each information exchange including the author and user of each exchange
7. Allow sub-teams for each information exchange to coordinate potential interim meetings as needed to discuss the information exchange requirements
8. Agree on the tasks ahead and who is responsible for each

This meeting should be attended by the owner, BIM managers and project manager for the project (depending on stage and contract form). It may also be valuable to have contracting managers in attendance or have them briefed soon after this meeting.

**Tasks Prior to Meeting 3**

After the Design BIM Project Execution Process meeting, the team must focus on developing the information exchanges. Each responsible party for an exchange should take the lead in developing the information exchanges. The authors of the information exchange will need to coordinate with the information receivers to ensure that they have developed consistent information exchanges with minimal inconsistencies to discuss at Meeting Three.

The team members should also prepare for the discussions regarding infrastructure requirements which will occur in Meeting Three. Team members should compile examples of typical methods that they have used or wish to use on the project to share with the team.

**Meeting 3: Develop Information Exchanges and Define Supporting Infrastructure for BIM Implementation:**

The agenda for this meeting will include:

1. Review the initial BIM Goals and BIM Uses to ensure that the project planning remains consistent with the initial goals
2. Review the information exchange requirements developed by the team members between Meeting Two and Meeting Three
3. Identify the IT infrastructure needed to support the process and information exchanges as defined in Chapter Five
4. Agree on tasks ahead and who is responsible for each

This meeting should be attended by the BIM managers. It may also be valuable to have contracting managers in attendance or briefed soon after this meeting.

**Tasks Prior to Meeting 4**
The categories and information should be compiled into the final BIM Execution Plan or ICT specification and distributed to the project team in preparation for the final BEP/ICT review meeting.

**Meeting 4: Review Final BIM Execution Plan or ICT specification**

The agenda for this meeting will include:

1. Review the draft BIM Execution Plan
2. Develop the project controls system to ensure that the plan is being followed, and that the plan is up to date
3. Outline the procedure for formal adoption of the BIM Execution Plan and monitoring process
4. Agree on tasks ahead and who is responsible for each

This meeting should be attended by the owner, BIM managers, and all parties that are responsible for the identified BIM Uses.

## 7 BIMinfra working group members

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BIM Anlægsforum (For sparing and communication related to test projects)

Foreningen af Rådgivende Ingeniører, FRI (For sparing and Communications related to test projects)

COWI a/s (For BIM wheel and other material on BIM uses)
9 Reference list

**BIM planning execution guide incl. templates:**
https://www.bim.psu.edu/#guides

**BIMinfra ICT specifications:**
https://biminfra.dk/portfolio-item/ikt-specifikationer/

**BEP content based on ISO19650:**
https://share.mindmanager.com/#publish/e_8bY9bdS0Wsp2YaMVsmZL-KHEDU3-RQtaAiGd7
The following pages will present the 25 BIM uses. They have been grouped into categories dictated by the BIM wheel and some workflows are still missing or under development. Please note that all uses are currently on tactical or strategic level. It is intended that the individual projects update the tactical workflow into operational workflows. BIM Uses can be classified primarily based on their purpose in implementing BIM throughout the life of an asset. In addition to the purpose alone, several other characteristics can be defined to properly identify and communicate a BIM Use. These purposes and characteristics can be defined at varying levels depending upon the level of maturity and detail required for different applications of the Uses. The BIM Use Characteristics allow a user to further define the BIM Use based on common asset and project attributes (Project information requirements and asset information requirements, REF ISO19650) project element, project phase, discipline, and Level of Development (LOD).
BIM Uses
A guide on understanding and selecting BIM uses
Sept. 2020

Appendix
## The 25 BIM Uses

### Generic project phases

<table>
<thead>
<tr>
<th>Plan</th>
<th>Design</th>
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### Mapping BIM uses to BIM Wheel

<table>
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<th>BIM Use</th>
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<td>Existing Conditions</td>
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<td>Modeling</td>
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### Diagram

The diagram illustrates the mapping of BIM uses to the BIM wheel, with labels such as "Existing Conditions," "Modeling," and "Cost Estimation," each corresponding to specific sections of the wheel. The diagram also includes elements like "3D Coordination," "Digital Fabrication," and "Asset Management," each represented with specific tools or symbols. The wheel itself is labeled with sections like "Existing Conditions Modeling," "Existing Conditions Modelling," and "Analysis," each highlighting different aspects of BIM use.
BIM use’s revised in phase 1
Why
Modelling existing conditions is a quick and accurate generation of a 3D model to refurbishment or as-built documentation or other specific purposes, based on actual collectable information.

When
Before design and for as-built.

What
A process where information from existing conditions is collected to develop a 3D model. Depending on what is most efficient, the model creation can be based on: laser scanning, drones, photos, conventional surveying techniques. Once the model is generated, it can be used for design basis or facility management purposes.

Value examples
› Establishment of a 3D model with details and information for specific purposes
› Rapidly collects information for communication and visualisation of existing conditions
› Enhances the efficiency and accuracy of existing condition information
› Provides accurate documentation of the environment for future use
› Verifies real-time progress
EXISTING CONDITIONS MODELLING

Description:
A process in which a project team develops a 3D model of the existing conditions for a site, facilities on a site, or a specific area within a project. This model can be developed in multiple ways: including laser scanning and conventional surveying techniques, depending on what is desired and what is most efficient. Once the model is constructed, it can be queried for information, whether it is for new construction or a modernization project.

Potential Value:
- Enhances the efficiency and accuracy of existing conditions documentation
- Provides documentation of environment for future uses
- Aids in future modeling and 3D design coordination
- Provides an accurate representation of work that has been put into place
- Real-time quantity verification for accounting purposes
- Provides detailed layout information
- Use for visualization purposes

Resources Required:
- CAD software
- 3D Laser scanning (depending on BAS model required)
- Conventional surveying equipment (depending on BAS model required)
- BAS models in Denmark can be downloaded at: http://kortforsyningen.dk/ http://ler.dk/

Team Competencies Required:
- Ability to manipulate, navigate, and review a 3D model
- Knowledge of Building Information Model authoring tools
- Knowledge of 3D laser scanning tools
- Knowledge of conventional surveying tools and equipment
- Ability to sift through mass quantities of data that is generated by a 3D laser scan
- Ability to determine what level of detail will be required to add “value” to the project
- Ability to generate Building Information Model from 3D laser scan and/or conventional survey data
BIM USE, EXISTING CONDITIONS MODELING

1. Collect Current Site Conditions Data
   Responsible Party

2. Survey Existing Site Conditions
   Responsible Party

3. Collect Data through Photographs
   Responsible Party

4. Laser Scan Existing Conditions
   Responsible Party

5. Compile Existing Conditions Information
   Responsible Party

6. Model check
   Responsible Party

7. Amodel re the approved?
   YES END

8. Laser Scan Model
9. Survey Model
10. Existing Conditions Information Model
Why
Model-based programming allows stakeholders to collect, communicate and verify the design intention during the process and within the design team.

