

Indiana University

BUILDING INFORMATION MODELING (BIM)

GUIDELINES and STANDARDS for ARCHITECTS, ENGINEERS, and CONTRACTORS

Sept. 10th, 2009



INDIANA UNIVERSITY

UNIVERSITY ARCHITECT'S OFFICE

Acknowledgements

Indiana University is indebted to those many organizations that have helped pave the path for Owner organizations like ourselves in their development of Building Information Modeling (BIM) Guidelines, Standards, and Execution strategies. We wish to acknowledge that their progress in this area has helped provide a framework for Indiana University. Our hope is that as we move forward in the use of BIM and IPD that our progress and experiences will help others as well.

Special thanks and acknowledgement goes to:

- General Services Administration (GSA) – 2003 National 3D-4D BIM Program
- U.S Army Corps of Engineers – 2006 BIM Road Map
- NBIMS National BIM Standard – 3/2007
- U.S Army Corps of Engineers - Construction Operations Building Information Exchange (COBIE) - 8/2007
- Triton College Building Information Modeling (BIM) Standards Model – 2005-2009
- State of Wisconsin Dept. of Administration – July 2009 BIM Guidelines and Standards
- buildingSMART Alliance and CFTA (Campus FM Technology Association) – vital organizations that foster collaboration and the sharing of BIM knowledge and expertise
- SHP Leading Design – for their expertise and guidance in BIM and IPD

Building Information Modeling (BIM) Guidelines and Standards for Architects, Engineers, and Contractors

This BIM Guideline and Standard applies to Indiana University A/E selections advertised on or after **October 1st, 2009** for the following projects:

- ***Required on all construction (new and addition/alteration) with total project funding of \$5M or greater, and on any project that has already been delivered with a BIM requirement.***
- ***Encouraged but not required on all other projects. (The Indiana University goal is to have all IU projects using BIM by 2011)***

For more information and updates on Indiana University BIM guidelines and standards – please visit our website: <http://www.indiana.edu/~uao/iubim.html>

1. Requirements

1.1. Design Team Software

1.1.1. General

Building information models shall be created that include all geometry, physical characteristics and product data needed to describe the design and construction work. All drawings, schedules, simulations, and services required for assessment, review, bidding and construction shall be extractions from this model. The Design Team shall follow the guidelines and requirements detailed in this document for BIM related services. Deliverable requirements are as specified in the Indiana University professional services contract (deliverables sections) and the Indiana University As-Builts Requirements and Standards document.

1.2. Civil Engineering Software

1.2.1. General

Models shall be created that include all geometry, physical characteristics and product data needed to describe the design and construction work to within 5' of building envelope. Drawings and schedules required for assessment, review, bidding and construction shall be extractions from this model. Software shall be capable of interfacing with The Design Teams BIM authored software. In all cases, model building and infrastructure systems to a level that allows the team to verify clearances, analyze conflicts/clashes and properly coordinate the work with all other aspects of the project. The Design Team shall follow the guidelines and requirements detailed in this document for BIM related services. Deliverable requirements are as specified in the Indiana University professional services contract (deliverables sections) and the Indiana University As-Builts Requirement document.

1.3. BIM Authoring Software

1.3.1. General

The Design Team is required to use parametric BIM Authoring software for Indiana University projects. The deliverable file format for all BIM project models is to be .RVT (Autodesk Revit).

1.4. Open Architecture for Interoperability

1.4.1. General

Indiana University has adopted open architecture for data exchange. The Design Team is encouraged to use products based on or using open architecture for greatest interoperability between consultants and Indiana University.

1.5. Geo-referenced model

1.5.1. General

The Design Team shall geo-reference site plans and building models to the following:

- Bloomington and Northwest (Gary) campuses - Indiana State Plane West, NAD 1983 – foot coordinate system and North American Datum of 1983 - GCS.
- Columbus, East (Richmond), IUPUI, Kokomo, South Bend, and Southeast (New Albany) – Indiana State Plane East, NAD 1983 – foot coordinate system and North American Datum of 1983 - GCS.

1.6. Project collaboration tools

1.6.1. General

The Design and Construction Team is required to use Indiana University's electronic project collaboration environment – ProjectDox for document management and file sharing, reviewing tools, project communication, and a built-in .NWD viewer(Navisworks) for reviewing 3D BIM models (supports up to .NWD version 4 at this time).

2. Process

2.1. BIM Execution Plan

The Design Team shall submit to Indiana University within thirty (30) days of contract award, a BIM Execution Plan. The BIM Execution Plan's template is located on the web for download at: <http://www.indiana.edu/~uao/iubim.html>. The BIM Execution Plan will be reviewed and approved by Indiana University within fourteen (14) days after the submitting of the BIM Execution Plan. The BIM Execution Plan shall identify the entire Design Team including all consulting engineers and any specialty consultant. The BIM Execution Plan also should include roles and responsibilities of the contractor(s) even if that party has not yet been identified. The BIM Execution Plan will be a part of the final bid documents.

