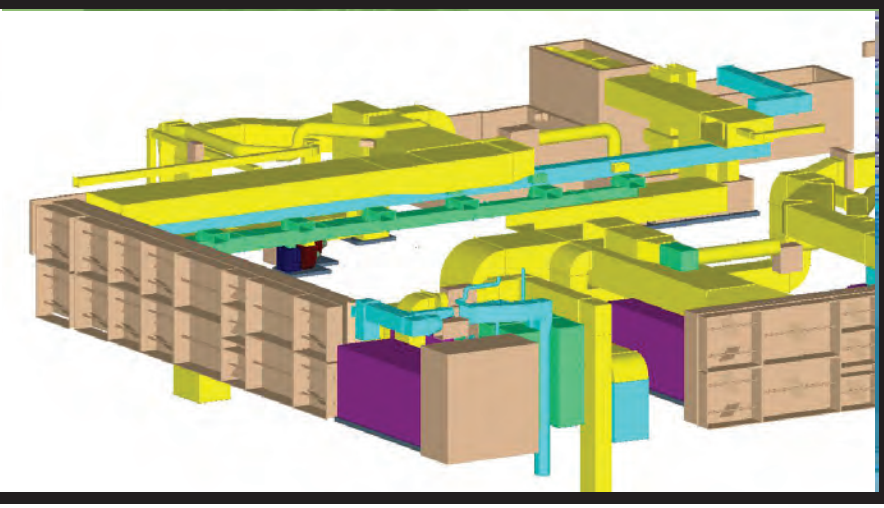
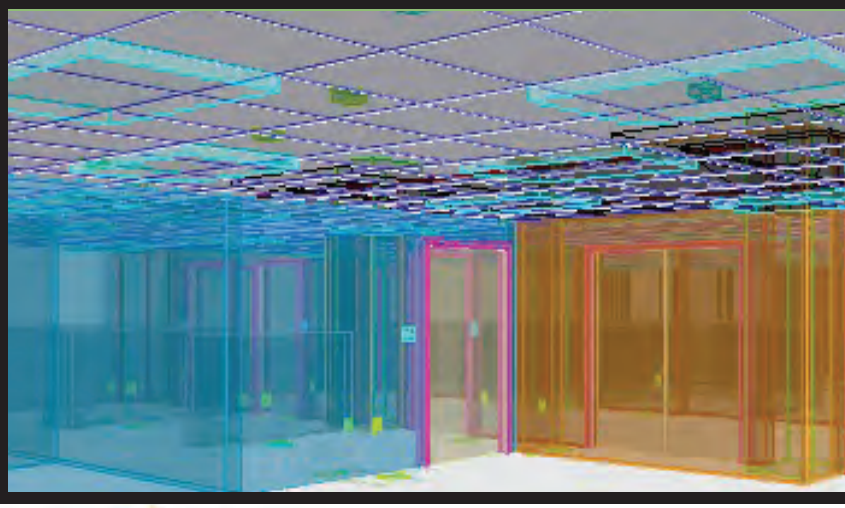
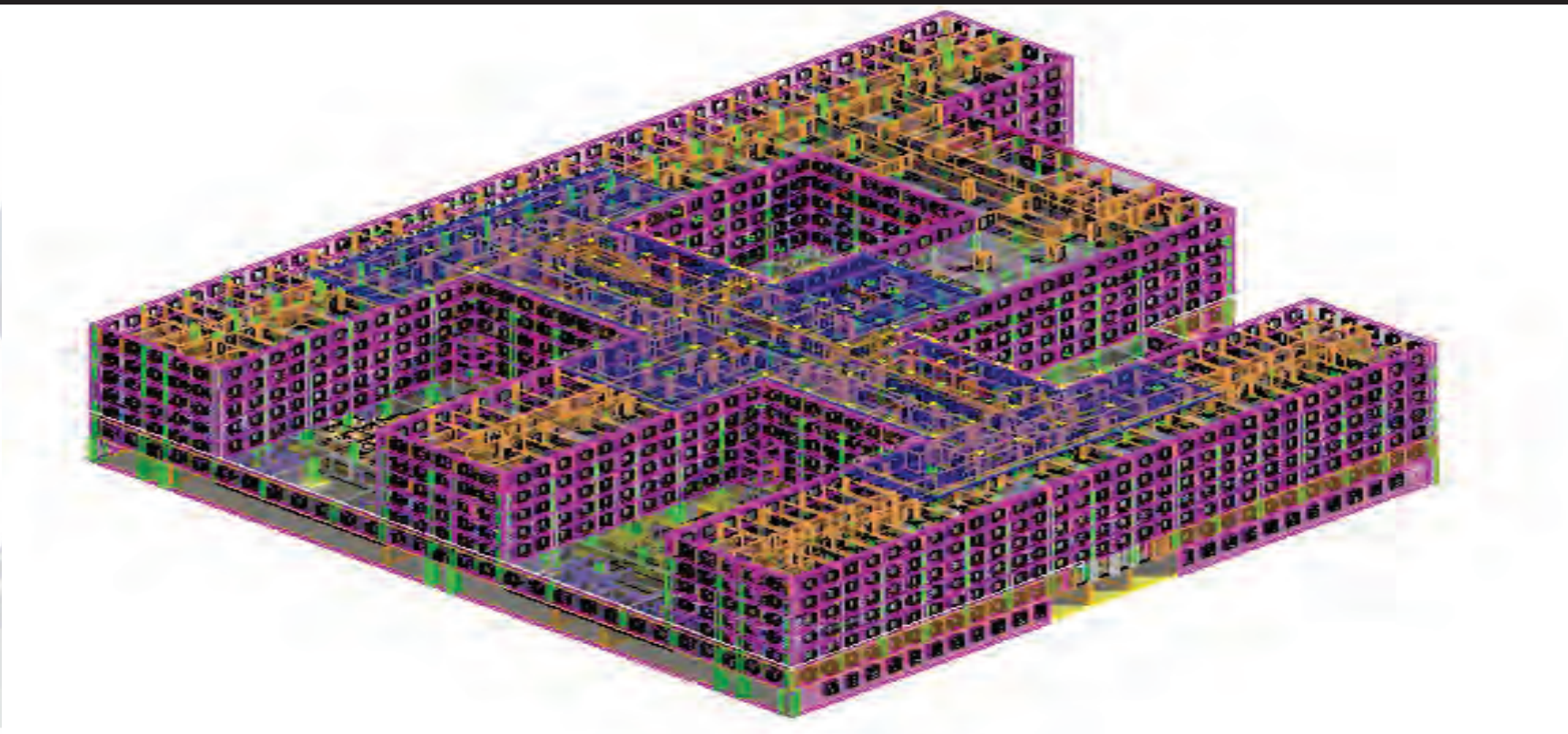
ARCHITECT OF THE CAPITOL

Building Information Modeling (BIM) Guide

September 2013







INTENTIONALLY BLANK

Contents

PREFACE

The Office of the Architect of the Capitol (AOC) is the steward of thirty historically significant buildings on Capitol Hill, and additional leased spaces in and around Washington, DC. AOC's mission is to efficiently manage, preserve, and sustain the Capitol facilities and grounds, while providing Congress and the Court with continuous access to safe, comfortable, and modern work environments. As these facilities age, maintenance, historic preservation, renovation and rehabilitation, expansion and reconfiguration projects help AOC sustain the facility value, historic integrity, and support of Congress and the Court.

A. BACKGROUND

The AOC has determined that Building Information Modeling (BIM), an evolving AECO[1] industry standard, will provide better project execution and facility management for the AOC facility mission.

> *"Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition".* (National BIM Standard - United States (NBIMS))

As defined, the Building Information *Model* is an integrated database of 2D-3D object-based graphics and attribute data used in creating an intelligent virtual model of a facility design and its building systems before it is built. It is a deliverable for AOC with important facility management information.

Building Information *Modeling* refers to processes and technologies used for collaborative project execution, model analysis, costing and simulation for decision support (3D-4D-5D[2]), and integrated construction documentation.

It is important that nationally recognized standards as well as AOC standards and protocols are used when developing BIMs so that both model and data are normalized for multiple uses and support the lifecycle facility vision.

BIM also:

- **Improves accuracy in project information**. BIM potentially increases design quality through effective visual design, analysis and enhanced communication. BIM reduces design errors, and change orders during a project, by exposing them in a virtual model rather than in the construction phase.
- **BIM can support specific analyses**. BIM can utilize intelligent, spatially identifiable objects/elements[3] that support specific analyses and simulations.

[1] AECO - Architecture, Engineering, Construction, Operations

[2] 4D and 5D refer to the addition of cost and time to the 3D model to support cost burn rate and phasing analyses.

[3] Object/Element – a BIM representation for a building product (BIM object) or an assembly (wall, roof, floor)

- **Aggregates data and graphics.** Model data can be grouped and calculated for quantities, costing and design-to-budget activities. Properly configured BIMs may automate and coordinate drafting tasks for construction documentation.
- **Automates reporting & analysis**. Additional data can be derived from the model. Space reporting and zoning for MEP, structural, and energy retro-fitting are facilitated.
- **Improves project execution**. Visualizing site logistics using 4D schedule simulation minimizes construction impact and safety issues for occupants and public.
- **Enables collaboration.** BIM enables team collaboration, automates project data sharing, and permits transparency for all stakeholders. That improves the decision process.
- **Facilitates prefabrication.** Predictable field conditions and digital mock-ups are designed with fabricators, reducing production errors and time to installation.
- **Supports emergency planning and security**. BIM as a 3D representation of the building provides useful simulations for line-of-site studies, crowd control, blast requirements, hazardous materials storage, and emergency response scenarios.
- **Shares data**: Creates a digital knowledgebase of a building for planning and facility asset management.

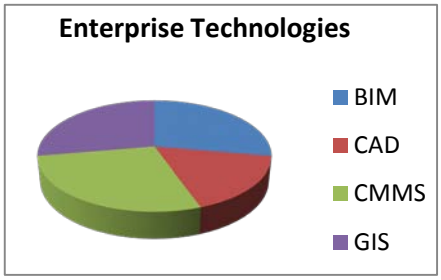


Figure 1 - AOC Enterprise Technologies

B. AOC ENTERPRISE INFORMATION VISION

AOC has established a multi-year enterprise information strategy for facilities management. This vision[4] includes BIM as one of the authoritative sources for standardized facility data. BIM data for spaces, equipment, zones, finishes, systems, and historic significance are essential data for facilities Management (FM). This data from BIM can be machine interpretable and interoperable, thereby reducing data reentry for Geographic Information Systems (GIS) and Computer Maintenance Management Systems (CMMS) applications used by AOC. This process improves workforce efficiency by providing AOC with consistent, reliable digital information for all phases of a project and building lifecycle. Data access improves preventive maintenance planning and procedures to extend asset life.

Enterprise Strategy for BIM Development

No complete BIMs exist for AOC buildings. The Planning and Project Management Division, Technical Support Division (hereafter PPM-TSD) and some Jurisdictions have developed partial models for testing and visualization. Currently it is not cost effective for AOC to create BIMS of entire buildings, separate of a project or facility need. Therefore, AOC will use a project-based strategy for developing its enterprise or Stewardship BIMs from the Record Models, and As-Built Model and Drawings submitted at project completion.

Model Development – From Single Spaces, Areas, to Full Buildings

Project models, representing part of the existing structure, known data, and new construction, will be created according for a project scope using the BIM standards defined herein. Upon project completion, the PPM-

[4] See *AOC Facility Data Vision* as Facility Management Data Vision (02 08 10).pdf

TSD or the Jurisdiction will integrate the project record[5] model with others of the same building. Thus, a complete BIM of the building will be gradually created. These Stewardship Models are digital knowledge bases of the facility capable of supporting the AOC building lifecycle missions: planning, operations, security, safety, communications, assessments, sustainability, maintenance, rehabilitation, renovation[6], historic preservation, documentation management, and sharing data with other AOC applications. The PPM-TSD is responsible for managing the AOC Master Drawings, data standards, and BIM, CMMS, and GIS integration. This group will support BIM implementation across the Jurisdictions[7].

