Helpful information related to the PSU OPP BIM requirements.

BIM User Guide

VERSION 1.0.6

DRAFT

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Design Services

Prepared for PSU OPP by:

Design Services | BIMteam

Tel 814.863.3301
Fax NA

113 Physical Plant
University Park, 16802

bim.opp.psu.edu
psubim@psu.edu

Contents

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"Insanity is doing the same thing over and over again and expecting different results"

Albert Einstein

Executive Summary

Basis / Background

PSU OPP's BIM efforts started back in 2010 with a collaborative effort with the PSU Architectural Engineering Department's CIC team. That led to many collaborative efforts and products that helped guide OPP's BIM implementation. The current minimum BIM Requirements are focused on four high level objectives that take wholistic facility lifecycle management perspective. The guide is provided to help those who want to better understand the details behind that perspective and the supporting objectives. Additionally, the BIMteam has provided useful information to answer common questions related to the PSU OPP Building Information Modeling (BIM) Universal Addendum. The BIM Requirements are a mix of performance and prescriptive based language.

It is a "Guide" not a requirement.

This guide is meant to help provide context, understanding, and examples of solutions that achieve certain elements of the PSU OPP BIM Requirements. Anything defined in this guide should not be interpreted as additional contractual requirements.

Many solutions to achieve the objectives

There are many ways to achieve the objectives sought by PSU OPP through the BIM Requirements. The solutions listed herein are only one of many, and hopefully represent best practices. However, the industry at large is encouraged to advance the known best practices. Feel free to share your ideas with the PSU OPP BIMteam at psubim@psu.edu.

Updates

This document will be updated continually as part of the PSU BIMteams continuous process improvement efforts. Check back often. PSU OPP's BIM efforts can be found at www.bim.opp.psu.edu.

The work contained within this report/study represents the opinions and views of Design Services | BIMteam.

Russ Manning, Ph.D, LEED AP, CEFP, CRL
Virtual Design & Construction Engineer
March 18, 2019

"Synergies are not only about cost reduction. Synergies can be access to markets, exchange of products, avoiding overlaps, exchange of best practices"

Carlos Ghosen

"Sometimes the best, and only effective, way to kill an idea is put it into practice."

Syndey J. Harris

Cautionary Disclaimers

Use of this guide is at the user's risks. While the guide is meant to inform best practices at the time, there is no guarantee it is current or that the solutions and approaches defined represent current industry best practices or best practices for your organization, firm, objectives, or efforts.

Relationship to Objectives

The guide supports the OPP BIM Requirements. Those requirements are completely focused on ensuring the defined OPP BIM Objectives are achieved. Therefore, the guide provides information related to successfully achieving those objectives. If your objectives vary from the PSU OPP objectives the information listed within this guide may not provide the same results expected.

Prescriptive vs Performance Based Language

The OPP BIM Requirements, where ever possible, are written from a performance-based approach, and where absolutely needed for clarity or PSU life cycle integration, prescriptive language is used. The performance-based approach allows for maximum flexibility on "how" to achieve a requirement and support the objectives.

Acquisition Strategy Alignment

The current AEC industry has an ever-changing set of acquisition strategies. These strategies incorporate various combinations of delivery methods, procurement methods and contracting methods/types. The approach chosen within BIM requirements is to have a singular addendum that can be used with all acquisition strategies for a project, and the examples listed within this guide are not meant to be all inclusive. Rather they are meant to give examples of how these requirements can be achieved within different acquisition strategies. Each project has different variables and considerations, so the guide provides these examples with the assumption that a basic level of abstraction can be used by the project delivery team (PDT) to successfully apply the concepts to the specific project.

Contradictory Statements

There may be examples or discussions in this document that are contradictory. This is the result of two possible situations (1) we have a mistake and request you contact us to let us know about it, or (2) like many aspects of construction industry some things that solve one problem cause conflicts relative to another problem and as professionals we must make optimization decisions related to what solves the broader project/enterprise goals and objectives.

Cautionary Disclaimers

It is a DRAFT

This document is in draft stage. We were torn between holding the release of this document until we got to a final, or releasing it now knowing we have some work that needs to be done. We finally decided that because this guide is not a contractual document, it was better to get the information it contains out there now rather than withhold it. Check back often as we are aggressively working to get this to a "final" status, and we will continually update as we learn.

Things Change…

Life cycle facilities management is not a static endeavor, and things change. At the same time, not everyone gets the memo! If you are working a project and you are being directed to do something different than is described in this document, consider doing the following:

1. Contact us and let us know what deviation is being suggested. (See Contact Information on page 87). We can talk with the PSU person giving you alternative guidance to better understand why they want to deviate from the enterprise approach. Additionally, sometimes people change things and we don't get memo!
2. Let the PSU employee telling you to do something different know that this varies from the user guide, and you want to make sure you are following the current guidance. PSU is a big place, and not everyone gets the memos (figuratively), so they may not know there is an enterprise approach that integrates a lot of moving pieces.