2.2. IPD (Integrated Project Delivery) Methodology Plan

The Design Team shall submit to Indiana University within thirty (30) days of contract award, an IPD Methodology Plan. The IPD Methodology Plan's template is located on the web for download at: <http://www.indiana.edu/~uao/iubim.html>. The IPD Methodology Plan will be reviewed and approved by Indiana University within fourteen (14) days after the submitting of the IPD Methodology Plan. The IPD Methodology Plan shall demonstrate a high level of integrated design while identifying project team members and how they will interact with each other during the project. This plan will include a critical path methodology on modeling procedures and model information validation. Examples of IPD Methodology plans are, but are not limited to, Reverse Phase Scheduling and Critical Path Modeling. The IPD Methodology Plan will be a part of the final bid documents.

2.3. Model quality

The Design Team shall establish and use in-house modeling quality control guidelines and exchange protocols. Good BIM practices may include but are not limited to:

- Use of element and component objects that embed the best practices of the firm.
- Maintenance of parametric linkages within the model at all times.
- The building envelope needs to be "air-tight" and correct to help support energy modeling activities and simulations.
- Use Indiana University defined nomenclature for objects and spaces – or if none exist then Industry standards.
- Use appropriate and interoperable viewing, checking, and output file formats.
- Use appropriate phasing throughout the project to maintain Indiana University's proper model nomenclature.

2.4. Energy requirements

The Design Team shall work with IU to establish project specific energy goals and energy use targets. The Design Team shall also establish an energy modeling methodology that will be included within the BIM Execution Plan that will detail how energy modeling will be accomplished for the project. At a minimum, the required software to perform the energy modeling for the project shall be any software as listed acceptable by the US Department of Energy, Energy Efficiency and Renewable Energy. A list of approved software can be found at the following link:

http://www1.eere.energy.gov/buildings/qualified_software.html

- In addition to this list, the designer may also use the following DOE 2 based software:
 - Green Building Studios
 - Ecotect
 - eQuest
- Local weather data shall be obtained from TMY2 or TMY3 weather data tables. Weather files can be downloaded from the National Renewable Energy Laboratory website at the following link: http://rredc.nrel.gov/solar/old_data/nsrdb/tmy2/

2.5. Design Team Deliverable Schedule and Milestones

The submittal schedule along with the milestones for any given project is listed below:

Milestone	Deliverable
Conceptualization Phase	Architectural Massing Model
	Preliminary Energy Model
Schematic Design Phase	Architectural Model
	Schematic Energy Model
	Civil Model
	Initial Collision Report
	Square Foot Cost Estimate
	COBIE Design Data (worksheets 02-05)
Design Development	Architectural Model
	Detailed Energy Model
	MEP Model or Models
	Structural Model
	Civil Model
	Discipline Collision Report
	System Cost Estimate
	Program Validation
	COBIE Design Data (worksheets 02-06)
Construction Documents	Architectural Model
	MEP Model or Models
	Structural Model
	Civil Model
	Pre-Bid Collision Report
	Quantity Estimate
	COBIE Design Data (worksheets 02-07)

The rest of the deliverables and milestones for the Design Team are shown later in the document.

3. Objectives and Application

3.1. Pre-Design (Conceptualization) Phase

3.1.1. General

The Design Team is encouraged to use electronic programming and planning tools that integrate into their BIM Authoring software to capture early cost, schedule and program information during this phase.

3.1.2. Topographic and Property Line Surveying

Detailed requirements of what is to be included in surveying deliverables is managed by Indiana University staff in consultation with the Design Team on a project-by-project basis. Surveys shall be provided in electronic format and minimally include 3D topographic information including paving and retaining walls. The file(s) shall be in a format that allows for importing into the Design Team's BIM authoring software. Survey requirements are outlined in the Indiana University Site/Landscaping Standards:

http://www.indiana.edu/~uao/IU_Landscape.pdf

3.1.3. Energy Modeling Requirements

3.1.3.1. General

The purpose of the preliminary (conceptualization) energy model is to narrow down design strategies from the multitude of design possibilities to those that are in line with and will achieve the projects energy goals and targets.

3.1.3.2. Simple Building Information Model (SBIM)

The design team shall develop a simplified BIM model for use in preliminary energy modeling.

This model shall define the building footprint and include all exterior walls.

Interior spaces of similar use and occupancy shall be grouped into larger blocks or rooms, with interior walls limited to those separating areas of dissimilar use.

All floors must be modeled.

All roofs must be modeled.

All rooms, or blocks of rooms, must be bounded.

Fenestration shall be calculated as a percentage of floor area and need not be modeled.

3.1.3.3. Information Exchange

Information that is developed in the SBIM should be formatted for a .GBXml export. This file standard is used by most energy modeling software or analysis software.

3.1.3.4. Comparative Design

The purpose of these simulations is to inform early design decisions with reference to building envelope, lighting, domestic water, and HVAC systems. Multiple energy simulation iterations shall be performed by changing one component at a time and comparing those results to the results of other iterations in a

“percent better” or “percent worse” scenario. Design components that present “percent better” that are in line with the project energy goals will then be developed further in the schematic (criteria) design phase.

3.1.3.5. Energy Modeling Deliverables

The Design Team shall submit to Indiana University, in spread sheet format, the list of design iterations and comparisons of the design iterations. The spread sheet should include columns for *Peak Monthly Load*, *Peak Yearly Load*, *Total Yearly Load*, and *Total Yearly Energy Use by Source Type*.

3.1.4. Existing Conditions

The Design Team shall model all existing conditions needed to explain the extent of the construction work for alterations and additions projects. The extent of modeling beyond the affected areas and the level information to be included will be determined based on project needs. These requirements may be stated in the project program or discussed during the project kickoff meeting. The BIM Execution Plan should define the agreed upon scope of the modeling effort.