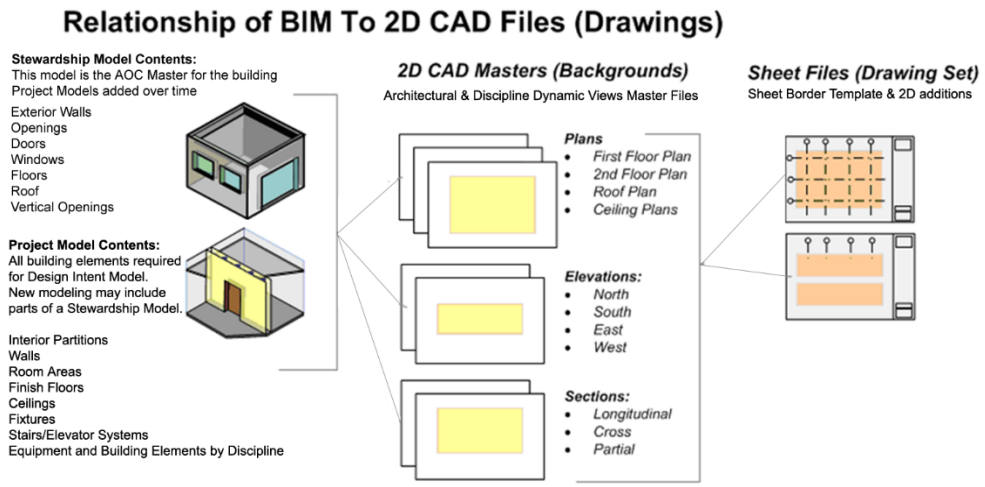


Figure 1- BIM Master Model to Project Models

Enterprise BIM Access

Currently AOC is not equipped to make AOC BIMs available for sharing outside its network. As part of the AOC BIM implementation, the issues of secure access and shared use are being explored with other Federal Agencies. On projects sharing BIM, the A/E, Contractor, or Construction Manager as Agent (CMa) shall define a collaboration environment outside the AOC network for the project stakeholders.

[5] A Record or As-Built model is an updated project model ready for submission to AOC and following prescribed guidelines in this document.

[6] *Renovation* typically refers to the total removal and replacement of building systems, while *rehabilitation* refers to the process of extending the useful life of an asset through repairs, alterations, and additions while preserving those portions or features which convey its historic, cultural or architectural values. These definitions do not affect those used by building and fire codes. *AOC Design Guide* (May 2012), Section 1, p. 3

[7] There are nine Jurisdictions responsible for specific buildings supported by AOC.

C. THE PURPOSE OF THE BIM GUIDE

This guide is one of several interrelated documents created by the PPM-TSD for AOC project requirements. BIM use shall conform to the design standards, code requirements, building system specifications, and documentation requirements in these manuals. The BIM Guide provides additional and complementary information.

The BIM Guide References:

- **AOC *Architect/Engineer Design Manual*, September 2011** (herein *A/E Design Manual*)
  Contains mandatory requirements for all size and type of projects
- **AOC Design Guide, May 2012**
  Provides additional design standards
- **AOC *Project Management Manual*, September 2011**
  Project phases and best practices
- **The BIM Execution Plan Template**[8]
  BIMPxP is used to document project specific BIM uses, teams, roles and responsibilities, data and standards for specific BIM-based projects.
- **The Object/Element Matrix**[9]
  O/E matrix is used as a reference document aligning Level of Detail with BIM uses to specify data attributes for BIM objects.
- The document **AOC_EnergyReport_FULL_2011_FINAL2.pdf**

BIM changes the scope, schedule, and deliverables for AOC projects. The AOC BIM Guide specifies BIM use requirements, processes, and standards to ensure consistent BIM quality across multiple projects from different service providers. While some BIM uses are not fully defined by the industry, the guide strives to provide a logical strategy for BIM innovation.

Uniformity in BIM development and data standardization is critical for AOC's stewardship BIMs and facility lifecycle data strategies. The reliability of BIM analytics, such as energy modeling is limited by incomplete and inaccurate data. The effort to produce such BIM-based analytics will decrease as geometry and data become more accessible and useful for data sharing.

BIM Authors and Users

Several AOC groups, and outside service providers can author or use BIM on AOC projects. These include: The Planning and Project Management Division, the Technical Support Division, the Design Services and Construction Divisions, the Jurisdictions, A/E's, and consultants. CMa, CMc, and sub-contractors may all author or use BIM on projects or for facilities management.

Updates to the BIM Guide

Updates will come from additional lessons learned and recommendations made to PPM-TSD. A periodic review by PPM-TSD will determine if any updates to the National BIM Standards, industry "best-practices" or technology changes should be incorporated into the BIM Guide to further maximize BIM's value to AOC.

---

[8] Appendix B.

[9] Appendix C. The Object/Element Matrix defines and organizes the AOC required attributes by object type.

D. BIM PROJECT MANAGEMENT REQUIREMENTS

This section is for AOC project managers, IDIQ contractors, and team members on BIM based projects. It covers project management structures and activities that influence BIM success on a project. The Planning and Project Management Division (PPMD), PPM-TSD, and the Jurisdictions are adapting to manage BIM-based project execution. Each Jurisdiction will integrate BIM into its project schedule based upon project size, complexity, acquisition strategy, and its in-house (local) capability to support BIM. Larger projects will be outsourced to a BIM capable A/E or Construction Manager as Agent (CMa). Smaller projects will typically use trained IDIQ teams or in-house personnel.

PROJECT BIM USE				
Project Size	**Small**	**Medium**	**Large**	**Mega**
Discipline	Single with minor assistance from others	Multiple	Multiple	Multiple
Cost Range	Up to $250,000	$250,000 to $5MM	Over $5MM	Over $50MM
Design Process	Consolidated into one phase	Two phases, Usually does not complete Schematic Design	All phases	All phases
Design Performed by	In-House or A/E task orders	A/E task orders with ongoing IDIQ contracts or professional services	A/E task orders with ongoing IDIQ contracts or professional services	External A/E firm
Construction Performed by	In-House	Varies by project acquisition strategy	Varies by project acquisition strategy	External construction
BIM Use	BIM optional Lower risk with an internal team. A-3 or BIMPxP	BIM Recommended Capable A/E, CM or internal team. IPD & BIMPxP, BIM Manager	BIM Required. Capable A/E & CM. IPD & BIMPxP. BIM Managers for Design &Construction	BIM Required. Capable A/E & CM. IPD & BIMPxP. BIM Managers for Design & Construction

Table 1 – Project Designations and BIM Use

1. Acquisition Strategies - Method of Project Delivery

AOC Responsibility

Project size and contracting methods impact BIM use, team responsibilities, and how model/data handovers are managed throughout a project. Therefore, the decision to use Design-Bid-Build (DBB), Design Build (DB), Integrated Project Delivery (IPD) or in-house project execution, should be determined early in AOC project *planning,* so that BIM use will be specified in the Request for Proposal (RFP) to assure contracting of qualified service providers. The AOC shall specify BIM requirements in the Task Order or Professional Services Contract for a BIM-based project.

AOC is considering Integrated Project Delivery (IPD), which will enable AOC to benefit from BIM-based collaboration. Apart from the acquisition strategy, the team shall make an effort to use IPD qualities to collaborate and share model information supporting cost effective project execution.

IPD Qualities and BIM enabled projects:

- All participants understand the value of collaboration and are committed to working together in the best interest of the project. Key decisions are evaluated by the project team.

- Project goals and objectives are developed early with BIM uses, roles, and responsibilities clearly defined from the SOW and in a BIM Project Execution Plan (BIMPxP)
- Project infrastructures including software, hardware and project collaboration site capabilities are defined at the outset of the project to maximize collaboration and reduce schedule delays.[10]
- The BIM Manager is an essential member of the project execution team and aligns BIM development and use with project goals, objectives, and milestones as part of the BIMPxP.
- A lifecycle approach is considered in the development of the model and data. "*Begin with the end in mind.*"
- Models are leveraged extensively throughout the project to support planning, analysis, estimating, designing to budget, design reviews, decision support, error reduction, and documentation. Reports, calculations, drawings, schedules, animations, 4D simulations and other project data is derived from the model, thus reducing effort and errors in information and documentation.
- Models are leveraged in construction to shorten the construction schedule and reduce construction costs
- The model contains, or is linked to, the information necessary to support the BIM uses, project processes, and facility operations and management at project turnover.
- The model provides data per AOC referenced standards, incorporates model Level of Development (LOD)[11] to show project progress, and contains COBie[12] compliant data during project milestones and for completion.

The AOC project team will review A/E and Construction teams' BIM capability and examples of building information models and BIM Execution Plans as part of team selection. A BIM Execution Plan (BIMPxP) using the AOC template will be created by the AOC and the project team for all BIM-based projects. (See BIM Execution Plan)

2. A BIM Execution Plan (BIMPxP)

Purpose of a BIM Execution Plan

Project teams are selected from different firms and include many professions, all with different experiences and understanding of how a BIM-based project is executed.[13] It is in the interests of the AOC that project teams arrive at a comprehensive and unified strategy for BIM-based project execution as quickly as possible. To achieve this unified team strategy, the AOC requires the development of a *project specific* BIM Execution Plan (BIMPxP) prior to BIM use on the project, unless modified by the AOC.

The BIMPxP is developed by the AOC and the project team using the AOC BIMPxP template. The BIMPxP documents the roles, responsibilities, BIM uses, model sharing, and deliverables for a *specific* project, based upon AOC guidelines and project requirements. The AOC project team shall define the project goals and objectives in Section 1 of the BIMPxP. These are then interpreted into BIM Uses and project scheduled actions by the project team in the remaining sections of the BIMPxP. Process diagrams of workflows are required for multi-discipline handovers and larger project workflows.

If the construction team is added at a later date, the BIMPxP will be updated to include their BIM roles, responsibilities, and processes.

---

[10] A/E provided collaboration sites are defined in the SOW before this phase.
[11] Level of Development defines the level of graphic detail and data reliability in the model. LOD requirements are defined for BIM use and deliverables.
[12] COBie is 'Construction Operations Building Information Exchange.' "COBie data is all the data required to operate a building." The "COBie spreadsheet" is not identical with the COBie data, but rather is COBie data in the form of a spreadsheet.
[13] Statistics show that 10 weeks to 6 months is necessary for a project team to develop a uniform project methodology.

The BIMPxP will:

- Align BIM uses to project goals, objectives, and guiding principles.
- Incorporate the applicable standards and requirements established in the AOC agency-wide BIM Guide.
- Determine possible adjustments or waivers to the BIM Guide to support the specific project. The AOC or its representative must approve any adjustments or waivers.
- Document project infrastructure, (software, hardware, server) suppliers, and hosts for project model(s)
- Assign BIM roles and responsibilities to the appropriate team or team member and communicate expectations to all team members and project stakeholders.
- Develop Meeting Schedule for BIM manager and BIM discipline teams – This sub-group shall develop a project template using AOC coordinates, model organizational structures, multi-user access, and show project phasing, and model/sub-model ownership.
- Develop a checking and validation process and schedule for BIM data and drawings.
- Identify the process flow for BIM tasks. Show the connection to submissions requirements, the project critical path, milestones, and deliverables. *Lean Pull Planning or Value Stream Mapping may facilitate this.*[14]
- Define information exchanges, shared access, and model consolidations
- Establish a basis for communication between BIM parties and a schedule for regular project meetings (The schedule may vary depending upon project progress and issues arising in BIM development.
- Document model access and security protocols
- Document model integrity and data safety plan
- Establish measureable goals for BIM success and team execution. This will become part of the project lessons learned, and may be incorporated into the AOC BIM Guide update.
- The BIMPxP, once delivered, provides the why, how, and what is to be included in the specific project model for AOC PPM-TSD and Jurisdiction handover.

BIMPxP Updates

The BIMPxP will be updated as needed to stay current with BIM development, new stakeholders, or new tasks. The BIM Manager will be responsible for BIMPxP updates to be reviewed by the AOC project manager to monitor BIM progress and model conformance to BIM milestone deliverables. The BIMPxP should be reviewed and updated at the start of new project phases, and whenever relevant stakeholders are added to the team.

Small Projects Using BIM:

If BIM is used on a small project, the modelers should document their processes as a project assessment using an abbreviated BIMPxP.

Medium and Large Projects: Use the BIMPxP template.

[14] Lean Construction Institute. *See* http://www.leanconstruction.org/readings.htm

3. Roles and Responsibilities

A project team has several BIM roles with responsibilities depending on project size and complexity.