Contradictions to the Addendum

This is a guide to help inform the BIM Addendum. If you find something in this document that contradicts your BIM Addendum, it is unintentional. The following would apply: (1) your contractual requirement is the Addendum on your contract, and (2) we ask that you please let us know so we can fix the conflict. (See **Contact Information** on page 87).

BIM Objectives

PSU OPP's BIM Requirements are directly related to achieving four high level objectives defined below. These high-level objectives have specific things that PSU OPP wants to achieve on all projects. BIM is used as a forcing function to enable, empower and ensure these objectives are met.

Philosophical Approach to BIM and Process

PSU OPP does not do BIM for the sake of BIM, instead we are focused on using BIM tools to help achieve specific outcomes. This means we also do not refer to it as a "BIM process." Rather we use BIM to support process, improve current process, and inform process. We acknowledge that certain process approaches allow for better outcomes using BIM tools than others. Likewise, certain processes are more feasible with BIM tools than without. Linking both BIM and process together as a single inseparable element far too often limits either (BIM tools or process improvement) from being advanced without the other and limits potential gains for an organization. Wherever possible it is best to advance tools and process improvement together, but it should not be used as an excuse to avoid either individually.

Many People, Many Backgrounds

PSU OPP's BIM approach acknowledges we have many members of the project delivery team (PDT) both internal and external to OPP that have varied opinions, experiences, and skills. The BIM Requirements defined through the BIM Addendum set a minimum threshold. In some cases, it creates a stretch goal for some PDT members, while for others it may be perceived as a bar too low. At its core it uses the objectives to guide the requirements. The objectives are key things PSU OPP needs to achieve. Where that raises the bar, we look for PDT members to grow and excel. Where it is a bar you already surpass, we hope to move there with time and hope you bring that added value to the PSU project!

Defined Objectives

The four PSU OPP BIM objectives are:

- Support high performance building design
- Support facility life cycle management
- Reduce project costs and schedules
- Effectively support PSU marketing, fundraising and recruitment using advanced visual immersion tools

BIM Objectives

Support high performance building design

- Facilitate early and accurate planning information allowing engineering design teams to more collaboratively explore design alternatives with architects and builders.
- Provide appropriate information allowing PSU sufficient time to consider various implications of alternatives of design for proposed projects

Support facility life cycle management

- Empower project delivery teams to better share information internally and externally to the project that is relevant for collaboration of the team and increases decision makers ability to provide timely and sound decisions.
- Effective handoff of relevant project data to PSU allowing effective and appropriate operations at substantial completion through efficient and accurate digital transfer of information
- Effectively engage facility management operators ensuring maintainable building design and construction through immersive virtual reviews during design and prior to construction
- Provide relevant data to operational entities with sufficient time plan and program operational priorities (criticality), funding, and asset (space and equipment) awareness.

Reduce project costs and schedules

- Use BIM tools effectively for reducing errors, omissions, RFI's, change orders, and improve safety (for users and builders alike)
- Provide appropriate visualization tools at the appropriate times allowing project stakeholders to have compressive spatial and visual awareness design and construction intent
- Optimize constructability through effective designer and builder dialog using Revit for design and Navisworks for builder coordination
- Effectively coordinate the elements identified for coordination and conflict elimination through frequent and incremental design / trade specialties communication and sharing information
- Increase the feasibility of modular and offsite fabrication through effective modeling and contractor (designers and builders) coordination eliminating waste, increasing quality, and increase onsite safety records
- Provide accurate and timely information enabling project status awareness and potential cost and schedule risks

Effectively support PSU marketing, fundraising and recruitment using advanced visual immersion tools

- Provide virtual visual experiences that encourage and build excitement for potential donors

- Provide virtual visual experiences that support the effective requirement of faculty, students, and athletes

BIM Objectives Relation to OPP Goals

The BIM objectives do not work separate from broader enterprise and leadership goals and visions. They in fact are defined to help the enterprise achieve efforts broader than individual tasks. Once a project is complete it must be effectively integrated into the broader enterprise where it will exist for most of its lifespan.