3.2. Schematic Design (Criteria Design)

3.2.1. General

Design Team may use any method to begin the design process but shall be using a BIM authored model(s) by completion of this phase. All information needed to describe the schematic design shall be graphically or alphanumerically included in and derived from these models. Indiana University expects the Design Team to use analysis tools, static images and interactive 3D to describe the design concepts. Deliverables are required as stated in Section 2.3.

3.2.2. Square Foot Cost Analysis

The Design Team shall extract square foot information using BIM Authoring Software and other BIM integrated tools to support comparative costs analysis of options studied. Outputs shall be converted to spreadsheets and submitted as part of the design solution justification at end of this phase.

3.2.3. Energy Modeling Requirements

3.2.3.1. General

The purpose of the schematic design (criteria design) energy model is to continue to refine design strategies and to calibrate the building’s energy performance.

3.2.3.2. Building Information Model

The design team shall develop a BIM model for use in schematic energy modeling.

- The model shall define the building footprint and include all exterior walls.
- The model shall define all interior walls, with all rooms modeled individually.
- All fenestration shall be modeled.
- All doors shall be modeled.
- All overhangs, sun shades and roof monitors shall be modeled.
- All floors must be modeled.

- All roofs must be modeled.
- All ceilings must be modeled.
- All rooms must be bounded.
- All room names and numbers must be defined and entered into the element properties.

The following information shall also be incorporated into the energy model:

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, etc) and schedules.

Building plug load information (kW, Btuh) and schedules.

Building process load information (kW, Btuh) and schedules.

- Building envelope construction components including U-values, SHGC, absorptivity, SRI value, color, thickness, etc, as applicable to the component.

3.2.3.3. Software requirements

The schematic model incorporating all of the components described above shall than be exported using a .GBXml file into a DOE 2 based energy modeling software. See Section 2.4 for a list of software.

3.2.3.4. Deliverables

The design components that provide a “percent better” result as developed in the preliminary energy model shall now be modeled based on the schematic BIM model. Multiple iterations shall be performed and compared in order to ascertain the best design of envelope, lighting, domestic water, and HVAC system for the project to meet the projects energy goals and targets.

The results from the energy model shall be submitted to justify the design solution. The results shall include, but are not limited to, the following:

Annual and monthly energy usage broken down by component in kBtu, kBtu/ft² and cost in dollars.

Annual and monthly energy usage broken down by component in kWh or Therm.

Annual and monthly demand broken down by component in demand kW or demand MBH.

3.2.3.5. Energy Modeling Deliverables

The Design Team shall submit to Indiana University, in spread sheet format, the list of design iterations and comparisons of the design iterations. The spread sheet should include columns for *Peak Monthly Load, Peak Yearly Load, Total Yearly Load, and Total Yearly Energy Use by Source Type*.

Output format shall clearly communicate and be appropriate to project needs and submitted as part of the design solution justification at the end of this phase.

3.2.4. Program and Space Validation

The Design Team shall use the BIM Authoring software or other analysis tools to compare and validate stated program requirements (normally provided by Indiana University) with the actual design solution.

The space validation shall be based on the Postsecondary Education Facilities Inventory and Classification Manual (FICM).

The following shall be developed automatically from the building information model:

- Assignable Areas (ASF) and Non-assignable Areas (NaSF) measured to inside face of wall objects and designated boundaries of areas.

- Gross Area (GSF) measured to the outside face of wall objects.

3.2.5 COBIE Design Data

The Design Team shall submit to Indiana University, in spread sheet format using the most current version of COBIE (Construction Operations Building Information Exchange). This data set shall include those COBIE "designer" worksheets related to architectural program. The designer shall specifically identify spatial and systems zoning to reflect the space circulation zones and building service zones that are reflected in the design drawings and specifications. The following COBIE Design worksheets shall be provided in the Schematic Design Set:

- (2) Facility - Facility(ies) referenced in the file
- (3) Floor - Description of vertical levels
- (4) Space - Spaces referenced in a project
- (5) System - Systems referenced in a project

The COBIE spreadsheet and information on how to use COBIE may be found at:

<http://www.wbdg.org/tools/cobiex.php>

3.2.6. Initial Collision Report

3.2.6.1. General

The Design Team is to use automated conflict checking software for this phase of the work and shall be outlined in the BIM Execution Plan. The collision report should show any outstanding coordination issues between the Design Team members.

3.2.6.2. Level One Collisions

Level One Collisions are reported collisions 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 Verse Ceilings
- Mechanical Ductwork and Piping Verse Rated Walls (For coordination of Dampers and other mechanical equipment needs)
- Mechanical Ductwork and Piping Verse Structure (Columns, Beams, Framing, etc.)
- All Equipment and their applicable Clearances Verse Walls
- All Equipment and their applicable Clearances Verse Structure
- Mechanical Equipment and Fixtures Verse Electrical Equipment and Fixtures
- Mechanical Ductwork and Piping Verse Plumbing Piping

3.2.6.3 Level Two Collisions

Level Two Collisions are reported collisions 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 Verse Electrical Fixtures and Devices
- Furnishings Verse Electrical Fixtures and Devices
- Structure (Columns, Beams, Framing, etc.) Verse Specialty Equipment
- Structure (Columns, Beams, Framing, etc.) Verse Electrical Equipment, Fixtures and Devices
- Ductwork and Piping Verse Electrical Equipment, Fixtures, and Devices

- Ductwork Verse Floors

3.2.6.4. Level Three Collisions

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

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

3.2.6.5. All other Collisions

While the above collisions have been assigned priorities other collisions will exist within the models. The collisions are not all ignorable nor should they be discarded. Some collisions will be because of the software available not yet being mature enough to support the modeling efforts. The intention should be to have as error and collision free model as possible at each submission phase with documented proof that the design team addressed the prior collisions above.

