Building Information Modeling (BIM) Guide

March 2015

Fermilab

Facilities Engineering Services Section

Purpose:

The primary objective at Fermilab is that operations be conducted in a safe, deliberate and controlled manner. The role of the FESS/Engineering (FESS/E) procedures is to provide the best knowledge available in order to accomplish the task.

This BIM Guide provides a compilation of the FESS/Engineering policies and procedures specific to the utilization of in-house projects and projects developed by outside A/E Consultants.

This BIM Guide provides guidance for the A/E Consultant services and is intended as a supplement to the A/E subcontract. In all cases the A/E subcontract shall take precedence over the procedures in this standard.

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Reference:

The following policies/procurers complement the CAD Standards and should be utilized.

A/E Consultant Handbook
FESS Engineering Design Guide
CAD Standards
GIS Standards

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1.0 INTRODUCTION

Building information Modeling (BIM) is a process focused on the development, use and transfer of a digital information model of a building project to improve the design, construction and operations of a project portfolio of facilities. The National Building Information Modeling Standards (NBIMS) Committee defines BIM as:

> *"…a digital representation of physical and functional characteristics of a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition. A basic premise of BIM is collaboration by different stakeholders and different phases of the life cycle of a facility to insert, extract, update or modify information in the BIM to support and reflect the roles of that stakeholder."*

Implementing BIM requires detailed planning and fundamental process modifications for the project team members to successfully achieve the value from the available information.

Traditionally, Fermilab utilizes the design-bid-build method of procuring design and construction services. The design-bid-build process consists of conceptual/preliminary plans, detail/design drawings, and construction documents are all separate phases since funds are normally committed over several fiscal years and not all at once. The U.S. Army Corps of Engineers along with the National Institute of Building Sciences has developed Construction Operations Building Information Exchange (COBie). If the project team deems that the traditional design-bid-build method is not acceptable and the project level of development exceeds 300, then the Integrated Product Delivery (IPD) developed by American Institute of Architects (AIA) should be utilized. This will involve the Procurement Department to define the integration and/or separation of risk and responsibilities for the design and construction and therefore, the Level of Development (LOD). Furthermore, a BIM Execution plan should be developed for all projects exceeding LOD of 300.

1.1 Level of Development (LOD)

The Level of Development (LOD) descriptions are based on AIA Document E202-2008 entitled Building Information Modeling Protocol Exhibit. There are five levels, from conceptual through as-built. In essence, the levels are as follows:

100 – Conceptual/Preliminary
200 - Approximate geometry (Design/Bid)
300 - Precise geometry (Design/Bid/Constructability)
400 – Fabrication (Shop Drawing)
500 - As-Built/COBie

	Design/Bid			As-Built/COBie	
Level of Development	**100**	**200**	**300**	**400**	**500**
Model Content					
Design & Coordination (function/form/behavior)	Non-geometric data or line work areas, volumes zones, etc.	Generic elements shown in three dimensions – Maximum size – purpose	Specific elements confirmed 3D object geometry – dimensions – capacities – connections	Shop drawing/ fabrication – purchase – manufacture – install – specified	As-builts – actual
Uses					
Scheduling	Total project construction duration Phasing of major elements	Time-scaled, ordered appearance of major activities	Time-scaled, ordered appearance of detailed assemblies	Fabrication and assembly detail including construction means and methods (cranes, man-lifts, shoring, etc.)	
Cost Estimating	Conceptual cost allowance Example $/sf of floor area, $/, $/parking stall, etc. Assumptions on future content	Estimated cost based on measurement of generic element, e.g., generic interior wall	Estimated cost based on measurement of specific assembly, e.g., specific wall type	Committed purchase price of specific assembly at buyout	Record costs
Program Compliance	Gross departmental areas	Specific room requirements	Utility connections		
Sustainable Materials	Guiding Principles strategies	Approximate quantities of materials by Guiding Principles categories	Precise quantities of materials with percentages of recycled/locally purchased materials	Specific manufacturer selections	Purchase documents
Environmental: Lighting, Energy Use, Air Movement Analysis/Simulation	Strategy and performance criteria based on volumes and areas	Conceptual design based on geometry and assumed system types.	Approximate simulation based on specific building assemblies and engineered systems	Precise simulation based in specific manufacturer and detailed system components	Commissioning and recording of measured performance

Fermilab will typically use a LOD of 300 or less.