When
During planning and design.

What
A process of determining and collecting project requirements in a model before design. The model allows the entire project team to analyze and understand the needs and complexity of the project, as well as design requirements. This ensures that the project deliveries aligned with the design requirements.

Value examples
› Defines detailing, information enrichment and design requirements in the model, and provides a solid basis for the design team
› Enables efficient and accurate assessment of design performance such as requirements to areas, spaces, rooms, surfaces, materials etc.
› Captures design changers during the design process
› Enables ongoing digital verification of the design model against the specified project requirements
Description:
A process in which a spatial program is used to efficiently and accurately assess design performance in regard to spatial requirements. The developed BIM model allows the project team to analyze space and understand the complexity of space standards and regulations. Critical decisions are made in this phase of design and bring the most value to the project when needs and options are discussed with the client and the best approach is analyzed.

Potential Value:
- Efficient and accurate assessment of design performance in regard to spatial requirements by the owner.

Resources Required:
- Design Authoring Software

Team Competencies Required:
- Ability to manipulate, navigate, and review a 3D model
BIM USE, PROGRAMMING

1. Site Information
2. Identify Area Requirements
   - Owner
3. Create Program
   - Owner
4. Design Program
5. Identify Final List of Requirements
   - Owner
6. Identify Cost Targets
   - Owner
7. Start Design Programming
8. Generate Conceptual Building Layout
   - Architect
9. Is site acceptable and available?
   - Yes
   - No
10. Identify Existing Conditions
    - Owner
11. Identify Building Use/Type
    - Owner
12. Program Model
13. END PROCES S
DESIGN AUTHORING

Why
Design authoring by a digital model is one of the core BIM uses. It defines the basis for project specific BIM uses which provide a streamlined and transparent way of designing, collaborating and communicating throughout the entire project.

When
Primarily used in planning and during the design.

What
A process of creating the digital model of the proposed design. The model is a central part of the project execution of the design, and is gradually enriched with the required information and detailing. Digital project collaboration is based on the efficient use and reuse of digital data among stakeholders through the use of open file formats, whenever feasible.

Value examples
› Establishes a 3D model of the project
› Promotes collaboration, communication and transparency internally and externally on the project
› Encourages sharing of project information across the design team and other stakeholders which reduces communication time and increases quality
DESIGN AUTHORING

Description:
A process in which 3D software is used to develop a Building Information Model based on criteria that is important to the translation of the project's design. Authoring tools create models while audit and analysis tools study or add to the richness of information in a designed model. Most of audit and analysis tools can be used for Design Review and Engineering Analysis BIM Uses.

Design authoring tools are a first step towards BIM and the key is connecting the 3D model with a powerful database of properties, quantities, means and methods, costs and schedules.

Potential Value:
• Improved communication of design to all stakeholders
• Improved ability for quality control of project design, costs and schedule
• Powerful design visualization
• True collaboration between project stakeholders and BIM users

Resources Required:
• Design Authoring Software
• Common Data Platform for sharing design models

Team Competencies Required:
• Ability to manipulate, navigate and review a 3D model
• Knowledge of construction means and methods
• 3D Design experience
BIM USE, DESIGN AUTHORING

Identify Models Required

Identify Content for Model Creation

Create Initial design models
  Centerlines and Corridors

Agree schedule for update of disciplinary models considering the critical path of process iteration

Have relevant changes been made?

YES

NO

The iterative design process

Create Design Model
  Discipline A

Create Design Model
  Discipline B

Create Design Model
  Discipline C

Consistency Control

Does the model meet the requirements?

NO

YES

END

6.1 Identify Models Required

6.2 Identify Content for Model Creation

6.3 Create Initial design models
  Centerlines and Corridors

6.4 Create Design Model
  Discipline A

6.5 Create Design Model
  Discipline B

6.6 Create Design Model
  Discipline C

6.7 Consistency Control

6.8 Does the model meet the requirements?

NO

YES

6.9 END

Program Model

Initial Disciplinary models
  Centerlines
  Corridors

WIP Disciplinary models
  Centerlines
  Corridors
  Disciplinary model A
  Disciplinary model B
  Disciplinary model C

Shared Disciplinary models
  Disciplinary model A
  Disciplinary model B
  Disciplinary model C
  Disciplinary model D

Geometric prerequisites

Information models

Program Model

Initial Disciplinary models
  Centerlines
  Corridors

WIP Disciplinary models
  Centerlines
  Corridors
  Disciplinary model A
  Disciplinary model B
  Disciplinary model C

Shared Disciplinary models
  Disciplinary model A
  Disciplinary model B
  Disciplinary model C
  Disciplinary model D

Geometric prerequisites

Basis data

Process
Identify which models are required.

Identify what the content shall be for the models (e.g. CAD manual or Modelstandard)

It is important to know the geometric prerequisites and to have basis data/models available.

It is important to identify the critical path for updating the disciplinary models in the iteration process of a design project. The different disciplines are interdependent and updating the different disciplinary models must be planned and stage of models must be known at all times. All the disciplines must be aware of and agree to this schedule.

Initial design models for Centerlines and Corridors are created and shared. In Civil works Centerlines and Corridors serve as basic models for other disciplines.

According to schedule disciplines creates a design model. Starting from updated disciplinary models from other disciplines. These models are all shared as disciplinary models according to schedule and as to a certain point of stage (WIP). These models are now avaible to other disciplines and adjustments to design in models will take place.

NB! Before sharing a disciplinary model, each discipline performs a Discipline Control. Relevant models and areas to check are predefined. Depending on phase and stages of models, the check will contain controls like Grafical Control and Consistency Control. Each discipline consider if the design meets the requirements.

Have relevant changes been made? Consider if relevant changes is made and locate which disciplines it will affect.

If “YES” relevant changes have been made go back to 6.5. and adjust design, the iterative process will begin or continue.

if “NO”, no changes OR all changes have been implemented in all disciplines, then the iterative process will end, go to 6.7

Perform final Consistency Control.

Does the model meet the requirements?

If “YES” then the you have some finish design models to be used in the further BIM uses.

If “NO” then you have to go back to process 6.4 and adjust the design models.
3D COORDINATION

Why
With virtual 3D coordination of the project during the design, critical clashes can be managed and solved before construction, reduces costs and increase efficiency.

When
Design stages.

What
A process in which the model information and geometry are used for ongoing coordination of interfaces among all the disciplines. E.g. automated clash detection to determine inconsistencies across disciplines in the project. The goal of clash detection is to eliminate critical clashes during design and prior to construction.

Value examples
› Coordinates through a digital model, and reduces and eliminates critical clashes
› Increases productivity for design and construction
› Leads to more accurate design results and reduced construction costs and time
› Ensures improved and more efficient ongoing coordination throughout the design stages
3D COORDINATION

Description:
A process in which Collision control software is used during the coordination process to determine field conflicts by comparing Disciplinary 3d models. The goal of clash detection is to eliminate the major disciplinary conflicts prior to construction.