Team BIM Manager

The BIM Manager supports the core modeling activities, model merging, project BIM use execution, and final deliverables. The Manager's responsibilities require technical expertise in the BIM software and model development strategies to achieve the BIM deliverables. The BIM Manager is responsible for:

- Developing the BIMPxP. Ensure that the BIMPxP, once accepted, is adhered to for the duration of the project.
- Providing a schedule for BIM uses and coordination with overall project schedule.
- Adhering to AOC standards and guidelines.
- Coordinating and managing BIM meetings. The BIM Manager facilitates project team responses to modifications by Jurisdictions
- Model merging and producing model views and construction documentation.
- Import and export of required data.
- Coordinating with AOC Technical Services to review the model for standards compliance and project deliverables

A BIM Manager is chosen for each project. Smaller in-house projects requiring very little modeling may use BIM trained staff from the PPM-TSD staff, AOC facilities, or the Jurisdiction. For larger projects, the A/E team shall have a BIM Manager to coordinate BIM use amongst the discipline teams.

Team Discipline BIM Managers

BIM discipline managers are the primary discipline modelers on a project. They work with the BIM Managers on all activities related to their model. Minimum responsibilities include:

- Coordination of discipline model at BIM meetings and reviews.
- Adherence to AOC standards and guidelines within the discipline.
- Supporting team information requirements
- Supporting model merging
- Working with other modelers on BIM uses

AOC Project Manager – BIM Oversight Responsibilities

The AOC project manager/team shall facilitate the coordination, organization, and direction of the integrated team with respect to project requirements that impact BIM development. This may be done with the cooperation of the A/E BIM Manager, support of a CMa, and/or AOC Technical Services.

- If BIM is to be used on a project, the AOC project manager should review the SOW to insure that the teams competing for the project understands that BIM use is a requirement.
- The AOC project manager or managing team participates in the creation, review, and approval of the Project BIM Execution Plan (BIMPxP). They:
    - Develop initial AOC project information for the BIMPxP meetings
    - Review the responsibilities, actions, and completion requirements.
    - Review the overall BIM project schedule for BIMPxP compliance

- Facilitate stakeholder reviews and deliver feedback to the team regarding revisions.
- Ensure that the BIMPxP, once accepted is adhered to for the duration of the project
- Facilitate project team responses to modifications by Jurisdictions
- Coordinate with AOC Technical Services to review the model for standards compliance, and all project deliverables, including as-built BIM.

E. AOC BIM REQUIREMENTS

1. Model Ownership and After Project Use

The Record Model (final Project Master Model) deliverable, the As-Built Model, all sub-models, model objects and elements, the associated and embedded data, BIM reports, and all views within the construction set or used as presentation are part of the instrument of service and considered a component of the Design and Construction Documents which AOC owns. These items may be used and re-used at AOC's discretion for additional facility lifecycle and new project needs beyond the original project execution and project information turnover.

No parties involved in creating the model shall be held responsible for costs, expenses, liabilities, or damages which may result from the use of the model after project completion or beyond the uses described and agreed to in the original project SOW and documented in the BIMPxP.

2. Model and Data Security and Shared File Server

The A/E or other responsible party for the project collaboration environment shall establish protocols for model and data security, permissions, and access rights to the stakeholders. These access controls shall be subject to AOC review and approval. These shall be referenced in a user access matrix as part of the BIMPxP. This environment will establish a single point to upload, share, and exchange models and project data. The same server shall be used to assemble project deliverables at pre-defined milestones across the project phases. AOC project managers and assigned PPM-TSD personnel shall have access to this collaboration site.

3. BIM Deliverables

To the current list of project deliverables,[15] AOC adds the BIM Record Model and all sub-models, model views, and referenced reports and schedules in the construction documentation. The BIM will be in .DGN format delivered on CD-ROM or DVD. The linked model views and referenced discipline sub-models will be maintained in the master model.

Hard Copy

Requirements for traditional reproducible and printed copies of design and construction documents are enumerated in the A/E's contract.[16] Before delivering the model or construction documentation files to AOC, any unnecessary drawing layers, groupings, and components that are not part of the actual design must be deleted from the model. These may also include "temporary," "working," "scratch," "underlay" layers, stories, and/or other logical or graphical groupings.

File Formats

BIM Models and Construction Set files shall be exported as .DGN files and as PDF. In addition, IFC files may be required. All subcontractors providing modeling are required to have the capability of saving BIMs in DGN or the most current version of IFC. A .DWG may be saved from Bentley if needed. Any use of file formats other than Bentley .DGN shall be documented in the BIMPxP.

---

[15] Section 1, 1.4.4. Deliverables, p. 15, *A/E Design Manual.pdf*

[16] ibid

Non-editable model and construction documentation may be saved as PDF. I-model (3D model) can be saved in PDF.

4. BIM Software

The AOC supports the use of IFC compliant software and industry standards for BIM use. The PPM-TSD periodically reviews software interoperability and industry standards to enhance AOC BIM efficiencies, to maintain flexibility of model manipulation and exploration, and to sustain or improve information flow. The AOC PPM-TSD will make project stakeholders aware of the current version of any software to be used before project execution.

The software versions will be documented in the BIMPxP and maintained throughout the project unless approved by AOC and the project BIM Manager. Any deviation from this requirement must be approved by the AOC prior to commencement of work.

BIM Authoring Tools

AOC currently requires Bentley AECOsim, V8i *SELECT* Series 3 – Architecture, Bentley Building Electrical, Bentley Building Mechanical, and Bentley Structural BIM.[17]

Contractor and Trades Software

The GC shall list the software and version they and their subcontractors will be using for BIM authoring, shop drawings or fabrication on a project in the software section of the project BIMPxP. Any software, not currently approved by AOC for use on its projects, must be tested for graphic and data exchange compatibility and approved by AOC prior to commencement of work.

Additional Software

Additional third party applications compatible with Bentley BIM and IFC 2x3 that provide additional BIM use or reporting capabilities may be considered for AOC projects. Examples include: Trelligence *Affinity* for programming, *Bentley FM. I-model*, *Bentley View* (free viewer), *Bentley Navigator*, *Model Server Publisher*, *Microsoft Project, Primavera*, or *Synchro* for scheduling and 4D[18], *Autodesk Navisworks* for clash detection and viewing, *EcoDomus* for managing and extracting COBie data, *Solibri Model Checker* for model integrity review, and *Energy Analysis AECOsim Energy Simulator* software, used to predict building energy usage and loads.

5. BIM Project Management Requirements

There are several NBIMS[19] and industry best practices that AOC adheres to for BIM projects.

Model Quality and Assurance

BIM Quality Assurance is jointly managed by the BIM Manager, the project team involved in BIM use, and the AOC. The assurance methodology will be documented in the project BIMPxP. Quality assurance should be exercised at the point of creation[20] in the form of visual inspection model reviews, component

[17] "Workspaces," Section 1, p.14, *A/E Design Manual.pdf.*

[18] 4D – A model-based simulation used to show changes to the model over time as the 4th dimension or axis.

[19] NBIMS – National BIM Standard

[20] This approximates a Lean principle.

reporting, and partial merged models to detect[21] object/element interferences. The main objective of the AOC BIM Quality Assurance and Validation (QA/V) requirement is to detect potential modeling, program conformance, and BIM use issues as early as possible, and then identify any discrepancies and correct any deficiencies before they negatively impact model use, the project goals, or other downstream providers.[22] The BIM QA/V process determines if the BIM, as authored, coordinated, and used, meets the prescribed AOC modeling requirements in the SOW, integrates the necessary data standards, and performs as documented in the BIMPxP.

Each discipline modeling team is responsible for the quality of its model, and shall perform quality assurance on its working models[23] in the form of visual inspection model reviews, component reporting, and partial merged models to detect[24] object/element interferences. This periodic interference checking (*See* BIM Use Interference Checking) will help the team avert end-of-design "clash detection" results that potentially stop work and require re-design.

The goal of this BIM requirement is to improve the quality of the model and modeling processes to meet AOC needs, ensuring a functional, high-quality project as the result. The review schedule or reporting will be documented in the BIMPxP.
For smaller projects QA/V should take place before the creation of dynamic views, and construction drawing creation. The models should be 100% accurate before construction documentation is annotated.

Data and Classification Standards

Objects and spaces managed through the facility lifecycle and shared across applications are to be classified using current Omniclass, MasterFormat, UniFormat,[25] and all required AOC space naming and space numbering per the AOC *A/E Design Manual.* Omniclass, MasterFormat and UniFormat are three of the foundation systems available to structure construction data attached to a model. Omniclass is used in the Construction Operations Building Information Exchange (COBie).

Attributes and Historic Preservation Attribute

AOC has developed a Bentley specific object/element attribute file. Objects and elements shall have a Historic Asset attribute added to the object/cell or element.

Model Accuracy and Tolerances

All models, from site to building, to equipment are to be created with the highest *reasonable* level of accuracy and support the AOC scale requirements for construction documentation. Modeling existing buildings shall be based upon Master Drawings provided by AOC, with field measuring or electronic verification conducted by the project team to validate the information's level of accuracy. All conditions must be verified in the field by the contractor prior to fabrication.

In general, BIM elements should be dimensionally accurate and of a Level of Detail (LOD) to support the creation of AOC drawings per the scale requirements in the AOC *A/E Design Manual.* Objects that are

[21] *See* Clash Detection Use Case
[22] This also follows Lean principles.
[23] Working models are models in progress, not finished deliverables. Quality assurance is a continuous process.
[24] *See* Clash Detection Use Case
[25] Omniclass, MasterFormat, and Uniformat are the trademarks of their respective holders.

smaller than 6 cubic inches, or parts within a larger piece of equipment, need not be modeled unless specified by AOC. Accuracy requirements should be mutually agreed upon, and all disciplines must comply with the agreed practice and documented in the BIMPxP.

Model Accuracy Examples:

- **Models created from Master Drawings**: AOC will provide the project team Master Drawings and the required degree of information reliability before modeling commences. Models may follow these drawings with field verification for a higher level of accuracy before new construction modeling.
- **Existing Conditions Modeling** does not require modeling of all slants, inclinations, defects, and other changes in existing walls, ceilings, and other building elements' thickness or height. The "as documented" dimension shall be used in the model.
- **Models from Laser Scanning**: Laser scanning develops a highly accurate "point cloud" which may contain information too detailed for efficient modeling and manipulation, and is not required in the model. (*See* Laser Scanning BIM Use)

Levels of Development

(LOD) defines the graphic complexity and information reliability of an object or element in models. Associated General Contractors (AGC), American Institute of Architects (AIA), and Building Smart Alliance (BSa).[26]

- **LOD 100 -** The Model Element may be graphically represented in the Model with a symbol or other generic representation, but does not satisfy the requirements for LOD 200. Information related to the Model Element (i.e. cost per square foot, tonnage of HVAC, etc.) can be derived from other Model Elements.

- **LOD 200 -** The Model Element is graphically represented within the Model as a generic system, object, or assembly with approximate quantities, size, shape, location, and orientation. Non-graphic information may also be attached to the Model Element.

Figure 2- LOD 300

- **LOD 300 -** The Model Element is graphically represented within the Model as a specific system, object or assembly in terms of quantity, size, shape, location, and orientation. Non-graphic information may also be attached to the Model Element.

- **LOD 350 -** The Model Element is graphically represented within the Model as a specific system, object, or assembly in terms of quantity, size, shape, orientation, and interfaces with other building systems. Non-graphic information may also be attached to the Model Element.

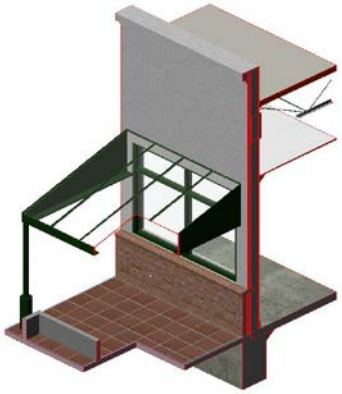


Figure 3- LOD 400

- **LOD 400 -** The Model Element is graphically represented within the Model as a specific system, object or assembly in terms of size, shape,

[26] Level of Development Specification (April 2013)

location, quantity, and orientation with detailing, fabrication, assembly, and installation information. Non-graphic information may also be attached to the Model Element.