	Design/Bid			Asbuilt/COBie	
Level of Development	**100**	**200**	**300**	**400**	**500**
Element					
Interior wall	Not modeled Cost and other information can be included as an amount per s.f. of floor area	A generic interior wall, modeled with an assumed normal thickness Properties such as cost, rating, or U-value may be included as a range	A specific wall type modeled with the actual thickness of the assembly Properties such as cost, rating, or U-value can be specified	Fabrication details are modeled where needed	The actual installed wall is modeled
Duct run	Not modeled Cost and other information can be included as an amount per s.f. of floor area	Potential display of 3-dimesional duct with approximate dimensions	A 3-dimensional duct with precise engineered dimensions	A 3-dimensional duct with precise engineered dimensions and fabrication details	A 3-dimensional representation of the installed duct

2.0 REQUIREMENTS

2.1 BIM Software and Information Exchange

The A/E firm shall develop the design at each stage using building information modeling (BIM) software and related technologies – specifically, the 2013 or later versions of Autodesk "Revit Architecture" for Architectural, Revit Structure, and/or Revit MEP. If LOD exceeds 300, then a BIM Execution Plan will be developed and submitted to Fermilab prior to commencement of the BIM model.

For general project correspondence and milestone/phase BIM deliverables, the team will use the A/E's file transfer platform as a means of sharing and storing information. During the design phase, BIM-related files utilized by the design team will be shared through the FTP site.

It shall be the Design Team BIM Manager's responsibility to monitor and regulate software version updating if required during the course of the Project. It is understood that a number of the software tools utilized are not backwards compatible and must be carefully synchronized. Since the majority of the BIM software platforms utilized on this project do not contain backward capabilities, the entire Project Team will need to evaluate the advantages and disadvantages of performing software upgrades during the design phase, and reach an agreement on whether or not to proceed with such upgrades if/when they may become available.

2.2 Ownership

Fermilab will have unlimited use of the design models produced for the project. The A/E firm acknowledges that the design models are an instrument of the A/E services and that the A/E firm does not represent or guarantee that the Models will be useful to Fermilab for any purposes beyond those uses that they were authored for.

2.3 Model Management

Unless otherwise agreed upon in the BIM Execution Plan, the A/E firm shall be established as the lead party responsible for managing the design model, and shall facilitate the establishment of initial protocols relating to model management. Subsequently, the model manager from each design discipline may have specific responsibilities as deemed necessary and agreed upon by the project team.

2.4 File Naming Conventions

All Project central files and model files shall have a consistent naming convention as established by the project design team for discipline specific model coordination. The Design Team BIM Manager shall coordinate this activity with all sub-consultants and design disciplines. (The naming convention as illustrated below is for example and is not a specific requirement.)

File Type	Naming Convention	Discipline	Authoring
Revit Project File (.rvt)	FNAL_X-XX-XXX_ARCH_[Central] (Project number)	Architectural	Revit Architecture 2013
Revit Project File (.rvt)	FNAL_X-XX-XXX_STRUCT[Central]	Structural	Revit Structure 2013
Revit Project File (.rvt)	FNAL_X-XX-XXX_MEP_[Central]	Mechanical, Electrical, Plumbing and Fire Protection	Revit MEP 2013

**For project number, reference the CAD Standard Manual*
*** Suffix Central is optional*
BIM Template is provided at:
ftp://fess-ftp.fnal.gov/public/BIM-CAD%20Standard%20Blocks%20Tempates/

2.5 View Naming Conventions

Model views shall have a consistent naming convention as established by the Design Team/BIM Manager. Consistent view naming allows for the automatic sorting of views for ease of identification. The protocol facilitates low maintenance of the view name as project conditions change throughout the Project.

2.6 Sheet Sizes and Naming Conventions

- Preferred format size for Construction Drawings is 22" X 34" ("D" Size). Other sizes may be used if required (coordinate with Fermilab).
- Sheet names should be descriptive of drawing content and the building discipline represented (i.e., A-1, P-1, and M-1 would be typical designations for Architectural, Plumbing, and Mechanical Drawings, respectively). Reference the CAD Standard Manual for specific building discipline.

2.7 Origin and Orientation

The design team shall geo-reference site plans and building models to Fermi Coordinate System – reference the CAD Standard Manual. To acquire a coordinate from AutoCAD DWG file within Revit:

1. Link CAD file Center to Center

2. Move and rotate CAD file to the Revit building model. Do not MOVE the Revit building model.
3. Acquire the coordinate from the CAD file, and then delete the link. Note the shared coordinate change.
4. To reset the coordinate system, link the reset CAD file, repeat above step. Not the shared coordinate should be 0,0,0. Reset CAD file is located in the Fermilab Revit Template folder.