Potential Value:
- Coordinate construction project through a model
- Reduce and eliminate field conflicts; which reduces RFI's significantly compared to other manually methods
- Visualize construction
- Increase productivity
- Reduced construction cost; potentially less cost growth (i.e. less change orders)
- Decrease construction time
- Increase productivity on site
- Models become more accurate to construct from

Resources Required:
- Design Authoring Software
- Model Review Software
- 3d disciplinary models

Team Competencies Required:
- Ability to deal with people and project challenges
- Ability to manipulate, navigate, and review a 3D model
- Knowledge of BIM model applications
- Knowledge of building systems.
**BIM USE, 3D COORDINATION**

**START**

14.1 | Develop Schedule for Coordination
All Disciplines

14.2 | Compile Composite Model (Interdisciplinary models)
BIM Coordinator

14.3 | Perform Collision control
BIM Coordinator

14.4 | Fill out Clash check form
BIM Coordinator

14.5 | Any collisions?
YES | Identify Solutions to Collisions
NO | Return to Design Authoring

14.6 | Approved Clash check form

- Company Implementation Standards
- Contract Requirements
- Information Exchange Standards

**Process**

**Information models**

**Company Implementation Standards**

**Contract Requirements**

**Information Exchange Standards**

**Design Models** (Design Authoring)

**Clash rapport**

**Approved Clash check form**

**END**
Description:
14.1 Develop a schedule for how often 3D Coordination shall be done
14.2 Make a compile model to where to perform 3D coordination
   Perform collision control. Use predefined Clash check form. This form tells you which models and elements that needs to be check against each other.
14.3 Fill out the Clash check form.
14.4 Check clash check form. If there are not Clash, you are finish with this process. If there are Clash you need to continue to process 14.6.
14.6 Consider if the clashes are relevant to correct. If yes, find a solution to correct the clashes and return to the BIM uses #6 - Design authoring to correct the clash.
   If no, the process will end and there will be an approved clash check form.
Why
Model-based design review ensures continuous evaluation and QA of the evolving design, and enables visual communication and feedback directly in the model.

When
During planning and design.

What
The process of ongoing model review as part of the QA process which implies that model content is validated within and across disciplines. It allows the design team and other stakeholders to provide their feedback directly into the model. This includes evaluation of the design criteria and layout in a virtual environment.

Value examples
- Increases coordination and communication among different parties which improves design decisions
- Ensures that all model content is reviewed and that the review is fed directly into the model
- Ensures effective evaluation of design against project criteria
- Ensures an efficient design review and QA process
DESIGN REVIEW

Description:
A process in which stakeholders view a 3D collaboration model and provide their feedbacks to validate multiple design aspects. These aspects include evaluating meeting the program, in a virtual environment, and setting criteria such as. This BIM use can be done by using computer software only. This use is executed through project meetings, internally and externally.

Potential Value:
• All reviews are recorded within the collaboration model and it provides you with a detailed history of the reviews
• Different design options and alternatives may be easily modeled and changed during design phase.
• Create shorter and more efficient design
• Evaluate to what extent the design meet the project criteria and owner’s needs
• Enhance constructability and work safety
• Easily communicate the design to the owner, construction team and end users
• Get instant feedbacks on meeting program requirements and owner’s needs.
• Greatly increase coordination and communication between different parties. More likely to generate better decisions for design

Resources Required:
• Common Data Platform
• Design Review Software
• Interactive review space
• Hardware which is capable of processing potential large model files

Team Competencies Required:
• Ability to review, navigate and create mock-ups of 3D models
• Ability to model photo realistically including textures, colors and finishes and easily navigable by using different software or plug-ins
• Strong sense of coordination, Understanding roles and responsibilities of team members
• Strong understanding of how disciplines are interdependent
BIM USE, DESIGN REVIEWS

- **Information models**
  - Discipling model
  - Models Sharing on CDE (Design Authoring)
- **Process**
  - Company Implementation Standards
  - Contract Requirements
- **Design Acceptable?**
  - **Yes**
    - Return to Design Authoring
  - **No**
    - 7.8 Design acceptability?
- 7.1 Create Virtual viewpoints in collaboration tool
- 7.2 BIM coordinator
- 7.3 Compile Model for constructability Review
- 7.4 Perform User Review
  - Create virtual/Mock ups
  - Supplier
  - BIM coordinator
- 7.5 Perform O & M Review
  - Create virtual/Mock ups
  - Asset owner
- 7.6 Perform User Review
  - Create virtual/Mock ups
  - Client
- 7.7 Perform User Review
  - Create virtual/Mock ups
  - Contractor
- 7.9 Compile Design Review Feedback
  - BIM coordinator
- Published discipling model
Description:

7.1  BIM coordinator create Virtual viewpoints in collaboration tool
7.2  BIM coordinator link necessary information and create Virtual viewpoints for operation and maintenance review.
7.3  BIM coordinator link necessary information and create Virtual viewpoints for constructability review.
7.4  Supplier perform user review, create virtual Mock-ups
7.5  Client perform user review, create virtual Mock-ups
7.6  Asset owner perform operation and maintenance review, create virtual Mock-ups
7.7  Contractor perform constructability review, create virtual Mock-ups
7.8  Client and supplier evaluate if design is acceptable. If the model not meet the requirements, you need to go to process 7.9.
7.9  BIM coordinator compile design review feedback, and you need to go back to design authoring adjust the model.
VISUALISATION

Why
Simple visual communication to all project stakeholders by using the model content and information to early involvement and enhance understanding to improve the basis for decisions.

When
During planning, design and construction.

What
A process intended to communicate the design or analysis results based on the model. Visualisations include photorealistic images, presentations of flow (sequencing, people etc.) and advanced augmented reality presentations. It also includes dynamic visualisations such as walk-throughs and virtual reality experiences with acoustics.

Value examples
› Easy communication of design intent to non-technical stakeholders
› Basis for faster decision making
› Simple visualisation of results from technical analysis and simulations
› Co-creation with external parties such as end users and operational staff
› Marketing and publicising the project using virtual reality
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A process intended to communicate the design or analysis results based on the model. Visualisations include photorealistic images, presentations of flow (sequencing, people etc.) and advanced augmented reality presentations.

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• Easy communication of design intent to non-technical stakeholders
• Basis for faster decision making
• Simple visualisation of results from technical analysis and simulations
• Co-creation with external parties such as end users and operational staff
• Marketing and publicising the project using virtual reality

Resources Required:
• Model Review Software

Team Competencies Required:
• Ability to manipulate, navigate, and review BIM model
**Why**
Model-based analysis enables creating multiple virtual scenarios to support project decisions during design, reducing time spent in planning, design and operation.

**When**
During planning and design and construction.

**What**
The process of performing analyses based on the model content or enriching the model with the results from an analysis by use or reuse of information. The design process can also be automated using advanced analysis tools based on artificial intelligence (AI) applied to the digital model.