- **LOD 500 -** The Model Element is a field verified representation in terms of size, shape, location, quantity, and orientation. Non-graphic information may also be attached to the Model Elements.[27]

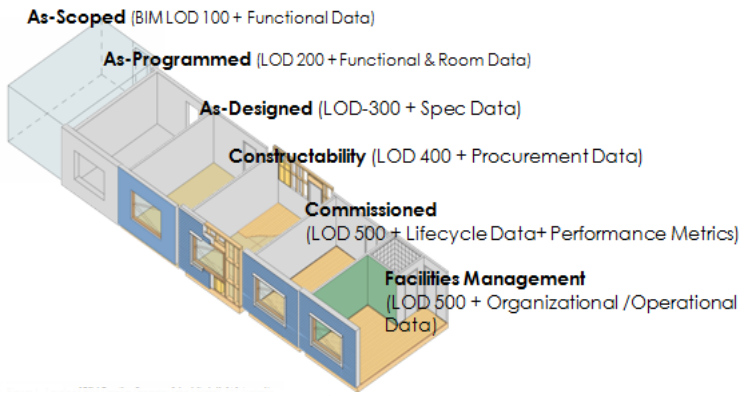


Figure 4-Level of Development

Modeling with Proper Elements

All modeled elements shall use the proper object or element when modeling. Walls should be created with "the wall tool," floors with "the slab tool." If an element is created using a tool other than that provided by the BIM authoring software developer, then it must be named for the building entity or product it represents, and placed on the appropriate layer in the appropriate model for the project.[28]

Maintenance Clearance Modeling

All models shall include separate 3D representations of required clearances for mechanical equipment, light fixture access, overhead cable tray access, accesses required by code, or by AOC for purposes of operations and maintenance, for assessment, repair, or replacement[29]. These clearance/access representations should be on a separate layer for each system and clearly named as such so they will not be calculated or counted as a building product. A clearance space entity or material type can be created such that it can be filtered out or reported at will. Maintenance reservation (clearance) spaces should be reviewed by the Jurisdiction and maintenance staff at approximately 80% coordination completion of each floor to verify their adequacy and practicality, and signed off at 95% to 100% coordination of each floor. AOC's project manager shall coordinate this process.

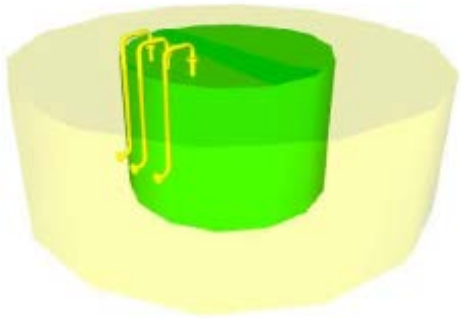


Figure 5 - Maintenance Clearance Space (shown in yellow)

[27] Level of Development Specification, (DRAFT 2013)
[28] IFC models can also accommodate the distinction between a product or construction entity type and the BIM authoring tool that creates it, provided the user so indicates. Therefore a rolled-arm sofa made with a terrain mesh tool can be correctly counted as furniture, not as terrain.
[29] *AOC Design Guide* (May 2012), Section 1, p. 6, Maintenance Precepts

Working and Finished Rendering Levels

The AOC values visualization to support stakeholder communication and decision support. During the design phases, prior to final design review, the team may present working level renderings and 3D views to avoid the time and expense of post-modeling photorealistic rendering. Finished high quality renderings may be required or suggested as part of client communication and shall be documented in the BIMPxP. (*See* Figure 5, Figure 6.)

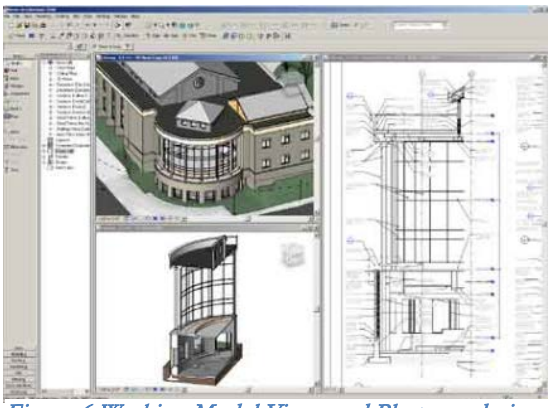


Figure 6-Working Model Views and Photo rendering

Derived Data

Derived data is a fundamental benefit of BIM. For graphics the system provides Extracted views from the model to support coordinated drawings. The model can calculate and report data from the model, objects, and elements for analysis, quantities, and construction documentation schedules and views. Volumes are a simple example of data derived from length, width and height of designated spaces. Summing linear feet of crown moldings and counts of file cabinets are other simple examples of data derived from the model and objects.

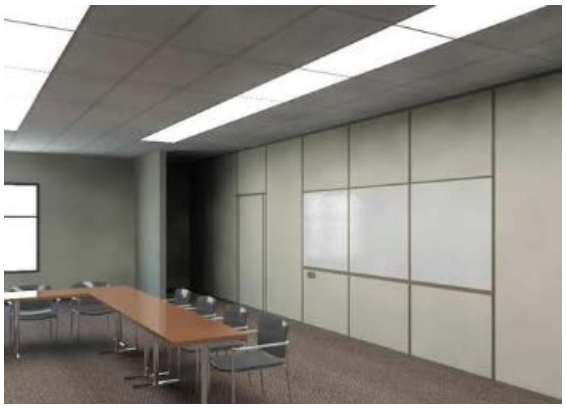


Figure 7 – High quality rendering

F. BIM USES

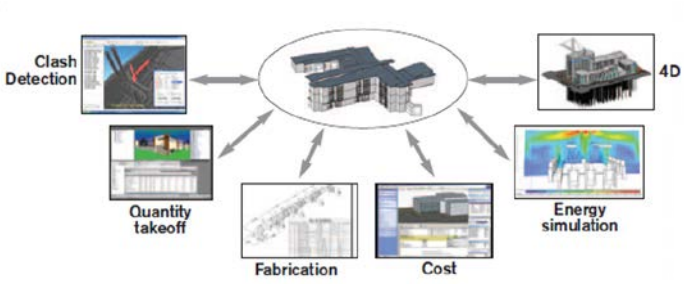


Figure 8 - BIM Use Examples

Established project goals and stakeholder needs inform the AOC project team about which BIM uses to specify in a SOW. However, there are several BIM Uses applicable to all AOC projects. Existing conditions modeling, estimate and costing, space validation; clash detection and constructability exercises; design review; commissioning and close out requirements for as-built documentation; and COBie facility data, are all BIM Uses generally required for a project.

1. Existing Conditions Modeling

These models support additional work at AOC for historic preservation, renovation, new systems retrofitting, reallocation of space, and new construction. The existing condition models may be used as a basis for design studies, sight line studies, move management and logistics, day lighting, area calculations, space allocation studies, volume calculations for HVAC, planning standards, phasing studies, testing locations, and other studies relevant to the project SOW.

The project SOW will define the approximate area, relevant building systems, and associated equipment to be modeled. The BIMPxP will define the agreed upon modeling effort.

The PPM-TSD or Jurisdiction will provide access to master drawings and any partial models for preliminary modeling. Field verification is part of this process unless otherwise specified by AOC. All applicable AOC BIM and CAD standards and requirements apply.

At a minimum, an existing conditions model will contain:

- The visible architecture and equipment, (LOD300) walls, floors, ceilings, columns, and roof. Assembly and product information must be added to the model as required by the SOW.
- Space volumes and room data (numbers, functional use[30], space ownership)
- Date attribute when the existing conditions were verified. This easy to add metric indicates how current the facility base models are, and the associated data. This helps the beginning of a "corporate memory."

Optional:

- Furniture and fixtures may be modeled in accordance with the SOW.
- Extend the modeling beyond the immediate SOW areas to show context and additional information based on project needs.

Additional AOC Attributes:

- Jurisdiction
- Building Type

[30] Omniclass *Table 13 – Spaces by Function* classification is strongly recommended. *Table 11 – Construction Entities by Function* and/or *Table 14 – Spaces by Form* may be helpful.

- Historic Preservation Asset
- Space Type
- Alternate potential use(s) for the space
- Historic zones
- Noise Level Standard (if applicable to the SOW)
- Security requirements, levels, applicable standards

2. Laser Scanning for Existing Conditions

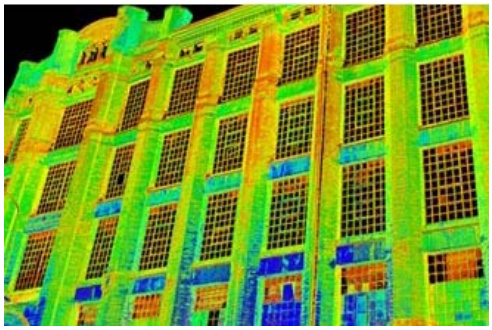


Figure 9-Point Cloud and cloud to BIM

Laser scanning is an efficient, automated process for measuring distances from predefined surfaces capturing millions of measurements in a 3D point cloud[31]. Large projects or areas needing greater detail may use laser scanning to capture as-is conditions for historic documentation of previously unseen conditions during demolition and before close-in during construction.

The AOC Photographic Department has responsibility for documenting existing and new construction. The AOC, the design team, and the photographic department will evaluate the cost and efficiency benefits of laser scanning to capture existing conditions and the attendant point cloud conversion to BIM, based upon the size and complexity of the project.

Laser scanning conversion should be part of the SOW or given as an option by AOC in project planning. The project team shall define the process in the BIMPxP process diagram.

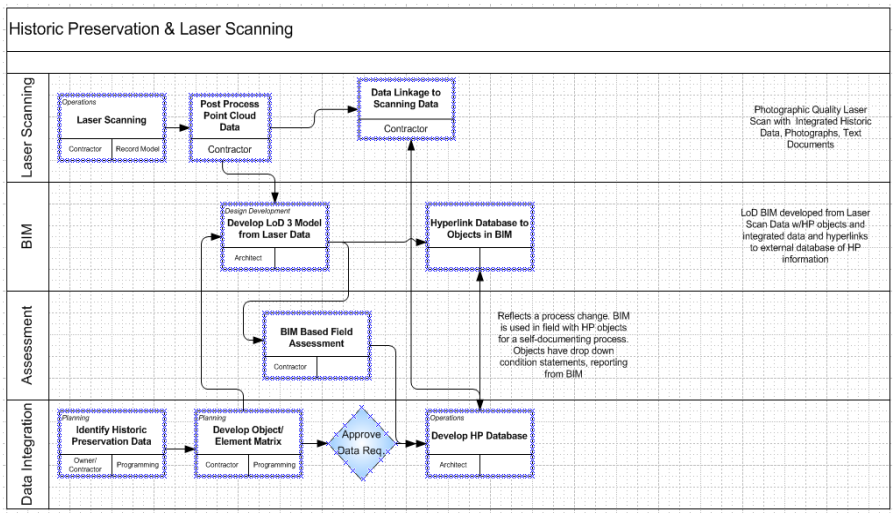


Figure 10 – Example Laser to BIM Process Map

[31] A Laser point cloud is a graphical representation of measured points from a specific location. The point cloud may have added data, but requires conversion to become a BIM.

3. Space Modeling and Program Validation

AOC requires space program information, reports, adjacency and stacking diagrams. Historically a Summary Space List[32] has been developed in Word or in a spreadsheet. A BIM based project should utilize the space/area tool with assigned space standard data[33] to generate space requirements.

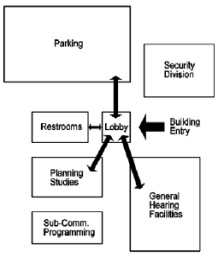


Figure 11 - Traditional AOC Diagram

Room Boundaries and volumetric shapes shall be a "closed element" modeled to the face of finished construction. Used as a 3D volumetric shape, the area of a room will go to the finished drop ceiling. The following shall be developed for automatic reporting from the model: Assignable Areas (ASF) and Non-assignable Areas (NaSF) measured to inside face of wall elements and designated boundaries of areas. Gross Area (GSF) is measured to the outside face of wall elements.