2.8 Units and Tolerances

The Revit project units and tolerances settings affect the way that information in the model is displayed. It does not limit tolerances of how things are modeled. The project will utilize the Revit project unit settings as established by the Design Team/BIM Manager.

2.9 Grids and Levels

Naming conventions for Grids and Levels will be established by Fermilab and/or by the conceptual drawings.

2.10 WorkSets

Generally, the project team should always simplify, and keep Worksets to a minimum to facilitate efficient project team workflow. The disciplined use of Worksets will allow the project team to work more efficiently and will promote the collaborative BIM project delivery platform. The Project Team should discuss the applicability of the use of Revit tools that will help to ensure that all elements are assigned to their proper Worksets. The A/E firm will be provided with Fermilab's Revit templates to be incorporated into the projects.

2.11 2D CAD File Linking Protocols

The Design Team BIM Manager shall establish protocols for 2D Cad file linking (no importing) otherwise the following protocols are recommended for use by the team:

- Minimize the number of 2D CAD files linked to the model.
- 2D CAD files should be audited and purged before linking.
- Set reference links from the link management menu to Overlay.
- Always link to 2D CAD files instead of importing them.
- Never explode 2D CAD files within a Revit file.
- Pin position of linked file.

2.12 3D model linking protocols

The Design Team BIM Manager shall establish protocols for 3D Model linking, otherwise the following protocols are suggested for use by the team:

- Set reference links from the link management menu to Overlay.
- Create an individual Workset for each Revit Model linked into the Project. Workset Naming & Use Conventions (above) for additional information.
- Use the Specify Worksets option when linking 3D models. Only open the Worksets needed for model collaboration.
- Use the Positioning: Auto - Origin to Origin option when linking 3D models. Pin position of linked file.

2.13 Energy Model

Energy simulation and life-cycle cost calculations shall be based on information extracted directly from BIM and validated by energy modeling, reference Section 5.0 for deliverables.

3.0 DESIGN & BID PHASE

3.1 Design Team & BIM Manager

Projects requiring a different method than the design-bid-build, that is higher LOD then 300, shall develop a BIM Execution Plan and incorporate Section 4.0 of this document. Regardless if a BIM Execution Plan is required, the A/E firm shall assign an individual to serve as the main point of contact between the Design Team and Fermilab for all BIM related issues. This individual shall have sufficient BIM experience required for the size and complexity of the project and shall have relevant proficiency in the BIM authoring and coordination software. Responsibilities include the following:

1. Overall development and delivery of the Building Information Model.

2. Monitors compliance with the Level of Development (LOD) and when required, BIM Execution Plan.

3. The development, coordination, publication, and verification that all BIM configurations are in place as required for bidding and able to construct from the bid documents.

4. Coordinates the file management procedures and protocols for the BIM Model.

5. Coordination and set-up of shared file servers to be utilized for the BIM, including related access, permissions, protocols, etc.

6. Prepares, assembles, and facilitates the use of the Building Information Model for design meetings, coordination meetings, and BIM deliverables.

7. Proper classification of all spaces, equipment, and components within the Building Information Model.

8. Schedules, coordinates, and facilitates BIM technical meetings between the Design-Build Team and all design disciplines.

9. Coordinates and facilitates the clash detection and coordination efforts among all design disciplines.

10. Determines the project BIM geo-reference point(s), and ensures that the models from all design disciplines are properly referenced and coordinated with the geo-reference point(s).

11. Primary interface between the Design-Build Team and Fermilab for BIM data and file transfers as required at each design phase or otherwise necessary.

12. Ensures that the BIM design deliverables specified and/or required by contract are provided in accordance with the Contract Documents.

13. Ensures that the 2D project drawings and project specifications produced for bidding and construction purposes are properly derived from and adequately represent the information contained within the Building Information Model. All BIMs shall be geometrically and dimensionally accurate in both 2D and 3D plan, elevation, and section views.

3.2 Project Goals

The BIM collaboration team shall present, discuss, and agree upon project specific goals. The relevant project experience, team strengths, BIM competencies, and scheduling factors should be considered during this discussion. The team should list goals and objectives for using BIM and collaborative project management technologies and processes to measure the achievement of these objectives.