3.2.7. Planning Tools

The Design Team is encouraged to use electronic programming and planning tools that integrate into BIM Authoring software to continue project development at this phase.

3.3. Design Development Phase (Detailed Design)

3.3.1. General

The Design Team shall continue development of their Building Information Model. Parametric links shall be maintained within the models to enable automatic generation of all plans, sections, elevations, custom details and schedules as well as 3D views.. All information needed to describe the “detailed design” shall be graphically or alphanumerically included in and derived from these models only, except for the Specifications. Documentation of the models shall not happen outside of the BIM Authoring software. Deliverables shall be as stated in Section 2.3.

3.3.2. Architectural Systems

Model the following 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 BIM Execution Plan.

- Architectural Site plan (also see Civil Engineering section below)
 - Paving, grades, sidewalks, curbs, gutters, site amenities and other elements typically included on enlarged scale site drawings in vicinity of building.
- Existing conditions to the extent required by 3.1.4.
- Demolished items to the extent required by 3.1.4.
- New interior and exterior walls including but not limited to:
 - Doors, windows, openings
 - All finishes need to be included within the wall type regardless of the thickness of the finish

- Interior and exterior soffits, overhangs, sun control elements
- Parapets, screening elements
- Architectural precast
- Floor, ceiling and roof systems including but not limited to:
 - 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 to be included.
 - Roof, floor and ceiling slopes, if needed, shall be modeled.
 - Soffits, openings, and accessories will also be modeled.
- Elevators, stairs, ramps including railing systems
- Casework, shelving, and other interior architectural elements
- 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 (food service, medical, etc)
 - Model mechanical, electrical and plumbing items that require architectural space (toilets/sinks/etc), require color/finish selection (louvers, diffusers, etc.) or 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 invisible solids within the object.

3.3.3. Structural Engineering

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

- Foundations such as:
 - Spread Foundations
 - Caisson Foundations
 - Pile Foundations
 - Mat Foundations
 - Load-bearing Wall Foundations
- Framing such as:
 - 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
- 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

- These items may be modeled at the Design Team's option:

Steel reinforcing in concrete

Embeds in concrete

- Miscellaneous Steel

Angles for openings, deck bearing, etc.

Channels for mechanical units needed for coordination reviews between structural and mechanical

Lintels (unless considered a major member)

3.3.4. 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 BIM Execution Plan.

- 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 BIM Execution Plan.

- 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.

3.3.5. 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 BIM Execution Plan.

- Power and Telecommunications

Interior and exterior transformers, emergency generators, and other equipment

Main and distribution panels and switchgear including access clearances

Main IDF's

Feeders and conduit at and over 3/4" diameter unless otherwise noted by the BIM Execution Plan.

Outlets, switches, junction boxes

- Lighting

Permanently mounted lighting fixtures (moveable, 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. Should be discussed and agreed upon within the BIM Execution Plan)

Lighting Controls

Switches

Junction Boxes

- Fire Alarm and Security Systems

Input devices

Notification devices

Associated equipment and access clearances

Permanently mounted fixtures.

- Building Controls
- Clearance zones for access, door swings, service space requirements, gauge reading, valve clearances and other operational clearance must be modeled as part of the electrical equipment for collision checking. These clearance zones should be modeled as invisible solids within the object.

3.3.6. Plumbing and Fire Protection

Model the following plumbing and fire protection elements at a minimum. The detail and responsibility to fulfill these modeling requirements should be addressed fully within the BIM Execution Plan.

- Waste and Vent
 - Piping sized at and over 3/4" diameter, includes any insulation in model unless otherwise noted by the BIM Execution Plan.
 - Roof and floor drains, leaders, sumps, grease interceptors, tanks, water treatments and other major items.
- Supply
 - Piping sized at and over 3/4" diameter, includes any insulation in model unless otherwise noted by the BIM Execution Plan.
 - Domestic Booster Pumps
- Fixtures: sinks, toilet fixtures, water tanks, floor sinks
- Fire protection
 - Sprinkler lines at and over 3/4" diameter
 - Sprinkler heads, Fire Protection Pumps
 - Stand pipes, wall hydrants, fire department connections, risers, including valve 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 the object.

3.3.7. Specialty Consultants

Model the following specialty consultant elements to correct size and location. Some of these items might occur in the above mentioned disciplines and should be discussed within the BIM Execution Plan.

- Equipment provided or specified by said consultant
- Rough-in connection points for power, data, communications, water service and waste, gas, steam, or other needed utilities.
- Extent of specialty consultant modeling shall be coordinated with the Design Team and described in the BIM Execution Plan.
- Clearance zones for access, doors swings, service space requirements, controls, gauge reading, and other operational clearance must be modeled as part of the equipment and checked for conflicts with other elements.