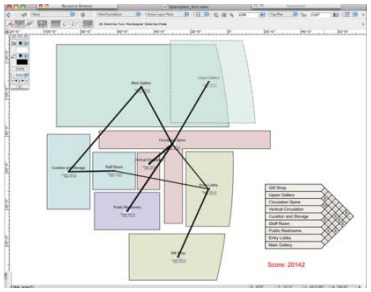


Figure 12 - BIM Diagrams w/Data

Overall Adjacency and Stacking Diagrams

The Design Team shall use BIM authoring software or other BIM space analysis tools to compare and validate the stated program of requirements (POR) with the actual design solution. Space validation ensures that as-designed conditions meet the AOC space standards and program requirements. Space validation may be accomplished through quantity take-off reporting of spaces/area/square footage.

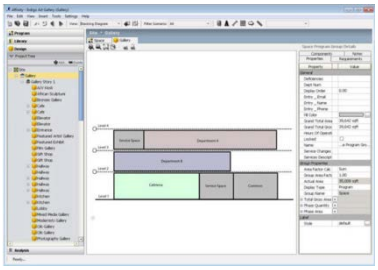


Figure 13 – Example Vertical Adjacencies

The design team shall provide:

- Diagrams to represent the overall relationships between all major functional areas at a glance.
- Ensure that department, organization, and functional unit locations on the diagram clearly reflect the degree of interaction needed between units. Movement, traffic flow, entrance, etc. can be conveyed with arrows, line of sight model views, or animations.
- Color coding spaces is recommended and will be documented in the BIMPxP.
- The adjacency diagrams and reports should reinforce the Space Summary and serve as a checklist to verify those requirements.
- Use of model checking programs may be used to automate program validation in BIM. Use of model checking software will be documented in the BIMPxP.

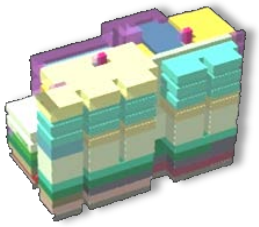


Figure 14 – Example Color Coded Space and Adjacency Stack

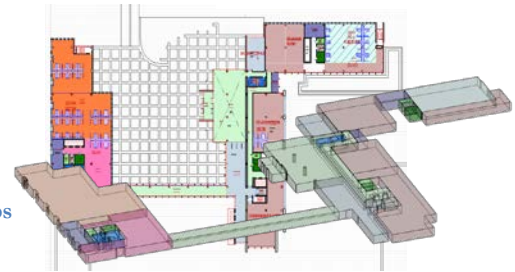


Figure 15 – Example Axon View of Space Relationships

[32] Appendix C *Design Phase Documents*, p. 106, *A/E Design Manual.pdf*

[33] Information on Space Categorization, Space Efficiency and Space Guidelines are found in the Reference Library.

4. COBie Data Handover

Projects for AOC will require COBie data utilizing the current COBie spreadsheet. COBie is an NBIMS, vendor-neutral data-set that specifies how to format design and construction data so it can be consumed by facilities management software. The AOC uses such a CMMS (Computerized Maintenance Management Software) application that supports COBie data.

AOC projects will comply with COBie data quality control rules and will produce a COBie2-compliant dataset. COBie describes both the process of collecting and validating data, and the required datasets collected throughout the project and by different stakeholders:

Design Phase:

- Facility and Floors are defined
- Spaces are classified using Omniclass and AOC classifications
- Zones have Categories assigned
- Types have Name, Category (Omniclass), Description, Asset Type
- Components have Name, Description, Type, and Space
- Systems have Name, Category (Omniclass), Components

Construction Phase:

- Type information is updated by providing Manufacturer, Model Number, Warranty information (Parts and Labor and Duration), Replacement Cost
- Component information is updated by providing Serial Number, Installation Date, Warranty Start Date, and (optional) Tag Number or Barcode. Installation Date for Major equipment will be the Finish Date of the corresponding schedule activity.
- Spare parts are provided for Types
- Attributes are provided for Types and Components

Commissioning Phase:

- Documents are assigned to corresponding BIM objects (Types, Components, Spaces, Facility)
- Attributes are corrected based on real measurements

COBie and Bentley

COBie is supported by one of the components of the AECOsim, not by Microstation directly. AECOsim is composed of three products, one of which is *Building Designer* with data group systems, including an IFC export engine. COBie (Construction Operations Building Information Exchange) Support - As part of the IFC Enhancements, AECOsim Building Designer V8*i* can export either a COBie compliant IFC file or a Microsoft Excel spreadsheet. The *COBie Challenge 2013*, demonstrated both updated COBie tables as well as improved COBie data capture and export from Bentley BIMs.

There are two high-level paths between a BIM and the spreadsheet view of the COBie data contained in it, known as a "COBie spreadsheet."

A two-step path first exports an IFC model with its associated data from the native BIM format. Then, a software utility[34] of some kind extracts the COBie data from the IFC and generates a spreadsheet with the formatted, color-coded, linked, data. The two-step path may be supplied or supported by the BIM software developer and/or third party software developers. At a minimum, however, the BIM software must have robust support for IFC output, and at a minimum the utility that creates the COBie spreadsheet format must be high quality. This is enough to assure very good (although not perfect) fidelity between the BIM and the COBie data it contains.

A one-step process bypasses the step that creates the IFC model. It takes the BIM in its native file format as input, and outputs the COBie data found therein as a COBie spreadsheet.

In both the two-step and one step process, additional COBie data can be manually added directly to the outputted spreadsheet in the traditional manual entry method. Using some third party middlewares, the data thus entered can flow from the spreadsheet back into the model[35] – in some cases just to the IFC model[36], and in other cases, back to the model in its authored environment.

[34] For example, AEC3 produces a free command-line operated BIMSERVICES.exe utility that will extract some COBie data from an IFC model to create the "COBie spreadsheet." AEC3 also offers a paid version with a smoother graphical interface. *See* http://www.aec3.com

[35] *EcodomusPM* is an example of this for the Revit® environment. Also, but with limitations is the free *Ecodomus COBie Basic.*

[36] AEC3's *BIMSERVICES.exe* free utility is an example of this.

ENGINEERING ANALYSIS

The A/E teams can use BIM to discover the most effective and efficient engineering designs and methods based on the project design specifications. This information will be passed on to the owner and/or operator for use in the building's systems. While this is an emerging capability,[37] analysis tools and performance simulations can significantly improve the design of the facility and its energy consumption during its lifecycle. These simulations support better sustainability and lifecycle costing decisions for AOC.

BIM Supported Engineering Analysis:

- Provides for an optimum, energy-efficient design solution
- Reduces the cycle time of the design analyses, yielding more explored options and higher quality
- Enables "what-if" lifecycle cost analysis for design

Each project team will work with the AOC to determine the best and most cost effective method for analysis.

1. Energy Modeling Requirements

Energy efficiency is a high priority for AOC. The goal of this BIM use is to support DOE 2 through data reporting, and to optimize proposed design solutions to reduce the facility life-cycle costs: "Design shall optimize building energy performance to meet performance targets by employing energy modeling programs." [38]

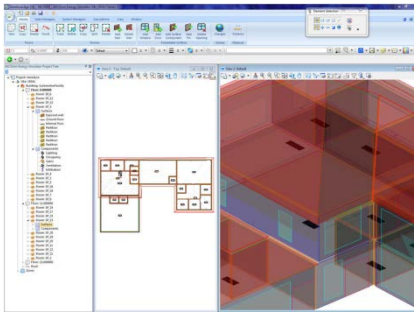
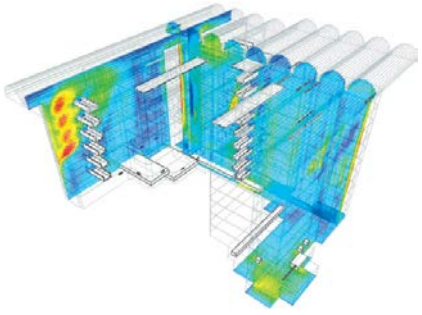


Figure 16-AECO Simulator Energy Model

All large system retrofit and major renovation projects should utilize energy modeling at an appropriate engineering level for existing buildings. Calculations are broken into 5 categories.[39]

Note: AOC requires a DOE 2 energy-based analysis. Most professionals using existing energy simulation tools do not find converting BIM geometry into these tools cost effective. However, there is information reportable from BIM that is of value in developing the energy analysis.



Some of these include:

- Space classifications (There is an alignment between ASHRAE [40]space classifications and *Omniclass Table 13 – Spaces by Function.*)
- The areas and volumes of building spaces
- The wall and roof assembly information, R-values &/or U-values
- Number of windows and (derived) glazing area
- Protective and reflective coatings or films

---

[37] Energy analysis via virtual building models has been available for about 15 years. It is an emerging capability relative to the history of Architecture and what is possible in analyzing BIMs.
[38] *AOC Design Guide* (May 2012), Section 3, p. 3, *3.3.2. Energy Performance.*
[39] *A/E Design Manual*, Section 4. Design Development, mechanical systems
[40] American Society of Heating, Refrigerating, and Air Conditioning Engineers

- Substantial internal building thermal masses that are exposed to sunlight
- Lighting types
- Climate
- Siting - building orientation and contextual geography
- Shading devices and nearby shading and shadow-producing structures

This information can be exported from BIM for use in DOE 2 based energy analysis software.[41] Substantial project information that drives both energy consumption and energy shedding may be decided or known early in the design cycle and may enable MEP teams to move ahead with preliminary calculations in parallel with Architectural schematic design and design development. When, how, and what information is needed and used from BIM will be documented in the BIMPxP and a process diagram will document the expected process efficiencies for future use by AOC.

Additional information may be incorporated into the energy model as needed for simulation:

- Detailed electric and fuel rates as defined by the local service provider.
- Building function and occupancy.
- Building operating schedules.
- Building lighting information in watts/ft2 and schedules.
- Building HVAC equipment information (EER, COP, MBH, kW, tons) and schedules.
- Building plug load information (kW, Btuh) and schedules.[42]
- Building process load information (kW, Btuh) and schedules.
- Building envelope construction components including U-values, SHGC, absorptivity, SRI value, color, and thickness, as applicable to the component. Energy Model Reports from the A/E team are dependent on size and complexity of the project: 100% SD, 75% DD, 100% DD, and 100% CD. The reporting scheduled will be documented in the BIMPxP.

Energy Analysis Software:

DOE 2 energy analysis software. Bentley AECOsim Energy Simulator incorporates the EnergyPlus simulation engine, the emerging standard for the industry developed by the U.S. Department of Energy. Additional information is available from the Bentley website in document file: WP_gbXML_LTR_v03.pdf.

2. Cost Estimation

Having the potential to save time and money by avoiding budget overruns, the project team will work with estimators using BIM to generate an accurate quantity take-off for cost estimates early in the design process. They will continue to refine and provide cost implications of design additions and modifications. This process allows designers to see the cost effects of their changes in a timely manner – before a substantial investment is made in pursuing an economically terminal design. This can help curb excessive budget overruns due to project modifications.

[41] *AOC Design Guide* (May 2012) Section 1, p. 8, 1.3.6. Energy Conservation
[42] There are commercially available devices and associated software that will monitor and control at the plug level.

The value of cost estimation is to:

- Stay within budget constraints while the design progresses.
- Permit exploring different design options and concepts within the owner's budget
- Precisely estimate material quantities and generate quicker revisions if needed
- Better discover and visually represent project and construction elements that need to be estimated
- Provide cost information to the owner during the early decision making phase of design
- Focus on more value-adding activities in estimating (identifying construction assemblies, generating pricing and factoring risks) which are essential for high-quality estimates
- Save estimators time by allowing them to focus on more important issues in an estimate since take-offs can be automatically and consistently provided: let the computer count what's in the design, and let estimators look at "or equals" and material pricing.

3. Interference Checking ("Clash Detection")

Models shall be free of conflicts among major systems, their subsystems and elements, prior to final construction documentation. Interference checking can be performed visually &/or automated. If automated in Navisworks®, then the following colors with the exception of architectural and structural elements are as shown in *Table 2*:

Lights	Yellow
Electrical	Cyan
HVAC Pipe	Lime Green
HVAC Duct	Blue
Fire Sprinklers	Red
Plumbing	Magenta
Ceilings	Orange
Framing	Purple
Steel	Maroon
Concrete	Grey
Methane	Forest Green

Table 2 - Required Color Coding in Clash Detection

Interference issues and clash detection, now known as *model coordination,* are prioritized into a high, medium or low status. The distinction among the priorities regards the urgency or speed with which they must be fixed due to their implications not only for the finished product but also for other design teams' progress. The priorities do not imply that some issues must be corrected while others do not. Whether a particular interference is classed as Level One or another Level is possibly project dependent; however, while there is some "wiggle room" on the status assigned to a discovered coordination issue, the issue must be must be corrected.