**Value examples**
- Enhanced design progress by performing analysis directly in the model such as energy, comfort, environmental, structural, fire and evacuation and lighting analyses
- Improves the quality of the design analyses and more accurate predictions by auto-determining model information
- Reduces time consumption by performing automated code checks
- Makes it easy to assess different design options, alternatives and consequences
Description:
A process in which analytical modeling software utilizes the BIM design authoring model so to determine the behavior of a given lighting system. This can also include artificial (indoor and outdoor) and natural (daylighting and solar shading) lighting. Based on this analysis further development and refinement of the lighting design takes place to create effective, efficient, and constructible lighting systems. The application of this analysis tool allows for performance simulations that can significantly improve the design, and performance of the facility's lighting over its lifecycle.

Potential Value:
• Save time and cost on creating extra models
• Easier transition BIM authoring tools allowing new firms implementing this use model
• Improve specialized expertise and services offered by the design firm
• Achieve optimum efficient design solutions by applying various rigorous analyses
• Faster return on investment with applying audit and analysis tools for lighting analyses
• Improve the quality of the design analyses
• Reduce the cycle time of the design analyses

Resources Required:
• Design Authoring Tools
• Lighting Analysis analysis tools and software
• Design standards and codes
• Adequate hardware for running software

Team Competencies Required:
• Ability to create, manipulate, navigate, and review a 3D Lighting Model
• Ability to assess a model through engineering analysis tools
• Lighting expertise
Description:
A process in which BIM/GIS tools are used to evaluate properties in a given area to determine the most optimal site location for a future project. The site data collected is used to first select the site and then position the project based on other criteria.

Potential Value:
• Use calculated decision making to determine if potential sites meet the required criteria according to project requirements, technical factors, and financial factors
• Decrease costs of utility demand and demolition
• Increase energy efficiency
• Minimize risk related to MSSS (health, safety, and welfare)
• Maximize return on investment

Resources Required:
• CAD and GIS software (Basis models)
• 3D model manipulation

Different locations of surfact interest can be found at Arealinfo.

Team Competencies Required:
• Ability to manipulate, navigate, and review a 3D model
• Knowledge and understanding of local authority’s system (GIS, database information)
Description:
A process in which intelligent modeling software uses the BIM model to determine the most effective engineering method based on design specifications. Development of this information is the basis for what will be passed on to the owner and/or operator for use in the building's systems (i.e. energy analysis, structural analysis, emergency evacuation planning, etc.). These analysis tools and performance simulations can significantly improve the design of the facility and its energy consumption during its lifecycle in the future.

Potential Value:
- Automating analysis and saving time and cost
- Analysis tools are less costly than BIM authoring tools, easier to learn and implement and less disruptive to established workflow
- Improve specialized expertise and services offered by the design firm
- Achieve optimum, energy-efficient design solution by applying various rigorous analyses
- Faster return on investment with applying audit and analysis tools for engineering analyses
- Improve the quality and reduce the cycle time of the design analyses

Resources Required:
- Design Authoring Tools
- Engineering analysis tools and software

Team Competencies Required:
- Ability to manipulate, navigate, and review a 3D Model
- Ability to assess a model through engineering analysis tools
- Knowledge of construction means and methods
- Design and construction experience
WORKFLOW COMING SOON
SUB Use: Sustainabiliy (6D)

Description:
A process in which a BIM project is evaluated based on LEED or other sustainable criteria. This process should occur during all stages of a facilities life including planning, design, construction, and operation. Applying sustainable features to a project in the planning and early design phases is more effective (ability to impact design) and efficient (cost and schedule of decisions). This comprehensive process requires more disciplines to interact earlier by providing valuable insights. This integration may require contractual integration in planning phase. In addition to achieving sustainable goals, having LEED approval process adds certain calculations, documentations, and verifications. Energy simulations, calculations, and documentations can be performed within an integrative environment when responsibilities are well defined and clearly shared.

Potential Value:
- Facilitates interaction, collaboration and coordination of team members early in the project process are considered to be favorable to sustainable projects.
- Enables early and reliable evaluation of design alternatives.
- Availability of critical information early helps problem resolution efficiently in terms of cost premium and schedule conflicts.
- Shortens the actual design process by the help of early facilitated design decisions. Shorter design process is cost effective and provides more time for other projects.
- Leads to delivery better project quality.
- Reduces documentation load after design and accelerates certification because concurrently prepared calculations can be used for verification.
- Reduces operational costs of the facility due to the energy performance of the project. It optimized building performance via improved energy management.
- Increases the emphasis on environmentally friendly and sustainable design.
- Assists project team with potential future revisions throughout the life cycle.

Resources Required:
- Design authoring software

Team Competencies Required:
- Ability to create and review 3D Model
- Knowledge of up-to-date LEED Credit Information
- Ability to organize and manage the database
WORKFLOW COMING SOON
SUB Use: Code Validation

Description:
A process in which code validation software is utilized to check the model parameters against project specific codes. Code validation is currently in its infant stage of development within the U.S. and is not in widespread use. However, as model checking tools continue to develop, code compliance software with more codes, code validation should become more prevalent within the design industry.

Potential Value:
• Validate that building design is in compliance with specific codes, e.g. IBC International Building Code, ADA Americans with Disabilities Act guidelines and other project related codes using the 3D BIM model.
• Code validation done early in design reduces the chance of code design errors, omissions or oversights that would be time consuming and more expensive to correct later in design or construction.
• Code validation done automatically while design progresses gives continuous feedback on code compliance.
• Reduced turnaround time for 3D BIM model review by local code officials or reduced time that needs to be spent meeting with code commissioners, visiting the site, etc. or fixing code violations during punch list or closeout phase.
• Saves time on multiple checking for code compliance and allows for a more efficient design process since mistakes cost time and money.

Resources Required:
• Local codes
• Model checking software
• 3D Model manipulation

Team Competencies Required:
• Ability to use BIM authoring tool for design and model checking tool for design review
• Ability to use code validation software and previous knowledge and experience with checking codes is needed.
WORKFLOW COMING SOON
SUB Use: Space Management and Tracking

Description:
A process in which BIM is utilized to effectively distribute, manage, and track appropriate spaces and related resources within a facility. A facility building information model allows the facility management team to analyze the existing use of the space and effectively apply transition planning management towards any applicable changes. Such applications are particularly useful during a project’s renovation or extend where existing segments are to remain occupied. Space Management and Tracking ensures the appropriate allocation of spatial resources throughout the life of the facility. This use benefits from the utilization of the record model. This application often requires integration with spatial tracking software.

Potential Value:
- More easily identify and allocate space for appropriate building use
- Increase the efficiency of transition planning and management
- Proficiently track the use of current space and resources
- Assist in planning future space needs for the facility

Resources Required:
- Bi-directional 3D Model Manipulation; software and record model integration
- Space mapping and management input application (Mapguide, Maximo, etc.)