3.3.8. Civil Engineering

Model the following civil engineering elements at a minimum:

- Topography – 3D terrain of all site work as designed, including retaining walls. This model should include the site and surrounding areas that contribute to the site's drainage system or otherwise impact on the site. In most cases this will require that adjacent roadways be modeled.
- Landscaping elements: planting areas, such as raised planting beds and berms, parking islands, pools/ponds/other water features, terraces and other items not included elsewhere in the model.

- Stormwater management structures, pump stations, fueling systems, manholes and other major items that impact on the overall project understanding or which may become project design constraints. All items must be geo-referenced such that all elements can be viewed as an overlay in the building information model or Indiana University's GIS system correctly positioned in the correct location, at all times.

3.3.9. Energy modeling

3.3.9.1 General

The Design Development phase energy model shall build upon the model developed in the Schematic Design phase. This energy model shall be complete enough to use for additional submissions, such as LEED EA Credit 1 calculations, should the building apply for LEED certification. This model shall be detailed and finalized enough to use as an indicator of approximate building energy use after occupancy. This model shall also serve as a baseline for future comparisons. After building completion and occupancy of a minimum of one year, actual building performance shall be evaluated against this model. This model shall be used as a tool to facilitate post-occupancy commissioning should discrepancies between modeled and actual energy use arise. Caution is advised in this, as deviations from design in weather, occupancy, plug loads, schedules, electric and fuel costs, etc. will affect actual energy use, and these factors must be taken into account.

3.3.9.2 Additional Modeling Requirements

In addition to the items included and submitted in the schematic design phase, the design development model shall include the following:

Energy Conservation Measures (ECMs). ECMs shall be used to evaluate control strategies and additional components for energy savings, life cycle cost (LCC) and return on investment (ROI) costs.

3.3.10. Discipline Collision Reports

See Section 3.2.5

3.3.11. Program and Space Validation

The Design Team shall use the methodology described in 3.2.4 above to reconfirm program.

3.3.12. Other analysis and checking tools

The Design Team is encouraged to analyze the design using software that interacts with the model in order to refine load calculations, daylighting, natural ventilation, acoustics, code issues, and design issues.

3.3.13. Systems Cost Estimating

The Design Team shall extract square foot and system information using BIM Authoring Software and other BIM integrated tools to support comparative costs analysis of options studied. Outputs shall be converted to spreadsheets and submitted as part of the deliverable at end of this phase.

3.3.14 COBIE Design Data

The Design Development Set shall be an update to the COBIE Schematic Design Set. The Register worksheet shall identify the types of equipment to be installed. The Component worksheet shall identify the major individual pieces of equipment individually identified at the Design Development Stage. The following worksheets shall be provided:

- (2) Facility - Facility(ies) referenced in the file
- (3) Floor - Description of vertical levels
- (4) Space - Spaces referenced in a project
- (5) System - Systems referenced in a project
- (6) Register - Material/equipment/etc. types (submittal register)
- (7) Component - Individually named materials and equipment

3.4. Construction Documents Phase

3.4.1. General

The Design Team shall continue development of the models created in the Design Development Phase. Maintain parametric links within the respective models to enable automatic generation of all plans, sections, elevations, custom details, schedules and 3D views. All information needed to describe the “Execution documents” shall be graphically or alphanumerically included in and derived from these models only. Specifications are not required to be linked within the models. Deliverables shall be as stated in Section 2.3.

3.4.2. Pre-Bid Collision Reports

See Section 3.2.6.

Submit at 95% Construction Document Submittals

3.4.3. Program and Space Validation

The Design Team shall use the methodology described in 3.2.4 above to reconfirm program.

3.4.4. Other analysis and checking tools

The Design Team is encouraged to analyze the design using software that interacts with the model in order to refine load calculations, daylighting, natural ventilation, acoustics, code issues and design issues.

3.4.5. Quantity Cost Estimating

The Design Team shall extract square quantity takeoff information using BIM Authoring Software and other BIM integrated tools to support comparative costs analysis of options studied. Outputs shall be converted to spreadsheets and submitted as part of the design solution justification at end of this phase.

3.4.6 COBIE Design Data

The Construction Document set shall be an update to the Design Development COBIE data set. All named products and equipment appearing in design schedules shall be listed in the Components Table. The designer shall ensure that the list of equipment provided in the COBIE "Component" worksheet includes all equipment specifically identified on the design drawings or BIM model. The following worksheets shall be provided.

- (2) Facility - Facility(ies) referenced in the file
- (3) Floor - Description of vertical levels
- (4) Space - Spaces referenced in a project
- (5) System - Systems referenced in a project
- (6) Register - Material/equipment/etc. types (submittal register)
- (7) Component - Individually named materials and equipment

3.5. Bidding Phase

3.5.1 General

The Design Team shall update the models with all addendum, accepted alternates and/or value enhancement proposals.

3.5.2. Bid and Post Bid Deliverable Schedule and Milestones

The submittal schedule along with the milestones for any given project is listed below:

Milestone	Deliverable
Bidding Phase (Design Team)	Architectural Model
	MEP Model or Models
	Structural Model
	Civil Model
	Any other models used in the construction documents

3.5.3. Contractor Bidding

Contractors who are bidding on this project are to review the BIM Execution Plan, the IPD Methodology Plan, and the BUILDING INFORMATION MODELING (BIM) GUIDELINES and STANDARDS for ARCHITECTS, ENGINEERS, and CONTRACTORS before bidding. Contractor will follow the guidelines and requirements as set forth by the BIM Execution Plan and the IPD Methodology Plan.