Level One Collisions/Issues

Level One Collisions/Issues are reported issues that are considered critical to the design and construction process. These collisions have been assigned the highest priority and should be rectified within the model as soon as possible:

- Mechanical Ductwork and Piping vs. Ceilings
- Mechanical Ductwork and Piping vs. Rated Walls (For coordination of Dampers and other mechanical equipment needs)
- Mechanical Ductwork and Piping vs. Structure (Columns, Beams, Framing, etc.)
- All Equipment and their applicable Clearances vs. Walls
- All Equipment and their applicable Clearances vs. Structure
- Mechanical Equipment and Fixtures vs. Electrical Equipment and Fixtures
- Mechanical Ductwork and Piping vs. Plumbing Piping
- Unique historic items which cannot be altered or moved vs. Plumbing, Piping, Electrical, Mechanical.

Level Two Collisions/Issues

Level Two Collisions/Issues are reported collision/issues that are considered important to the design and construction process. These collisions have been assigned a greater priority and should be rectified during project meetings during design:

- Casework vs. Electrical Fixtures and Devices
- Furnishings vs. Electrical Fixtures and Devices
- Structure (Columns, Beams, Framing, etc.) vs. Specialty Equipment
- Structure (Columns, Beams, Framing, etc.) vs. Electrical Equipment, Fixtures and Devices
- Ductwork and Piping vs. Electrical Equipment, Fixtures, and Devices
- Ductwork vs. Floors

Level Three Collisions/Issues

Level Three Collisions/Issues are reported collision/issues that while considered important to the correctness of the model will generally be changing on a regular basis throughout the design and construction process. These collision/issues have been assigned a lower priority and should be rectified before the phase submission of the models:

- Casework vs. Walls
- Plumbing Piping vs. Electrical Equipment, Fixtures, and Devices
- Plumbing Piping vs. Mechanical Equipment, Fixtures, and Devices
- ADA Clear Space Requirements vs. Doors, Fixtures, Walls, Structure

All Other Collisions/Issues

While the above coordination issues have been assigned priorities, it is likely that other issues will exist within the models. The collisions are not all ignorable nor should they be discarded. Some collisions will exist because the available software is not yet mature enough to support the modeling efforts or identify subtle interferences. The intention is to have a model that is as error and collision free as possible at each submission phase with documented proof that the design team addressed the collisions identified *(above)*. Issues which are discovered by design professionals but are missed by software analyses should be thoroughly documented for the AOC team in its "lessons learned" compilation.

G. BIM BASED PROJECT MANAGEMENT

Project managers' responsibilities change in a BIM based project. It requires an understanding of the BIM potential, how to facilitate the development and use of the BIM Execution Plan (BIMPxP), and how moving to BIM supports the AOC facility lifecycle vision. This section aligns BIM potential with the AOC Project Management Manual, September 2011.

Historically, owners did not care how paper documents were created; only that professional quality of care was evident. With CAD files, an owner knew they needed reliable standards to make the electronic form of the paper documents useful. In a BIM based project, the manager needs to review *how* the model is created, the data standards used, *what* it can be used for, and *when* it is used and shared. Understanding the changes BIM brings will come from BIM management training, and facilitated discussions with the project teams.

Model Stewardship

Models play a positive role in stakeholder reviews and project decision making. The As-Built is an important deliverable during project close for AOC. The model must be managed similarly to the project. Model reviews with the BIM Managers or modelers, verifies that the model is meeting the requirements outlined in the BIMPxP to meet project goals. It is assumed that PPM-TSD staff will be available to support model quality control and data integrity at defined milestones in the project.

Risk Management

Risk is inherent when using new processes and tools on a project. BIM's substantial benefits for AOC, must be weighed against the level of risk/reward to the project. Project size, complexity, available resources, the experience of the team, and the value of BIM use for project decision makers are criteria for the discussion. This discussion takes place *in planning* when defining the project, so that the Project Management Plan reflects this need for knowledgeable resources.

1. Project Team

AOC Project Manager – BIM Oversight Responsibilities

- The AOC project manager/team participates in the creation, review, and approval of the Project BIM Execution Plan (BIMPxP)
- Develop initial AOC project goals for the BIMPxP meetings
- Review the roles and responsibilities, and completion requirements.
- Facilitate BIM based stakeholder reviews and deliver feedback to the team regarding revisions.
- Ensure that the BIMPxP, once accepted is adhered to for the duration of the project.
- Coordinate with AOC PPM-TSD to review the model and project deliverables for standards compliance

AOC BIM Manager

Medium and large BIM projects should have an assigned AOC BIM Manager for the duration of the project. If turnover to another manager is required, then the BIMPxP becomes an important reference document for any new AOC BIM Manager.

Design Phase Specialist

The Design Phase Specialist should understand how BIM supports required reviews and will work with the project manager regarding how BIM will support this project phase.

> *The design phase specialist shall review the initial project scope, schedule, and budget and, if needed, shall notify the project manager of any revisions or adjustments. The design phase specialist communicates with the CM to ensure a smooth transition between designs and construct phases.*[43]

Construction Manager/Construct phase specialist/COTR

These team members should understand the value BIM brings to construction and should work with the project manager and BIM Manager to execute on the BIMPxP.

2. Project Classification and BIM Use

The chart from the PM Manual has been augmented for BIM Use. While most projects that traditionally used CAD will change to BIM, there is a transition time on AOC projects, based upon size, complexity, and the availability of resources.

Project Size	Small	Medium	Large	Mega
Discipline	Single with minor assistance from others	Multiple	Multiple	Multiple
Cost Range	Up to $250,000	$250,000 to $5MM	Over $5MM	Over $50MM
Design Process	Consolidated into one phase	Two phases, usually does not complete Schematic Design	All phases	All phases
Design Performed By	In-House or A/E task order	A/E task orders with ongoing IDIQ contracts or professional services	A/E task orders with ongoing IDIQ contracts or professional services	External A/E firm
Construction Performed	In-House	Varies by project acquisition strategy	Varies by project acquisition strategy	External construction
BIM Use	BIM optional. Strongly consider if CAD drawings, plans/ sections/elevations are required. Lower risk with an internal team. Perform A-3 or modified BIMPxP	BIM Highly Recommended; strongly consider if CAD drawings, plans/sections/ elevations are required and BIM uses are applicable. BIM capable A/E, CM or internal team. IPD & BIMPxP, BIM Manager	BIM Required. Capable A/E & CM. IPD & BIMPxP. BIM Managers for Design & Construction	BIM Required. Capable A/E & CM. IPD & BIMPxP. BIM Managers for Design & Construction

Figure 17- Additional Information on Project sizes and BIM

[43] Section 1, p. 12, *Project Management Manual.pdf*

3. BIM Execution Plan Template (BIMPxP)

The BIMPxP is a companion document to the Project Management Plan. The AOC project manager, AOC BIM Manager, and the design team shall align BIM uses to the project goals and milestones for larger projects. The project scope and method of procurement will dictate the milestones; however, some standard BIM uses are identified in this guide. The project manager and an AOC BIM Manager[44] shall interact on BIM based projects to achieve the SOW and the tasks to be identified in the BIMPxP.

Project Controls[45]

There are several project controls affected by BIM use. *Italic information concerns BIM use*

- Design Documents meet CAD *and BIM standards*
- Cost or Schedule Growth for design or construction within allowable deviation *Utilizing 4D scheduling and Lean project management help manage schedule*
- Record Drawings are collected and submitted in a timely manner. *Utilizing BIM and building to model supports fewer changes making Record Model and Drawings less costly*
- 100% new equipment added into CAFM / 100% demolished equipment removed from CAFM. *Continuous use of BIM and integrating COBie data provides a component level inventory for CAFM/CMMS systems*
- Client Satisfaction Score of 90% or higher – *Using BIM provides better communication for stakeholders allowing design decisions to be fully vetted faster.*

Project Prioritization and Funding

Utilizing BIM to capture a reliable project definition including estimates, project scope, schedule, and approved design is possible in BIM without risking full construction drawings prior to funding.

4. The Project Checklist

BIM use on a project is a new element in Project Definition and in the Procurement Request Package for A/E and contractor services. This information should be entered into the project management system.

5. BIM Uses for AOC Programs

Sustainability[46]

- Sustainable design is an integrated, synergistic approach that considers all phases of the facility life cycle during the design process. BIM provides analysis opportunities and a basis to review lifecycle operational efficiencies via its data, inherent visualization capabilities, material identification and quantity tracking that can feed costing engines.

Commissioning[47]

On June 7, 2010, the Architect of the Capitol issued a policy concerning Commissioning Guidelines. Commissioning at AOC should start in the Design phase and may begin in the Planning phase. Utilizing

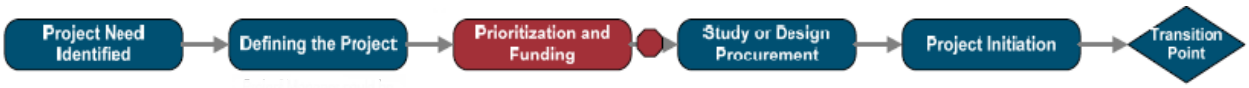
[44] The AOC PPM-TSD will fulfill the role of BIM Manager and support for AOC BIM based projects.
[45] Section 1, p. 20, Project Management at AOC, *Project Management Manual.pdf*
[46] Section 1, p. 26, *Project Management Manual.pdf*
[47] Section 1, p. 27, *Project Management Manual.pdf*

COBie data in BIM supports higher quality commissioning. A robust commissioning process will eventually require most if not all of the same data prepared for and found in the COBie spreadsheet. Therefore the commissioning agent will both provide and consume COBie data and can inform the BIM at all stages of its development.

H. PROJECT PHASING

This section identifies BIM requirements and options by AOC phases for projects. This first section provides general comments about how BIM consideration and use fit into the current project phasing.

1. Plan



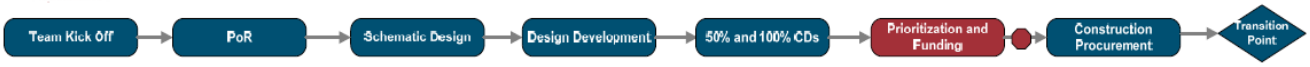
BIM must be considered when defining the project. An internal discussion should take place between the AOC BIM Manager and the project planning team to determine and prioritize use cases relevant to the proposed project and AOC's long-term interests.

2. Study

AOC GIS data, master drawings, and other AOC data may be of value to a project team, depending upon the scope of the study. GIS data used for move management may help with alternative ways of solving the need without construction. If an A/E is creating the report, then visualization of proposed options can be beneficial. Modeling BIM components or areas at a LOD 100 – 200 for spaces, from the Master drawings will help with early planning studies. For more complex projects, laser scanning may be an alternative if the drawings are considered out-of-date.

3. Design and Construct

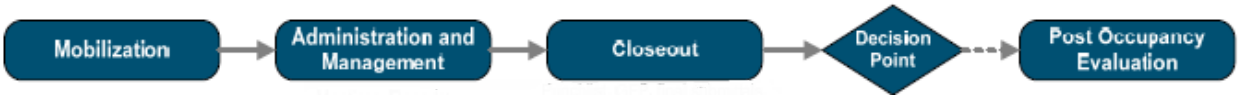
As much as possible, it is advantageous for the design and construction teams to work together and use BIM to facilitate constructability, costing, site logistics, security, and other BIM uses appropriate for the project.



Any deliverables which require CAD drawings should be evaluated for BIM deliverables. Wherever feasible, CAD drawings should be produced from the BIM to minimize the usual sheet coordination effort and ensure sheet coordination. If an external A/E is used, the project manager will facilitate the creation of the BIMPxP so that BIM can be used as part of design options, constructability, and decision support activities.

A determination should be made concerning partial set reviews vs. continuous use of the model in meetings so that the project issues are being addressed in a timely manner, and documentation is done when the model is correct and interference checking completed and interferences resolved. Continuous model review is a lean principle that helps parties work together, and avoids stops in design to create partial drawing sets.

If a separate construction team is used, either internal or external, the model should be made continuously available to the team.



If BIM has been used for design, then the project manager should have within the AOC SOW for the contractor, model handover and model use for construction.