Team Competencies Required:
- Ability to manipulate, navigate, and review record model
- Ability to assess current space and assets and manage appropriately for future needs
- Knowledge of facility management applications
- Ability to effectively integrate the record model with the Facility Management’s Application and appropriate software associated with the client’s needs.
<table>
<thead>
<tr>
<th>Information models</th>
<th>Basis data</th>
<th>Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIM USE, SPACE MANAGEMENT AND TRACKING</td>
<td>WORKFLOW COMING SOON</td>
<td></td>
</tr>
</tbody>
</table>
Analysis

Sub Use: Disaster Planning (PSS, TSR, CSM)

Description:
A process in which emergency responders would have access to critical building information in the form of a model and information system. The BIM would provide critical building information to the responders that would improve the efficiency of the response and minimize the safety risks. The dynamic building information would be provided by a building automation system (BAS), while the static building information, such as floor plans and equipment schematics, would reside in a BIM model. These two systems would be integrated via a wireless connection and emergency responders would be linked to an overall system. The BIM coupled with the BAS would be able to clearly display where the emergency was located within the building, possible routes to the area, and any other harmful locations within the building.

Potential Value:
• Provide police, fire, public safety officials, and first responders access to critical building information in real-time
• Improve the effectiveness of emergency response
• Minimize risks to responders

Resources Required:
• Design review software to view Record Model and components
• Building Automation System (BAS) linked to Record Model
• Computerized Maintenance Management System (CMMS) linked to Record Model

Team Competencies Required:
• Ability to manipulate, navigate, and review BIM model for facility updates
• Ability to understand dynamic building information through BAS
• Ability to make appropriate decisions during an emergency
WORKFLOW COMING SOON
SUB Use: Building Systems Analysis

Description:
A process that measures how a building’s performance compares to the specified design. This includes how the mechanical system operates and how much energy a building uses. Other aspects of this analysis include, but are not limited to, ventilated facade studies, lighting analysis, internal and external CFD airflow, and solar analysis.

Potential Value:
• Ensure building is operating to specified design and sustainable standards
• Identify opportunities to modify system operations to improve performance
• Create a "what if" scenario and change different materials throughout the building to show better or worse performance conditions

Resources Required:
• Building Systems Analysis Software (Energy, Lighting, Mechanical, Other)

Team Competencies Required:
• Ability to understand and manipulate CMMS and building control systems with Record Model
• Ability to understand typical equipment operation and maintenance practices
• Ability to manipulate, navigate, and review a 3D Model
BIM USE, BUILDING SYSTEMS ANALYSIS

**Information models**

**Basis data**

**Process**

**Building Performance Analysis Model**

**START PROCESS**

**Results acceptable?**

**Adjust BIM for Performance Analysis**

Responsible Party

**Energy Analysis Model**

**Sensor Data**

**Other Performance Data**

**Performance Data**

**Performance Targets**

**Perform Maintenance**

Responsible Party

**Prepare/Adjust Schedule**

Responsible Party

**Facility Manager**

**Is model ready for simulation?**

**YES**

**NO**

**END PROCESS**

**Before Use, Building Systems Analysis**
SUB Use: Construction System Design

Description:
A process in which 3D System Design Software is used to design and analyze the construction of a complex building system (e.g. form work, glazing, tie-backs, etc.) in order to increase planning.

Potential Value:
- Increase constructability of a complex project
- Increase construction productivity
- Increase safety awareness of a complex building system
- Decrease language barriers

Resources Required:
- 3D System design software

Team Competencies Required:
- Ability to manipulate, navigate, and review 3D model
- Ability to make appropriate construction decisions using a 3D System Design Software
- Knowledge of typical and appropriate construction practices for each component
WORKFLOW COMING SOON
Why
By generating drawings from the model it ensures consistency in the drawing sets and enables fast extracts of 2D/3D sketches.

When
During design, construction and operations.

What
A process to generate drawings based on the model throughout the project. This ensures consistency of geometry in all drawings and reduces the need for manual drawing updates. Simple 2D and 3D sketches for specific purposes can also be generated directly from the model.

Value examples
› Generation of coherent plans, elevations and sections for documentation
› Improves communication of design intent with additional 2D and 3D views and sketches
› Automatically updates drawing sets based on changes in the model
› Increases consistency between different type of drawings as the geometry and other information are extracted from the same model
Description:
A process in which building information modeling and the model itself is used to create drawings and drawing sets. This including Schematic, Design Development, Construction and Shop Drawing. "With building information modeling, each building object instance - its shape, properties, and placement in the model - is defined only once." (Eastman et al. 2008). The same building model can be used to create all drawing, reports, and analysis datasets. This eliminates the need to manually update each drawing for each design change. Additionally standard construction details can be generated directly from the model, however it may be necessary to add additional information that is not contained within the facility model.

Potential Value:
• Quickly generate multiple views (plan, elevations, sections, and details) from a single facility model
• Improved quality of drawing that better explain design intent with additional views such as isometric and 3D views
• Automatically update drawing sets based on changes in the model
• Autopopulate schedules
• All data is extracted from the same model therefore increasing consistency between different views of the same data

Resources Required:
• Design authoring software with the ability to generate drawings

Team Competencies Required:
• Ability to manipulate, navigate, and review a 3D Model
WORKFLOW COMING SOON
SCHEDULING

Why
Model-based scheduling is a powerful visualisation and communication tool that gives project stakeholders a better understanding of project milestones and construction plans.

What
A process in which the model is utilised to effectively plan and show the construction sequence and space requirements on a construction site as a repeatedly task.

Consists of 2 sub uses:
1. Scheduling (4D)
2. Site Utilization Planning

When
During design and construction.

Value examples
› Identifies scheduling, sequencing or phasing issues, enabling improved resource allocation
› Conveys the spatial complexities of the project and provides a better upfront understanding of the phasing schedule by showing the critical path of the project
› Space and workspace conflicts are identified and resolved ahead of the construction process
› Detailed location-based scheduling in major projects to accurately understand the construction phase
Description:
A process in which a 4D model (3D models with the added dimension of time) is utilized to effectively plan the phased occupancy in a renovation, retrofit, addition, or to show the construction sequence schedule update, workflow, space utilization and challenges on a building site. 4D modeling is a powerful visualization and communication tool that can give planner, designer, contractor, operator including the owner a better understanding of project milestones and live updates to avoid collision in same working area, to optimize cost and execution time schedule and increase efficiency.