Project Specific	Describe Requirements/Considerations
Visualization Requirements	The BIM Model will be utilized to convey the design to the Project Team. This should be of particular benefit to the client occupants, in
Sustainability/Guiding Principles Documentation	The design team will capture BIM model associated sustainability documentation in designated drawing sheets
Coordination/Clash Detection	When applicable, the Design-Build Team will utilize AutoDesk Revit Architecture, Revit Structure, Revit MEP, to coordinate design disciplines and perform clash detection analyses within the BIM Model.

O&M Integration (Required if LOD is beyond 300) – See Section 4.0	To be determined.
Facilitate Cost Estimating	Various components of the CM cost estimating effort may be derived directly from the BIM Model. Also, the BIM Model may be utilized for verification of manual take-off quantities.
Subcontractor Use (Bidding, Understanding, Fabrication) – See Section 4.0	To be determined.

3.3 Project Team Collaboration Meetings

There will be different types of Collaboration meetings needed for the project, including general progress meetings, design coordination meetings, etc. In the space below, list the types of meetings necessary for the project, meeting host(s), required attendees, and required technology.

Meeting Type	Host	Required Attendees	Required Technology
Design Meetings BIM Model Progress/Coordination	Architect / Design Disciplines	Fermilab, Design Team	Revit Architecture
Design Presentations BIM Model Presentations to Project Team	Owner / User Group	Fermilab, Design Team, User	Revit Architecture, possible use of Revit Structure, and Revit MEP
Design Team Coordination BIM Model Coordination/Clash Detection	Architect / Design Disciplines	Fermlab, Design Team	Revit Architecture, Revit Structure, and Revit MEP
Construction Coordination BIM Model Coordination/Clash	Requires BIM Execution Plan LOD > 300	Fermilab Team, Subcontractors, Design Team	

As-Built Coordination As-Built BIM Model Progress/Coordination	Requires BIM Execution Plan	Fermilab Team, Subcontractors, Design Team	Revit Architecture, Revit Structure, Revit MEP

3.4 Constructability Reviews

The BIM model shall be utilized for the purpose of constructability reviews. Use of the BIM Model for constructability review shall not be considered as in kind replacement for reviewing the traditional printed 2D line drawing documents but as a supplementary effort to improve the review process. Constructability reviews shall be accomplished as follows:

1. An analysis and evaluation of the constructability of the design concepts, narratives, or drawings.
2. An analysis and evaluation of the design concepts, narratives, or drawings in regard to the completeness of intended bid categories, conflicts or overlaps in the divisions of the work. An evaluation of design details affecting construction including, without limitation, unusual or custom materials.
3. Address problems, conflicts, defects, or deficiencies in the design concepts and offer resolutions.

3.5 Design Team Responsibilities

During the bid phase, the designer shall update the design bid documents with addendums and revisions. At the end of the bidding period, the designer shall submit the conformed bid set.

If included in the A/E firm scope of work, the Design Team will manage and update the Revit Model(s) through the end of the construction phase, incorporating all updates and/or revisions to the model(s) as necessary to reflect design changes initiated by RFI, Change Orders, or coordination with existing conditions.

All model updates by the Design Team shall be complete at Substantial Completion at which time the Revit Model(s) shall be transmitted to Fermilab who shall be responsible for the construction related updates to the model(s)

4.0 CONSTRUCTION PHASE

4.1 Resolution of Interferences (if subcontract includes Title III services)

The Design Team shall participate in the coordination meetings as necessary to timely resolve design conflicts and/or coordination issues. Design changes made during this process shall be properly documented by the Contractor and Design Team and the model(s) shall be updated as necessary.

4.2 Project Close Out (RESERVED)

4.3 Operations and Maintenance (O&M) Documentation (RESERVED)

4.4 COBie Data (RESERVED)

4.5 Commissioning Requirements (RESERVED)

5.0 DELIVERABLES

5.1 Design & Bid

Build Information Model partitioned by discipline central files in native Autodesk Revit file format and exported to Autodesk AutoCAD (DWG) format with any external reference file embedded within the DWG file. All entities in Exported AutoCAD files shall be bylayer and follow Fermilab pen tables. File naming convention shall be in accordance with the CAD Standard. Energy models shall be in Trace 700 format.

5.2 Construction (RESERVED)

Works Cited

1. AECbytes, September 18, 2008, Article: Organizing the Development of a Building Information Model, by Jim Bedrick AIA, Vice President of Virtual Building and Design, Webcor Builders
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