I. DESIGN PRODUCTION PLAN

At design kick-off, the team will develop a work plan for BIM use and submittals as part of the BIM Execution Plan development. The BIMPxP shall be developed at this time to align BIM modeling and uses with design submittals.

1. Design Development

Comparison of proposed design solutions using simulations is one of the principal benefits of integrated models. Comprehensive comparisons performed at an early stage are important because investment in the model and in the design are relatively low so changes can still be easily made when discussing the general outlines of the project. The later the potential problems emerge in the process, the more difficult it is to resolve them without a major impact on cost or quality or schedule.

Architectural

Model the architectural elements to a level that defines the design intent and accurately represents the design solution. The detail and responsibility to fulfill these modeling requirements should be addressed fully within the BIMPxP. These elements should be modeled:

The Architectural Site plan (per project requirement). Paving, grades, sidewalks, curbs, gutters, site amenities and other elements typically included on enlarged scale site drawings in the vicinity of a building should be included.

Existing conditions to the extent required by the project. New interior and exterior walls to **their correct and accurate height** including but not limited to:

- Doors, windows, openings – identify historically significant or unique elements. For AOC a high percentage of these elements will be unique, so AOC should consider creating custom parametric libraries of such elements so that hundreds of unique objects need not burden its BIMs.
- Interior and exterior soffits, overhangs, sun control elements
- Parapets, screening elements
- Architectural precast

- Floor, ceiling and roof systems
    - Model appropriate structural items listed below if not provided by the structural engineer and integrated into the architectural model for coordination and document generation. Insulation, ceiling systems, and floor are included.
        - Roof, floor, and ceiling slopes, if needed, shall be modeled. If the elements are modeled, then they must be modeled correctly.
        - Soffits, openings, and accessories shall be modeled.
- Elevators, stairs, ramps including railing systems.
- Casework, shelving, and other interior architectural elements.
- Model furnishings, fixtures, and equipment if not provided by others and integrated into the architectural model for coordination and document generation.
    - Furniture (Fixed and Loose)
    - Furniture Systems
    - Specialty equipment (for example, food service equipment)
- Model mechanical, electrical, and plumbing items that require architectural space (toilets, sinks and other fixtures), that require color or finish selection (louvers, diffusers, etc.), or where the team or its customers benefit from visualization, or which affect 3D visualization (lighting fixtures) unless provided by engineers.
- Clearance zones for access, door swings, service space requirements, gauge reading, and other operational clearance must be modeled as part of all equipment and checked for conflicts with other elements. These clearance zones should be modeled as translucent solids on a separate layer or as described elsewhere in this document. (*See Figure 5 - Maintenance Clearance Space (shown in yellow)*)

Structural

Model the following structural elements. The detail and responsibility to fulfill these modeling requirements should be addressed fully within the BIMPxP.

If required for project type, foundations such as:

- Spread Foundations
- Caisson Foundations
- Pile Foundations
- Mat Foundations
- Load-bearing Wall Foundations

Framing:

- Steel Columns (with correct shape and size)
- Steel Floor C-Joists
- Open Web Joists
- Joist Girders
- Steel Beams (with correct shape and size)
- Precast Concrete Elements (Hollow Core Plank may be modeled as a slab unless coordination with mechanical systems needs to occur because the hollow core is being used for those systems)
- Cast-In-Place Concrete Elements

- Floors including overall extents and openings
- Model overall thickness of wood floor systems
- Wood Posts/Column
- All other Joists
- Wood Trusses
- Solid Wood or Laminated Beams
- Fireproofing, if required – alternatively use a 2" clearance for clash detection.

Wall Types including openings:

- Load Bearing Walls – for calculations only (Masonry, Concrete, Cold-Formed Steel, and Wood)
- Model overall thickness of Cold-Formed Steel and Wood Stud walls (individual members may be modeled at the Design Team's option)
- Structural Foundation Walls including brick ledges

HVAC Systems

Model the following HVAC elements at a minimum. The detail and responsibility to fulfill these modeling requirements should be addressed fully within the BIMPxP.

- Equipment
- Fans, VAV's, compressors, chillers, cooling towers, air handlers etc. Distribution
- Supply, return, exhaust, relief and outside air ductwork modeled to outside face dimension or duct insulation (whichever is greater)
- Duct Joints
- Diffusers, grilles, louvers, hoods, radiant panels, perimeter units, wall units
- Pipes sized at and over 3/4" Diameter include any insulation in model unless otherwise noted by the BIMPxP.
- Clearance zones for access, door swings, service space requirements, gauge reading, and other operational clearance must be modeled as part of the HVAC equipment and checked for conflicts with other elements. These clearance zones should be modeled as invisible solids within the object.

Electrical Systems

Model the following electrical elements at a minimum. The detail and responsibility to fulfill these modeling requirements should be addressed fully within the BIMPxP.

- Data, Power and Telecommunications
- Interior and exterior transformers, emergency generators, and other equipment
- Main and distribution panels and switchgear including access clearances
- Main IDF's
- Outlets, switches, junction boxes
- Lighting

Permanently mounted lighting fixtures (movable, plug-in fixtures need not be modeled as part of the electrical package unless needed for plug load calculations or for estimating purposes within a loose furnishings package. This should be discussed, agreed upon, and documented within the BIMPxP).

- Lighting Controls
- Switches

- Junction Boxes
- Fire Alarm and Security Systems
- Input devices
- Notification devices
- Associated equipment and access clearances
- Permanently mounted fixtures
- Electrical Power Off Buttons (EPOs)
- Clearance zones for access, service space requirements, meter reading, switch access, and other operational clearances must be modeled as part of the electrical system and checked for conflicts with other elements. These clearance zones should be modeled as invisible solids within or as part of the BIM object or element, as necessary to support interference detection software.

Plumbing

Model the following plumbing elements at a minimum. The detail and responsibility to fulfill these modeling requirements should be addressed fully within the BIMPxP.

- Waste and Vent
- Piping sized at and over 3/4" inside diameter, plus any insulation, should be in the model unless otherwise noted by the BIMPxP.
- Roof and floor drains, leaders, sumps, grease interceptors, tanks, water treatments and other major items.
- Supply
- Piping sized at and over 3/4" inside diameter, plus any insulation in model unless otherwise noted by the BIMPxP.
- Fixtures: sinks, toilet fixtures, water tanks, floor sinks

Fire Protection

- Sprinkler lines at and over 3/4" inside diameter
- Sprinkler heads, Fire Protection Pumps
- Stand pipes, wall hydrants, fire department connections, risers, including valve and access clearances
- Clearance zones for access, service space requirements, gauge reading, valve clearances, and other operational clearance must be modeled as part of the plumbing and fire protections system and checked for conflicts with other elements. These clearance zones should be modeled as invisible solids within or as part of the BIM object or element, as necessary to support interference detection software.

2. Mid-Point Submissions

At expected project duration mid-point, schedule a model review to determine BIM use to date, and documentation of model calculations, drawings as needed, and an estimate review and calculation if required. The BIMPxP should be reviewed and updated at that time, as well as any design alternatives (options). Three-dimensional modeling and visualization facilitate the comparison between different alternatives and bring the design solutions to a concrete level.

3. Pre-Project Package Submission

There are several times in an AOC project when work typically stops for funding reasons. At such a time the model must be documented in a "state of the project" snapshot or archive suitable for later reactivation. This includes the context:

- which BIM use cases have been invoked and therefore which are supported by the model;
- the data elements and LOD assigned to objects and elements in the updated project BIMPxP, oftentimes interdependent with one or more BIM use cases;
- a listing of the BIM authoring softwares, software versions and builds, add-ons, utilities, and third party tools, object libraries, layers and groups used to produce the model and its documentation up to that point; and
- generally, the software configuration(s) and all other information required to reconstitute the project at a later time with minimal disruption.

This information will be used to "refresh" the model for the next stage of the project if and when it becomes funded and thus reactivated.

4. Finalize Design – Pre-100% Submission Review

The team shall "refresh" the model and update the design as necessary to support teams contributing to and "consuming" the BIM. Any changes to the project program will be documented in the BIMPxP, including:

- Reports showing LOD of the objects and elements
- Quantity take-offs that support final cost estimate(s). This stage of the model should be complete enough to support finalizing construction documentation
- Drawings and Schedules and other data outputs
- Renderings

5. Construction Documentation

The team shall finish the construction documentation drawings generated from the model, per the BIMPxP. Construction documentation shall follow the AOC CAD Manual requirements with an inclusion of 3D views in the construction documents.

6. Mobilization for Construction

Depending upon the procurement type, the BIM will be provided to the construction team either by access from the design team, or from the AOC Technical Support Division.

Administration & Management

The BIM manager for construction will administer and manage the model during construction. The responsibilities are the same as the Design BIM manager's.

7. Close Out and Commissioning

The design team shall submit the design data as a COBie-compliant Microsoft Excel® spreadsheet. The COBie compliant file should be the current version at the time of submission for review. If the requirements are not met, the design team will resubmit the data within two weeks after AOC reports on missing data. The COBie spreadsheet is available from http://www.wbdg.org/resources/cobie.php?r=om#ar During construction, additional data will be entered. All data requirements should be fulfilled by project closeout

J. PROJECT MODEL CONVENTIONS

This section provides additional standards information for BIM use at AOC. It adheres to the DOCUMENTS section of the *Architect/Engineer Design Guide*. The information in the *A/E Design Guide* is to be followed with respect to:

- General Conventions
- Document Security
- Drawing Sheet Numbers and Appendix B
- Sheet Type Designations
- CAD File Numbers
- Project Model Files
- Title Pages, Cover Sheets
- Scales
- Discipline Drawings – In this instance the drawings will be derived views from the model
- Drafting Conventions – objects (3D cells) substituted for 2D symbols

Deliverables:

Per this *Guide* the model, sub-models, dynamic views, reports, and linked references are to be the property of AOC and provided on CD-ROM or DVD. All links are to remain intact on the media deliverable.

Model Content

Before delivering the model and construction documentation files to AOC, all unnecessary drawing layers, groupings, and components that are not part of the actual design or documentation are to be deleted from the BIM files.

1. Project Model Naming

The A/E Design Manual CAD file naming instructions for construction worksheets and drawings shall be followed for all project BIM discipline models and the project master model.

AOC will develop a Stewardship model to incorporate project models. This stewardship model will be named for the Jurisdiction. Stewardship models will contain the exterior and shell of the facility. Projects which are renovation, rehabilitation, retrofit, will be incorporated into the Stewardship file over time.

All project files will follow the AOC project numbering convention.
(Project Model File, Sub-Model and Discipline Model files, Dynamic Views,
Sheet Drawings)

2. Consolidated Models and BIM Derived Construction Documentation

Different disciplines are responsible for different parts of the design and the corresponding model. These discipline specific sub-models are merged into model sets for architectural reviews, interference checking, analysis review, and construction documentation. The BIM Manager is responsible for the consolidation of the discipline specific models according to the project needs as defined in the BIMPxP. Large projects may

require further division of discipline specific models because of technology issues, performance constraints or ease of use. If single models are divided, then the methodology for the division will be documented in an updated BIMPxP.