3.5.4. Construction Docs Deliverable

Thirty days after the project is awarded for construction, the Design Team shall submit to the University Architect's Office one set of the Construction Document Deliverables. This deliverable shall consist of CAD files representing every sheet in the Bid Documents. Each sheet is to have its own unique file and comply with the current Indiana University CAD Standards. Native word processing files (Word or WordPerfect) for all specifications shall also be included. Any addenda files in their native format shall also be included. Final payment for services rendered during the bidding phase is contingent upon approved acceptance of these documents.

3.6. Construction Phase

3.6.1. General

The Design Team is expected to continuously maintain and update the design intent model(s) with changes made from official Construction Change Directives and as-built mark-ups maintained on site by the Contractor(s) during construction. At an interval that is decided within the BIM Execution plan or at minimum once a month during construction the updated design intent model will be published in NavisWorks format (version 5) and posted to the ProjectDox site for each project.

Milestone	Deliverable
Construction Phase (Contractor)	Discipline Specific Coordination Models
	Shop Drawing Models (If Applicable)
	Fabrication Models
	As-Built Markups (3D DWF or 2D DWF format)
	Scheduling and Phasing Models
Operations Planning Set	COBIE Construction (worksheets 11, 14-17)
Beneficial Occupancy Set	COBIE Construction (worksheets 11, 14-28)
Construction Phase (Design Team)	Current As-Built Models for Each Discipline

3.6.2. BIM Execution Plan Review

The Contractor shall review the BIM Execution Plan with the Design Team and Indiana University and submit any Addendums within thirty (30) days of contract award. The Design Team and Indiana University will review and approve of any Addendum within fourteen (14) days of submittal.

3.6.3. Construction Models

3.6.2.1 General

These models could include fabrication models, coordination models, or shop drawing models. These models will now be referred to as the Construction Models.

3.6.3.2. Modeling Requirements

The Construction Models should reflect the exact geometric properties of the materials and/or systems being submitted. These models should as reflect the exact material properties and performance data.

3.6.3.3. Deliverables

The Contractor shall require subcontractors, fabricators, suppliers, and manufactures to submit all models to the contractor in both a Navisworks format and a 3D DWF format. These models should be updated after each project coordination meeting or as changes occur in the field during construction.

3.6.3.4. COBIE Construction Data

The Contractor shall submit to the Owner and Architect of Record, four (4) copies of each COBIE data set listed below.

Operations Planning Set

This data set shall be an update to the designer's COBIE worksheets. This set shall be provided at 70% fiscal completion or four (4) months prior to beneficial occupancy, whichever is earlier. The following worksheets shall be provided.

- (11) Document - Documents referenced in this file
- (14) Installation - Location and serial no. of installed components
- (15) Manual – Manufacturer provided operation, maintenance, and installation manuals for sets of/or components
- (16) Warranty - Warranty information for sets of/or components
- (17) Spare - Spare/parts reordering info for sets of/or components

Beneficial Occupancy Set

This data set shall be an update to the Operations Planning Set. Tag numbers for valves, controls, or other "tagged" items shall be individually identified in the "Component" worksheet. The following worksheets shall be provided.

- (11) Document - Documents referenced in this file
- (14) Installation - Location and serial no. of installed components
- (15) Manual - Instruction manuals for sets of/or components
- (16) Warranty - Warranty information for sets of/or components
- (17) Spare - Spare/parts reordering info for sets of/or components
- (18) Instruction – Installation/operating instructions
- (19) Test – System/component test results
- (20) Certification – Installation certifications
- (21) Material – Special materials needed for a given Job Plan Task
- (22) Tool – Special tools needed for a given Job Plan Task
- (23) Training – Special training needed for a given Job Plan Task
- (24) PM – Identifies specific PM tasks and frequency
- (25) Safety – Identifies required safety tasks
- (26) Trouble –Manufacturer start-up procedures/reports
- (27) Start-Up – Shut-down procedures
- (28) Shut-Down - Emergency operating procedures

3.6.4. Coordination Meetings

3.6.4.1. General

The contractor shall submit a plan to the Owner for review, prior to the start of construction that outlines the process for concurrent as-built documentation. Concurrency is mandated. Methods for recording as-built information are left to the discretion of the contractor. Potential options include traditional methods, and/or periodic laser scanning of completed or partially completed primary systems coordinated with the sequence of construction. Primary systems fall into two categories. The first category is Primary Architectural Systems. The second is Primary Engineering Systems. Primary Architectural Systems include, but may not be limited to: Partition systems with structure, flooring systems, major HVAC, piping, sewerage and /or conduit systems, partition systems with bulkheads, partition systems with expansion control, vertical transportation systems with primary engineering systems, millwork and casework systems with power and data outlets, horizontal ceiling systems with window openings, bulkheads, partitions, lighting, fire protection and HVAC outlet locations, exterior skin systems with window openings, structure, roof edge conditions, parapets, roof penetrations, and equipment locations. Primary Engineering Systems include, but may not be limited to: structural framing, primary HVAC duct runs, primary fire protection main runs, primary electrical conduits (2"+), ceiling grids layouts, primary data, audio visual, security and communication distribution systems (cable trays, etc).