Potential Value:
• Better understanding of the phasing schedule by the owner and project participants and showing risk buffers including Critical Path of the project
• Risk analysis with mitigated or un-mitigated aspects
• Dynamic phasing plans of occupancy offering multiple options and solutions to site space conflicts
• Integrate planning of human, equipment, location and material resources with the BIM model to better schedule and cost estimate the projects
• Space and workspace conflicts identified and resolved ahead of the construction process
• Preliminary design assessment (black box) Early stage assumption of future elements allocation and proportions
• Avoiding collision in same working area or to follow chronological steps, such as earthworks, sewage system, sleepers and then catenary masts
• Control of quantity (removal, disposal, intermediate storage, reusage, incoming)
• Optimize location vs. time as much as possible
• Client has overview of planned vs. actual (real time) progress on site
• Early implementation of Facility Management to contribute data for optimization.
• Better method for tender/bidding procedure, and contractors will be able to see the complexity of individual task, and to influate the conditions (turnkey contracts)
• Workshop for site planning with participants from all interface projects - optimizing Site Management
• Marketing purposes and publicity
• Weekly or regular Design update to project owner
• Weekly or regular site update based on progress, which show planned progress vs. actual progress and result of remaining works (depend on units)
• Animation showing execution possibilities (methods)
• Identification of schedule, sequencing or phasing issues
• More readily constructible, operable and maintainable project
• Monitor procurement status of project materials
• Increased productivity and decreased waste on job sites
• Conveying the spatial complexities of the project, planning information, and support conducting additional analyses
Resources Required:

- Design Authoring Software
- Scheduling software
- 4D Modeling Software required by the project owner
- Define a Common Data Environment platform for every phase and agreements across interface projects to use software and tools, that meets requirements from master planner
- Implementation of the International Infrastructure standards
- Unlimited access to traffic planning and bindings including collaboration between them.
- Individually determine LOD for each deliverance (discipline)
- Site map/logistics planning

Team Competencies Required:

- FM expertise must be included from early stage
- Knowledge of construction scheduling and general construction process. A 4D model is connected to a schedule, and is therefore only as good as the schedule to which it is linked.
- Ability to manipulate, navigate, analyse, share and review a 3D model.
- Qualified employee appointed in early stage to define execution methods (best practice)
- Knowledge of 4D software: import geometry, manage links to schedules, produce and control animations, appearance visibility, workflow, scripting etc.
SCHEDULING

SUB Use: SCHEDULING (4D)

Description:

3.1 Establish organisational workflow and define, which data to be used and whom to contribute all project related data/information
   Select a 4D-coordinator in every project as a main contact
   Overall early stage planning with known information to be added. This schedule is active through entire process
   Establish common 3D-model to be on right file-format and conditions regarding Common Data Environment and update time schedule (developed early stage planning) based on this model
   Update the common 3D-model and schedule according to upcoming details/information
   Create sub tasks in the main schedule according to objects in main 3D-model
   Q/A the 4D-model is coordinated by the project team (Reoccurrence)

3.2 Prepare schedule of the execution process. If you later en the proces find out that the schedule is not optimized. You have to go back to this part of the proces and make some adjustments to the schedule.

3.3 Create a new 3D model as a copy of the original 3D model. Spilt the new 3D model into elements that fits the different activities in the schedule.

3.4 Make a link from the 3D element to the different activities in the schedule.

3.5 Check the model to see if all elements in the model is linked to the right activity in the schedule. If the model is correct, then continue to the next step. If the model is not correct, then you need to go back to process 3.5.

3.7 Make a review of the 4D model to beside if the schedule is optimized. If it is optimized, then you have a finish schedule and 4D model. If not, then you need to go back to process 3.3/3.4 and adjust the schedule and the 3D model.

3.8 Automated system to synchronize communication between contractors to clear their way for begin upcoming work

3.8 Proper 3D-model with required metadata to have complete 4D-procedure

Create competition between contractors while making complex tasks transparent

Forecast the schedule in advance of (delayed) tasks or clearing area for upcoming material delivery within the nearest future
SCHEDULING

SUB Use: SITE UTILIZATION PLANNING

Description:
A process in which BIM is used to graphically represent both permanent and temporary facilities on site during multiple phases of the construction process. It may also be linked with the construction activity schedule to convey space and sequencing requirements. Additional information incorporated into the model can include labor resources, materials with associated deliveries, and equipment location. Because the 3D model components can be directly linked to the schedule, site management functions such as visualized planning, short-term re-planning, and resource analysis can be analyzed over different spatial and temporal data.

Potential Value:
• Efficiently generate site usage layout for temporary facilities, assembly areas, and material deliveries for all phases of construction
• Quickly identify potential and critical space and time conflicts
• Accurately evaluate site layout for safety concerns
• Select a feasible construction scheme
• Effectively communicate construction sequence and layout to all interested parties
• Easily update site organization and space usage as construction progresses
• Minimize the amount of time spent performing site utilization planning

Resources Required:
• Design authoring software
• Scheduling software
• 4D model integration software
• Detailed existing conditions site plan

Team Competencies Required:
• Ability to create, manipulate, navigate, and review a 3D Model
• Ability to manipulate and assess construction schedule with a 3D model
• Ability to understand typical construction methods
• Ability to translate field knowledge to a technological process
BIM USE, SITE UTILIZATION PLANNING

- Identify Construction Phases
- Contractor

- Add Construction Equipment
- Contractor

- Insert Phased Staging Areas
- Contractor

- Determine Temporary Facilities
- Contractor

- Analyze Site Layout for Space and Time Conflict
- Contractor

- Analyze Site Layout for Phase Transition
- Contractor

- Add Construction Equipment
- Contractor

- Insert Phased Staging Areas
- Contractor

- Design Model
- Existing Site Conditions
- Model

- Analyze Site Layout for Space and Time Conflict
- Contractor

- Is plan acceptable?
- YES
- NO
- Distribute Plan to Various Parties
- Contractor

- Schedule
- Site Utilization Plan

- START

- END PROCESS

- Information models
- Basis data

- Process
**COST ESTIMATION**

**Why**
Cost estimates based on quantities from the model gives a precise estimate of quantities and the possibility to constantly verify that the design is on budget.

**When**
During planning, design and construction.

**What**
A process in which a model can be used to assist in the generation of accurate quantity take-offs and cost estimates throughout the lifecycle of a project. This process ensures consistency between the actual design and the budget and allows one to see the cost effects of any changes in the project.

**Value examples**
- Quick generation of quantities from the model for cost estimates
- Better visual representation of cost elements that must be estimated in the model
- Allows estimators to focus on more value-adding activities in estimating such as identifying construction assemblies, generating pricing and factoring in risks, which are essential for high quality estimates
- Easier exploration of different design options and concepts based on project budget
- More accurate cost estimation from early stages to tendering
COST ESTIMATION

Description:
A process in which BIM can be used to assist in the generation of accurate quantity take-offs and cost estimates throughout the lifecycle of a project. This process allows the project team to see the cost effects of their changes, during all phases of the project, which can help curb excessive budget overruns due to project modifications. Specifically, BIM can provide cost effects of additions and modifications, with potential to save time and money and is beneficial already from early design stages to Facility Management stage of any project.