BIM driven construction documentation sets shall follow the prescribed AOC drafting conventions.[48]

Project Explorer in Bentley provides an organizational structure to the views and files in a BIM environment. The following rules may be adopted to help organize, identify, and share the model effectively:

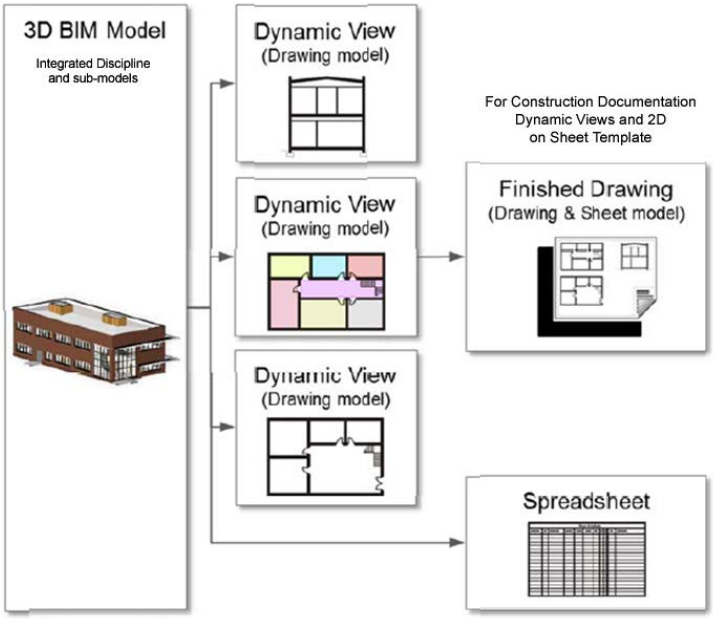


Figure 18-Bentley recommended Model Structure

- Design files should contain only one Design Model.
- Drawing files should contain only one Drawing Model.
- All sheet files from a specific discipline model should be kept in a discipline folder.
- All sheet files should contain only one sheet model, representing the single drawing that will be printed from that file.
- All sheet models shall be named to match the drawing number it contains. There should never be models named "sheet" or "untitled sheet" – Sheet Models should be named based upon the document and drawing number protocols established in the BIMPxP and based upon AOC A/E Design Guide Naming conventions. The names must match the text as it appears in the title block and any schedules. [49]

3. Discipline Designation for Models and Drawings

AOC Discipline Designations are based upon the Uniform Drawing System. The letter designations for disciplines shall be used for discipline models and drawings. **AOC A/E Design Manual.** All discipline models naming shall conform to the discipline layers and abbreviations. The building systems, assemblies, or products represented in a model shall be named according the Construction Specification Institute (CSI) Master Format and UniFormat used by AOC and be placed on the appropriate discipline layer in the model. **Note:** Omniclass designations shall be used for COBie data.

4. BIM Meta Data

All project model naming shall conform to the AOC building name conventions in the **AOC A/E Design Guide**. The model shall carry the following information:

- Project ID - AOC Project Number Convention

[48] Section 1. 1.4.3. Drafting Conventions, and Appendix B, p. 80-99, *A/E Design Manual.pdf*
[49] Bentley Best Practices, See *aecbimprotocolforbentleyabd-v2-0.pdf* (2012)

- Project Name - AOC Project Name
- AOC - Building Name and designation (Class of Building)[50]

5. Space/Area Naming Conventions and Identifiers

Area Data: Provide for core/vertical shafts area traces/perimeters and identification; for, occupants area and identification; for organization area and identification; for tenant area and identification; and for subtractable areas and identification. Comply with AOC standards for calculation/identification of space unless an alternative is approved and documented in the BIMPxP.
Provide for room occupant names, room organization identification, room areas; subtractable area and identification; tenant common area and identification; and secondary area and identification. Additionally, provide for group area and identification.

- **Room Numbers:** Utilize room numbers that exactly match the actual numbers that are used in the facility. In conformance with the **AOC** ***Capitol Hill Graphics Manual***, include all hyphens delimiters, in any numbering convention.
- **Room Names:** Use the customary title associated with each room or space. Never identify a room or space by Member or Justice name.

Additional attributes for space may include:

- Omniclass Space Type as part of COBie data
- Historic Preservation – Heritage Asset

6. Site, Utilities, and Building Lines

Per the *A/E Design Manual*, location of utilities and external site information shall be shown within 5ft of the building footprint. It is recommended that utility cutoff switchgear and vaults associated with or controlling particular buildings or structures, should be shown in the BIM even though these will typically fall outside the 5-ft perimeter footprint.

7. Geo-Referenced Models

For seamless integration between models, drawings and AOC's Enterprise Geographic Information System (GIS), the following coordinate system (*see* Figure 17) shall be used for all BIM/CAD deliverables, unless otherwise specified:

Maryland State Plane Coordinate System, FIPS Zone 1900	
Projection	Lambert_Conformal_Conic
False Easting	1312333.333333 feet
False Northing	0.00 feet
Central Meridian	-77°00'00"
Latitude of Origin	37°39'39"
Angular Unit	Degree (0.0175329)
Linear Unit	US Foot (1ft = 0.304801 m)
Datum	NAD 1983
Geographic Coordinate System	GCS_North_American_1983
Vertical Measurements	
Vertical Datum	NAVD 88
Vertical Unit	International Foot (1ft = 0.304801 m)

Figure 19- Coordinates for BIM model

Geodetic Datum: The AOC uses the District of Columbia Engineer's Department datum for all vertical elevations. Horizontal control observes the Maryland State Coordinate System.
D.C. Engineers Datum: Zero = +2.11 ft. above low water in Washington Harbor.
Capitol Bench Mark: DC =+89.84 ft. The Capitol Bench Mark is the apex of a bronze bolt set in the east windowsill of the south side of the Senate Wing of the U.S. Capitol. The bolt was placed in position in 1894

[50] AOC Design Guide Section 1, pg.4 1.1.1. Design Requirements

and is inscribed "Capitol B.M." This was formally approved February 10, 1999, under Alan M. Hantman, FAIA, Architect of the Capitol.[51]

It is the BIM Manager's responsibility to verify the accuracy of the coordinates set in the model and provide a grid intersection at 0,0,0 and 2D reference grid for all other team members. The BIM Manager shall establish the protocol so that the various discipline and trade sub-models developed for the project will be modeled at the correct elevation. Once established, every trade must use the same agreed upon reference point or global coordinate system.

[51] AOC Design Guide 2012 Section 1.pg. 3

GLOSSARY

- **A/E**

Architect / Engineer (including sub-consultants)

- **A/E/C**

Architect / Engineer / Contractor

- **AECFM**

Architect / Engineer / Contractor / Facility Manager

- **AECO**

Architect / Engineer / Contractor / {Owner, Operator}

- **AOC**

The Architect of the Capitol; also The Office of the Architect of the Capitol

- **As-Built Model Deliverable**

Model(s) based on Fabrication Model(s) and installed conditions

- **ASHRAE**

American Society of Heating, Refrigerating, and Air Conditioning Engineers

- **BIM**

Building Information Model (Product).

- **BIM**

Building Information Modeling (Process).

- **Building Information Modeling (BIM)**

A process focused on the development, use and transfer of facility attribute data of a facility to improve the design, construction and operations of a facility in order to achieve project specific goals.

- **BIM**

Building Information Management (Information Management)

- **BIM Project Execution Plan (BIMPxP)**

BIMPxP is a plan that defines how BIM will be implemented throughout the project lifecycle.

- **BIMPxP**

BIM Project Execution Plan; see Section 3

- **CAD**

Computer-Aided Design

- **CAFM**

Computer-Aided Facilities Management

- **CMa**

Construction Manager as Agent

- **CMc**

Construction Manager as Constructor

- **CMMS**

Computerized Maintenance and Management System

- **COBIE**

Construction Operations Building Information Exchange

- **Consolidated model**

The Main model and federated sub-models incorporated into one file, typically for the purpose of interference checking and model integrity review

- **Construction Model**

Model(s) based on criteria that is important to the translation and interpretation of the means and methods of facility's construction processes. (LOD Varies).

- **CSI**

Construction Specifications Institute. Publishes authoritative MasterFormat and Omniclass documentation as well as other construction-oriented organizational information tools.

- **Design Intent Model**

Model(s) based on criteria that is important to the translation and interpretation of the facility's design. (LOD 300)

- **Drawing**

A drawing is a 2D representation of the intended design of a facility at various phases in its life. Drawings are developed from and produced by plan, section, and elevation cuts through the Design Intent Model. Drawings do not include metadata traditionally found in title block such as author, firm, permit stamps, sheet number, and references to other sheets. *See also* **Sheets**

- **DWF**

File extension indicating a file created in the *Drawing Web Format*

- **DWG**

DWG is a file extension indicating a *drawing* file created by Autodesk AutoCAD™. DWG is AutoCAD's native binary file format.

- **Fabrication Model**

Model(s) based on criteria that is important to the translation and interpretation of the facility's elements in order to fabricate them. (LOD 400).

- **Facility Attribute Data**

Associated intelligent attribute data (e.g. manufacturer, model, warranty information, etc.)
Record Model Deliverable: Model(s) based on Design Intent Model(s) and installed conditions

- **Facility Lifecycle**

From conception to demolition including five distinctive phases (Planning, Design, Construction, Operations, and Disposition)

- **Federated Model**

A main model which geometrically and textually references sub-models in such a way that the main model can display some or all of the sub-models as required.

- **Geo-referencing**

A BIM is said to be geo-referenced when it is located with respect to one of the standard grids established to represent locations on the Earth's surface.

- **GSA**

U.S. General Services Administration

- **IDF**

Intermediate Distribution Frame is a rack of wiring interconnects located between a Main Distribution Frame and intended end users of the signals running in the wiring.

- **IFC**

Industry Foundation Class. The Industry Foundations Classes is an open, neutral and standardized specification for Building Information Models. The foundation classes characterize design and construction objects in an open, non-proprietary way, to facilitate exchange of graphic and non-graphic data among differing BIM authoring software that supports IFC file output. "IFC" is also the filename extension associated with these text files. IFC is intended to be software vendor-neutral. IFC is an outgrowth of STEP, applied not only to product design and description, but to architectural built environment. The BuildingSMART Alliance (BSA), a NIBS Council, guides its development. *See also* http://buildingsmart.org/openbim

- **IPD**

Integrated Project Delivery. *See also* the AIA website, http://www.aia.org/about/initiatives/AIAS078435?dvid=&recspec=AIAS078435

- **Interoperability –** ability of information to move from one application to another without loss of data and model integrity

- **IWMS**

Integrated Workplace Management System. Such systems incorporate powerful database capabilities to capture enterprise-level functions, and serve as decision support tools at all organizational levels and throughout the whole building lifecycle.

- **Level of Development (LOD)**

Level of completeness to which a model element is developed at the end of each phase of the facility's life

Level of Development. *See also* "AIA Document E202 Building Information Modeling Protocol Exhibit" at http://www.aia.org. The document outlines five progressively more detailed levels of model development, their characteristics, and the associated uses appropriate for each of the levels

- **MasterFormat®**

A classification system of work results arranged by a series of numbers and titles, published by CSI and CSC.

- **Model Element**

Portion of the model(s) representing a component, system, or assembly within a building or site

- **Model Element Author**

Responsible party for developing the BIM content of a specific Model Element to the LOD required for a particular phase of the facility

- **native file format**

Typically proprietary, this refers to the internally formatted and structured file created or selected by the software developers and produced by their software. The internal organization, format, and structure of such a file is controlled by the software developer, although it can be licensed to other developers if they select it as their native file format (ZWCAD uses DWG as its native file format, e.g.). Users typically differentiate one file format from another by the 3 or 4 letter Windows(TM) file extension.

- **NWF**

File extension indicating a file created by Autodesk Navisworks™

- **Omniclass**

Omniclass Construction Classification System (OCCS). Omniclass is a modern classification system for the construction industry that incorporates many legacy classification systems developed by various industry groups under various trademarked names including *Uniclass, MasterFormat, and Uniformat.* The *Omniclass Construction Classification System* (OCCS), is both a distillation and expansion of classifications from versions of industry, national, and international standards including those created by General Services Administration (GSA), International Standards Organization (ISO), International Building Code (IBC), U.S. department of Defense, U.S. Geological Survey (USGS), Open Standards Consortium for Real Estate (OSCRE) and others. Key tables are *Table 13 - Spaces by Function, Table 22 – Work Results, Table 11 – Construction Entities by Function*, and *Table 23 – Products*. See http://www.omniclass.org.

- **Project Team:**

Organizational members of the project team include AOC, Architect, Engineers, CMa, CMc, Sub-contractor, other disciplines and Knowledge Experts

- **Project Team Member:**

An individual member organization or individual person that is part of the team (depends on context.)

- **PxP**

Project Execution Plan; *see also* **BIMPxP**

- **Sheets (Sheet Sets)**

A collection of tangible media-based 2D representations of the intended design of a facility at various phase in its life, developed from the Design Intent Model (includes titleblock). Sheet sets include metadata traditionally found in title block such as author, firm, permit stamps, sheet number, and references to other sheets.

- **SMC**

Solibri Model Checker, software for rules-based model integrity checking

- **TSD**

Technical Services Division

- **Uniformat**

Also, *Uniformat II*. This is also an ASTM standard

K. REFERENCES AND ADDITIONAL READING

- **GSA BIM Guide Series**
- **VA BIM Guide**
- **BSa NBIMS**
- **DRAFT-LOD-Spec.pdf –** from BIMForum and AGC, AIA, BSa
- **Penn State BIM Guide**