3.6.4.2. Projects without active REVIT Model at the start of construction.

In the case of no REVIT model at the start of construction, the contractor shall develop a REVIT model for use during construction according to the program requirement as established in the bid documents. The contractor shall coordinate REVIT model source with the Owner prior to selection. The purpose of this model shall be to house the pertinent data as established by the bid documents and program, necessary to support future facility management objectives. Additionally, this model shall be the repository of final "as-built" data incorporated either by concurrent laser scanning and/or traditional recording methods for as-built conditions.

3.6.4.3. Projects with active REVIT Model at the start of construction.

In the case of an existing REVIT model at the start of construction, the contractor shall use that model in support of the objectives noted in 3.6.4.2.

3.6.4.4. Coordination with Design Team and Owner

On no less than a biweekly basis, the contractor shall include the project model manager, (architect's or other) in a coordination established for the purpose of assessing and / or executing FM data transfers from the construction process into the REVIT model. The data transfer shall be coordinated with the Owner representative and the architect's model manager (when feasible) and be based on the FM objectives as defined in the BEP and project program.

3.6.4.5. Deliverables

Navisworks files should be created at all critical coordination milestones. This record format will document a coordinated section of the model, either by area of the building or between specific critical trades. The Collision report showing all applicable collisions as either Approved or Resolved along with the Navisworks file shall be uploaded together to ProjectDox. A text document shall also be uploaded which describes and references the approved coordination NWD File with respect to what has and has not been coordinated.

3.6.5. Collision Reports

3.6.5.1 General

The Contractor is to use Navisworks Manage software for collision reporting. Collision reports from Navisworks should be published weekly to the ProjectDox site in a standard XML, HTML, or Text format as created by Navisworks. These reports shall include the following information at a minimum:

Description of Collision Report

Date of Collision Report Run

List of all Collisions detected, their status, and their proposed solution.

3.6.6. Concurrent As-Builts

3.6.6.1. General

The contractor shall submit a plan to the Owner for review, prior to the start of construction that outlines the process for concurrent as-built documentation. Concurrency is mandated. Methods for recording as-built information are left to the discretion of the contractor. Potential options include traditional methods, and/or periodic laser scanning of completed or partially completed primary systems coordinated with the sequence of construction. Primary systems include, but may not be limited to: structural framing, primary HVAC duct runs, primary fire protection main runs, primary electrical conduits (2"+), ceiling grids layouts.

3.6.6.2. Scheduling

The sequence of concurrent as-builts shall be recorded in the contractor's project schedule as a line item event.

3.6.7. Commissioning Requirements

Commissioning data including but not limited to design intent, performance criteria and operations data shall be recorded and/or linked to the REVIT model as commissioning occurs throughout the project. Commissioning requirements shall be coordinated with the minimum LEED Silver requirements of the Owner. It shall be the contractor's responsibility to coordinate the information sources and integrate this information into the REVIT model for transfer at the completion of the project.

3.7. Project Close-out

Milestone – all due 30 days after substantial completion	Deliverable
Project Close-Out (Design Team)	As-Built Models (.rvt format)
	Record Document Project Drawings (.pdf format)
	Record Document Drawings (3 sets of paper)
Project Close-Out (Contractor)	Scanned Field Set Drawings – As-Builts (.tif format)
	O&M Manuals (paper/.pdf/excel format)
	As-Built COBIE Construction (worksheets 11, 14-28) (excel format)
	Coordination Models in their native file format

3.7.1. Design Team As-Builts

The Design Team shall update their respective models with contractor recorded changes (Record Documents). Republish record documents in paper and pdf formats. Also submit full model(s) with all needed objects and reference drawings, in original authored software. Submit all per Indiana University professional services contract (deliverables sections) and the Indiana University As-Builts Requirement document (due 30 days after substantial completion).

3.7.2. Contractor Record Documents

The contractor shall submit one set of scanned field set drawings (Record Documents) in tif format (due 30 days after substantial completion).

3.7.3. O&M (Operations & Maintenance) Manuals

The contractor shall submit the following information to Indiana University – two paper copies in binders of the O&M Manuals along with the Construction Operations Building Information Exchange (COBIE) format: (1) the make, model and serial number of each piece of installed equipment, (2) the location of any equipment installed in the building, and (3) manufacturer's documents including cut sheets, installation instructions, and recommend maintenance tasks, testing or other reports. An electronic format of the O&M manuals shall also be submitted along with the paper copies, the format shall be color PDF and native Excel files. (due 30 days after substantial completion).

3.7.4. COBIE As-Built Requirements

The Contractor shall update the COBIE Construction Beneficial Occupancy Set. Tag numbers for valves, controls, or other "tagged" items shall be individually identified in the "Component" worksheet. All

worksheets required for the Beneficial Occupancy set shall be updated to fully reflect as-built conditions (due 30 days after substantial completion).

4. Ownership and Rights of Data

Indiana University has ownership of and to all CAD files, BIM Models, and Facility Data developed for the Project. Indiana University may make use of this data following any deliverable.