Potential Value:
• Precisely quantify modeled materials
• Earn Value Analyse graphs (EVA) to control the actual budget to follow the planned
• Resource utilization diagram within contractors - to control site safety measures
• Cost risk analysis and easy way to add values to the system, no matter of units
• Quickly generate quantities to assist in the decision making process
• Generate more cost estimates at a faster rate
• Better visual representation of project and construction elements that must be estimated
• Provide cost information to the owner during the early decision making phase of design and throughout the lifecycle, including changes during construction
• Saves estimator's time by reducing quantity take-off time
• Allows estimator's to focus on more value adding activities in estimating such as: identifying construction assemblies, generating pricing and factoring risks, which are essential for high quality estimates
• Added to a construction schedule (such as a 4D Model), a BIM developed cost estimate can help track budgets throughout construction
• Easier exploration of different design options and concepts within the owner's budget
• Quickly determine costs of specific objects and processes
• Easier to strain new estimators through this highly visual process
• Real time budget/payment updates and billing process throughout all phases
• Lifecycle planning of components and its validity included to cost estimation
• FM overall budget specifies individual object/component based on FM system requirement (E.g. SAP S/4 HANA)
• Time schedule has an impact on cost estimation

Resources Required:
• Model-based estimating software (4D-model is prefered)
• Design authoring software
• Accurately built design model Accurately built design model combined with reduced level of information/models
• Cost data (Including Masterformat and Uniformat data)
• Access to asset data/pricebook for overall/detail price estimation

Team Competencies Required:
• FM expertise must be included from early stage
• Ability to define specific design modeling procedures which yield accurate quantity take-off information
• Ability to identify quantities for the appropriate estimating level upfront
• Ability to manipulate models to acquire quantities usable for estimation
• Access to knowhow (know-whom)/asset/experianced ressources and specialists
FIELD INFORMATION

Why
Use of model information in the field gives project teams the ability to coordinate better, communicate more effectively, and resolve issues quickly, resulting in faster and more efficient project execution.

When
During construction and maintenance.

What
A process of taking all the collected model information in the field and using it to drive accurate construction out on site. It reduces paperwork and supports better and more effective communication, and the ability to resolve issues quickly during construction.

Value examples
› Optimises and measures field performance of construction trends across progress and quality
› Allows the model to be used in daily inspections and to produce information take-off and 2D/3D views on the fly
› Supports daily reporting and communication of the construction progress directly in the model
› Improves construction quality control programs by creating and assigning issues directly in the model
› Provides accurate collection and documentation of asset data for commissioning and maintenance
SUB use: Digital Fabrication

Description:
A process that uses digitized information to facilitate the fabrication of construction materials or assemblies. Some uses of digital fabrication can be seen in sheet metal fabrication, structural steel fabrication, pipe cutting, prototyping for design intent reviews etc. It assists in ensuring that the downstream phase of manufacturing has minimum ambiguities and enough information to fabricate with minimal waste. An information model could also be used with suitable technologies to assemble the fabricated parts into the final assembly.

Potential Value:
- Ensuring quality of information
- Minimize tolerances through machine fabrication
- Increase fabrication productivity and safety
- Reduce lead time
- Adapt late changes in design
- Reduced dependency on 2D paper drawings

Resources Required:
- Design Authoring Software
- Machine readable data for fabrication
- Fabrication methods

Team Competencies Required:
- Ability to understand and create fabrication models
- Ability to manipulate, navigate, and review a 3D model
- Ability to extract digital information for fabrication from 3D models
- Ability to manufacture building components using digital information
- Ability to understand typical fabrication methods
WORKFLOW COMING SOON
SUB Use: 3D Control and Planning

Description:
A process that utilizes an information model to layout facility assemblies or automate control of equipment’s movement and location. The information model is used to create detailed control points aiding in assembly layout. An example of this is automated machine excavations or layout of walls using a total station with points preloaded and/or using GPS coordinates to determine if proper excavation depth is reached.

Potential Value:
- Decrease layout errors by linking model with real world coordinates
- Increase efficiency and productivity by decreasing time spent surveying in the field
- Reduce rework because control points are received directly from the model
- Decrease/Eliminate language barriers

Resources Required:
- Machinery with GPS capabilities
- Digital Layout Equipment
- Model Transition Software (what software takes model and converts it to usable information).

Team Competencies Required:
- Ability to create, manipulate, navigate and review 3D model
- Ability to interpret if model data is appropriate for layout and equipment control.
BIM USE, 3D CONTROL AND PLANNING

18.1 Determine Scope of Work to be Analyzed
18.2 Identify Alternative Construction Methods
18.3 Model Alternative Methods
18.4 Analyze Various Methods

Is model acceptable?

YES

NO

18.5 Compare and Select Options
18.6 Coordinate Construction Sequences

Is construction sequence acceptable?

YES

NO

18.7 Generate Construction Plans

Design Specifications and Intent
Schedule, Cost, and Labor Info
Construction Families and Libraries

Design Model
Site Utilization Model

Construction Model

3D Controls Report
ASSET MANAGEMENT

**Why**
Collected data from design and construction in the model linked to the asset management system automates the maintenance process and reduces time and cost during operation.

**What**
A process in which an operational system is linked to a model to efficiently assist in the maintenance and operation of a facility and its assets. During design and construction, the model is enriched with product and operation information that forms the basis for asset management.

**When**
During operation and maintenance.

**Value examples**
- Exports as-built information for the model to be reused in an external asset management system
- Stores and maintains up-to-date facility and equipment data, including but not limited to maintenance schedules, warranties, manufacturer’s data and equipment functionality
- Produces accurate quantity take-offs of current company assets to support financial reporting, tendering and estimating the future cost
- The model allows users to visualise the asset before servicing it, potentially reducing service time
Description:
Record Modeling is the process used to depict an accurate representation of the physical conditions, environment, and assets of a facility. The record model should, at a minimum, contain information relating to the main architectural, structural, and MEP elements. It is the culmination of all the BIM Modeling throughout the project, including linking Operation, Maintenance, and Asset data to the As-Built model (created from the Design, Construction, 4D Coordination Models, and Subcontractor Fabrication Models) to deliver a record model to the owner or facility manager. Additional information including equipment and space planning systems may be necessary if the owner intends to utilize the information in the future.

Potential Value:
- Aid in future modeling and 3D design coordination for renovation
- Improve documentation of environment for future uses, e.g., renovation or historical documentation
- Aid in the permitting process (e.g. continuous change vs. specified code.)
- Minimize facility turnover dispute (e.g. link to contract with historical data highlights expectations and comparisons drawn to final product.)
- Ability for embedding future data based upon renovation or equipment replacement
- Provide owner with accurate model of building, equipment, and spaces within a building to create possible synergies with other BIM Uses
- Minimize building turnover information and required storage space for this information
- Better accommodate owner’s needs and wants to help foster a stronger relationship and promote repeat business
- Easily assess client requirement data such as room areas or environmental performance to as-designed, as-built or as-performing data.