5. Terminology

A

As-Built Documents

As-built documents are the collection of paper drawings or electronic drawings that typically reside in the contractor's onsite trailer that contain mark-ups, annotations, and comments about changes that have been made to the contract documents during the construction phase.

As-Built Model

Design Intent Models that have been updated throughout the construction process. These changes and updates have been communicated from the Contractor to the Design Team through the comments, annotations, and mark-ups from the As-Built Documents. These typically, but not always, are discipline specific models.

B

BIM Execution Plan (BEP)

A plan that is created from Indiana Universities BIM Execution Plan Template that is to be submitted thirty (30) days after contract award. The BEP helps to define roles and responsibilities within a project team.

BIM Proficiency Matrix (BPM)

A matrix that was designed to measure the expertise of a firm as it relates to using a BIM process on projects. It will be used as one of the many selection criteria during the selection process.

C

C.O.B.I.E. – Construction Operations Building Information Exchange

C.O.B.I.E. is a standard of information exchange that allows information to be captured during design and construction in a format that can be used during the operations of a building once completed.

Critical Path Modeling

Critical Path Modeling is a method of demonstrating Integrated Project Delivery. It sets a plan within the design team that accounts for the activities of each discipline and how they interact with each other. It builds upon a critical path method for those activities, and allows the project team to schedule a complete project.

D

Design Team

The Design Team is considered to be the Architect and all of the consultants that provide design services for a project. These design services can be rendered at any time during the project.

DOE2 – Department of Energy Version 2

DOE2 is a file type that is an open file format. This file format is used by most energy modeling software. It is also an approved file type for LEED simulations.

.DWF

.DWF is a file type that was developed by Autodesk to be locked file for drawing sheets and model data. It can be used as a file transfer for estimating data, markups, and other third party software. It can be a combination of 3D and 2D information within the same file.

.DWG

.DWG is a native AutoCAD file format. It is a widely used file format for exchanging drawing information and 3D information to different programs. While not a database file type, it still has lots of uses for exchanging information.

F

FICM – Post Secondary Facilities Inventory and Classification Manual

FICM is standard that describes practices for initiating, conducting, reporting, and maintaining an institutional facilities inventory.

G

.GBxml

A .GBxml file is a Green Building file type. It is used to run simulations through energy modeling software. It is a widely accepted file format for those types of software.

I

IPD – Integrated Project Delivery

IPD describes a contractual relationship between Owner, Architect, and Contractor. It is a project delivery method that integrates people, systems, business structure and practices into a process that collaboratively harness the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction.

IPD Methodology

IPD Methodology is a concept that uses methods from the IPD contracts, but does not have the contracts actually in place. It idealizes the concepts of integration of all team members to try and benefit the entire project.

IPD Methodology Plan

The IPD Methodology Plan is a declaration of how the project team will achieve the goals of an IPD Methodology. The plan can have several components. The completion of a Reverse Phase Schedule or Critical Path Modeling is two examples of a IPD Methodology Plan

L

LEED

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System is a suite of standards for environmentally sustainable construction. Based on a point system, a building can achieve different ratings based on the performance of the design, construction, and operation of the building.

N

Navisworks

Navisworks is software that allows for the viewing of multiple model formats. This ability to “view” these files also allows for Navisworks to simulate the interaction between model files. That includes collision reporting, time lining, and coordination.

.NWC

A .NWC file is a Navisworks Cache File that is used by Navisworks to quickly read many other file types. All linked files in Navisworks have a .NWC file created automatically. In addition, Revit will export directly to the very small file type of .NWC for quick access by Navisworks.

.NWD

A much larger file than the .NWC, the .NWD file shows a snapshots in time of a Navisworks file. No linked files exist but all geometry is included.

.NWF

The .NWF file is a native Navisworks file which has all linked files, clashes, markups, animations, schedules, etc.

O

Open Architecture

Open Architecture is a concept of creating a framework that helps to describe a common set of rules for how a project is created. This includes what types of software, the interoperability of the information, and how the participants interact with each other. This is different than open standards in that it promotes progress while not anchoring forward thinkers to a rigid standard.

P

Phases

The phases of a project can be describe in two different ways as the adoption of IPD terminology starts to penetrate the BIM Execution Plan and the IPD Methodology Plan. Below is a list of the traditional names followed by the IPD name.

Pre-Design/Conceptualization Phase
Schematic Design/Criteria Design Phase
Design Development/Detailed Design Phase
Construction Documents/Implementation Phase

R

Record Drawing

The production of Record Drawings is the capturing of the As-Built Document's annotation, comments, and mark-ups in a drawing format only. This does not typically include the updating of any models.

Reverse Phase Scheduling

Reverse Phase Scheduling Is a method of demonstrating Integrated Project Delivery. It sets a plan within the design team that accounts for the activities of each discipline and how they interact with each other. It uses the completion date as a point to work backward from to schedule all of the project's activities.

.RVT

A .RVT file is a Revit native file type. It is also the deliverable file format for all projects. This includes all of the Design Team's models.

S

SBIM – Simple Building Information Modeling

SBIM is a concept of producing a "light" model that can be used for simulating the building's performance very early within the design process. The SBIM is the process of modeling only the exterior envelope, and the interior volumes to produce a model that energy modeling software can use.

T

TMY2/TMY3

The TMY2/3 file format is a Typical Meteorological Year file. It is used for in conjunction with a .GBxml file to create energy simulations.