Resources Required:
- 3D Model Manipulation Tools
- Compliant Model Authoring Tools to Accommodate Required Deliverable
- Access to Essential Information in Electronic Format
- Database of Assets and Equipment with Metadata (Based upon Owner's Capabilities)

Team Competencies Required:
- Ability to manipulate, navigate, and review 3D model
- Ability to use BIM modeling application for building updates
- Ability to thoroughly understand facility operations processes to ensure correct input of information
- Ability to effectively communicate between the design, construction, and facilities management teams
SUB Use: Record Modeling

Additional Information:

In order to properly exhaust all opportunities for utilizing such a model, dialog must take place before the project begins. The critical factor to the success of creating a record model comes with properly documenting the owner's intended use of the information stored within the model. Once these uses are outlined, the necessary parties can produce the required information and embed the necessary infrastructure into the model to support this future information. Other resources such as a deliver/tturnover strategy, comprehensive implementation plan and level of detail documents must also be established. Furthermore, with the continuous updating and improvement of the record model and the capability to store more information, the model serves as a living document that contains an accurate snapshot of the completed space. The model should contain necessary links to pertinent information such as serial codes, warranties, and operation and maintenance history of all the components within the building. Subsequently, this model could be used to monitor the efficiency of the building from an operating standpoint. The record model also contains information linking pre-build specifications to as-built conditions as well as post-construction/operations/renovations. This allows the owner to monitor the project relative to the specifications provided. Additionally, if the model contains the systems described herein, the owner could potentially use the model to aid in future projects and can effectively serve as an existing conditions model for any subsequent projects. This process should repeat with every modification to the building in order to maintain an accurate depiction of the space and equipment within. Finally, it is important that the owner views the facilities maintenance as beyond just a “glorified janitor” while the A/E and CM/GC’s consider post-construction design issues just as much as early design phases and pre-construction activities.
BIM USE, RECORD MODELING

**Information models**

- Design Model
- Coordination Model
- 4D Model
- Equipment Information
- Record Model

**Process**

1. **Is model acceptable?**
   - YES: Compile Information in FM Application
   - NO: Identify Information Requirements Owner

2. **Compile Information** Facility Manager

3. **Generate Additional Required Information** Facility Manager

4. **Compile Information in FM Application** Facility Manager

5. **Is model acceptable?**
   - YES: Proceed
   - NO: Return to step 1

**Equipment Information**

- Project Submittal Information
- CIP/As-Builts
- COBIE Requirements
- Compile Information

**Basis data**

- Project Submittal
- Equipment Information
- CIP/As-Builts
- COBIE Requirements

**Process**

- Identify Information Requirements Owner
- Compile Information Facility Manager
- Generate Additional Required Information Facility Manager
- Compile Information in FM Application Facility Manager
- Is model acceptable?
  - YES: Proceed
  - NO: Return to step 1
SUB Use: Maintenance Scheduling (7D)

Description:
A process in which the functionality of the project and equipment serving the project are maintained over the operational life of a facility. A successful maintenance program will improve building performance, reduce repairs, and reduce overall maintenance costs.

Potential Value:
• Plan maintenance activities proactively and appropriately allocate maintenance staff
• Track maintenance history
• Reduce corrective maintenance and emergency maintenance repairs
• Increase productivity of maintenance staff because the physical location of equipment/system is clearly understood
• Evaluate different maintenance approaches based on cost
• Allow facility managers to justify the need and cost of establishing a reliability centered maintenance program

Resources Required:
• Design review software to view Record Model and components
• Building Automation System (BAS) linked to Record Model
• Computerized Maintenance Management System (CMMS) linked to Record Model
• User-Friendly Dashboard Interface linked to Record Model to provide building performance information and/or other information to educate building users

Team Competencies Required:
• Ability to understand and manipulate CMMS and building control systems with Record Model
• Ability to understand typical equipment operation and maintenance practices
• Ability to manipulate, navigate, and review a 3D Model
BIM USE, MAINTENANCE SCHEDULING (7D)

START PROCESS
Correct?
Collect project Data
Facility Manager

Prepare/Adjust Schedule
Facility Manager

Perform Maintenance
Responsible Party

Validate Equipment Performance
Responsible Party

Regenerate Maintenance Data
Facility Manager

Record Model
Regenerate
Maintenance Data
Facility Manager

Interpret Data for Maintenance Needs
Facility Manager

Productivity Information
Prepare/Adjust Schedule
Facility Manager

CMMS Information
Warranty and Specification Information

End Process

BIM USE, MAINTENANCE SCHEDULING (7D)
ASSET MANAGEMENT

SUB Use: Asset Management (7D)

Description:
A process in which an organized management system is bi-directionally linked to a record model to efficiently aid in the maintenance and operation of a facility and its assets. These assets, consisting of the physical building, systems, surrounding environment, and equipment, must be maintained, upgraded, and operated at an efficiency which will satisfy both the owner and users in the most cost effective manner. It assists in financial decision-making, short-term and long-term planning, and generating scheduled work orders. Asset Management utilizes the data contained in a record model to populate an asset management system which is then used to determine cost implications of changing or upgrading building assets, segregate costs of assets for financial tax purposes, and maintain a current comprehensive database that can produce the value of a company's assets. The bi-directional link also allows users to visualize the asset in the model before servicing it potentially reducing service time.

Potential Value:
- Store operations, maintenance owner user manuals, and equipment specifications for faster access.
- Perform and analyze facility and equipment condition assessments.
- Maintain up-to-date facility and equipment data including but not limited to maintenance schedules, warranties, cost data, upgrades, replacements, damages/deterioration, maintenance records, manufacturer's data, and equipment functionality.
- Produce one comprehensive source for tracking the use, performance, and maintenance of a building's assets for the owner, maintenance team, and financial department.
- Produce accurate quantity takeoffs of current company assets which aids in financial reporting, bidding, and estimating the future cost implications of upgrades or replacements of a particular asset.
- Allow for future updates of record model to show current building asset information after upgrades, replacements, or maintenance by tracking changes and importing new information into model.
- Aid financial department in efficiently analyzing different types of assets through an increased level of visualization.
- Increase the opportunity for measurement and verification of systems during building occupation.
- Automatically generate scheduled work orders for maintenance staff.

Resources Required:
- Asset Management system
- Ability to bi-directional link facilities record model and Asset Management System.

Team Competencies Required:
- Ability to manipulate, navigate, and review a 3D Model (preferred but not required)
- Ability to manipulate an asset management system
- Knowledge of tax requirements and related financial software
- Knowledge of construction and the operation of a building (replacements, upgrades, etc.)
- Pre-design knowledge of which assets are worth tracking, whether the building is dynamic vs. static, and the end needs of the building to satisfy the owner.
WORKFLOW COMING SOON
TRY IMPLEMENTING THESE TWO BIM USES...

NO THANKS!

WE ARE TOO BUSY

MOVING FROM A TRADITIONAL APPROACH TO A BIM APPROACH IN PROJECT EXECUTION