Table 1: PSU OPP BIM Objectives Related to Stated Enterprise Goals

- *Direct relationship*
- *Indirect relationship*
- *Needs further investigation*

OPP Stated Enterprise Goals	1. Support High Performance Building Design	2. Support Facility Life Cycle Management	3. Reduce Project Costs & Schedules	4. Effectively support PSU Marketing, Fundraising, and Recruitment through Visual Immersive Tools
1. Foster a unified high-performing team with mutual respect for each person's uniqueness, talents, value, and perspective. We do this through:				
Employee Engagement	●			●
Rewards & Recognition				
Diversity & Inclusion				○
Professional Development	●	●		
Succession Planning				
Mentoring and Engagement at All Levels of the Organization	●	●		○

BIM Objectives

OPP Stated Enterprise Goals	Support High Performance Building Design	Support Facility Life Cycle Management	Reduce Project Costs & Schedules	Effectively support PSU Marketing, Fundraising, and Recruitment through Visual Immersive Tools
2. Fix, improve, and preserve the University's physical plant.				
Reduce backlog	●	●	●	◌
Provide new and improved facilities to support the mission of the University	●	●		
Employ a University-wide maintenance management program	●	●		
Reduce carbon footprint and energy consumption	●	●	●	
3. Optimize organizational structure and business processes.				
Collect/solicit customer feedback	●	●	●	
Expand and maximize opportunities for broadening external funding sources	●	●	●	●
Foster and develop relationships with Commonwealth campus maintenance staffs	●	●	●	
4. Implement business-centric IT structure.				
Review and implement all business process systems and budget models		●		
Deploy project management information system	◌			

BIM Objectives

OPP Stated Enterprise Goals	Support High Performance Building Design	Support Facility Life Cycle Management	Reduce Project Costs & Schedules	Effectively support PSU Marketing, Fundraising, and Recruitment through Visual Immersive Tools
5. Develop meaningful performance measures that guide our decisions to maximize our efficiency across many aspects of stewardship.				
Improve our use of data to support informed decision-making	●	◌	●	
Apply and maximize use of key performance indicators	○	○	○	
Become a learning organization	●	●	●	
6. Establish a unified vision for safety, health, and environmental protection throughout the University.				
Visibly demonstrate the safety commitment of the University administration to the entire organization (with the development of a University-wide advisory committee)	○	○		
Establish an integrated safety and environmental protection management system to support University-wide missions, goals, and objectives	○			
Enhance and expand leadership and employee engagement to promote a positive safety culture throughout all units and campus locations		○		
Measure safety progress using consistent key performance indicators	○			

Acquisition Strategies

Many acquisition strategies exist throughout the Architecture, Engineering and Construction (AEC) industry. The nomenclature used varies based on industry norms, intent and marketing considerations. The PSU OPP BIM Requirements are fundamentally agnostic to the specific acquisition strategy employed on the project. Rather it focusses on the delivery methodology prime contractor (designers, builders, consultants, etc.) relationship to the owner (in this case PSU). Who is directly contractually responsible to PSU? This is expressed in three primary ways “prime contractor” (all contractors in a direct contractual relationship with PSU), “design prime contractor”, and “construction prime contractor.” Detailed definitions can be found in the **Common Definitions** section of this document and examples are listed below.

Figure 1: Acquisition Strategy (Delivery, Procurement, Contract)

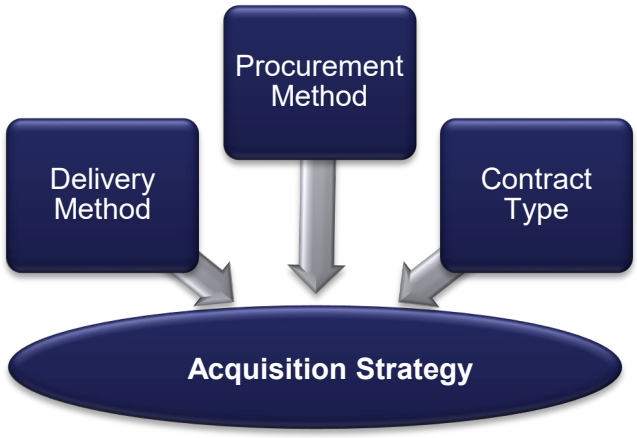


Table 2: Common Acquisition Strategies & Relative BIM Benefits

Delivery	Procurement	Contracting	BIM Benefits
CMAR	Best Value	GMP	High
Design-Bid-Build	Low Bid	Fixed Price	Moderate
Design-Bid-Build	Sole Source	Fixed Price	Highly variable
Design-Bid-Build Fast Track	Negotiated	Fixed Price	Moderate
Design-Build	Best Value	Fixed Price	High
IPD	Negotiated	GMP	Very High

Delivery Methods

Delivery methods are the methodology by which the project participant relationships are structured and the sequence in which they are acquired in the overall acquisition strategy. This is the primary differentiator for the BIM Addendum language, as it identifies which "supplier" has the contractual obligation to the "buyer" to deliver something.

Examples include design-bid-build, design-build, and construction manager at risk.

Examples

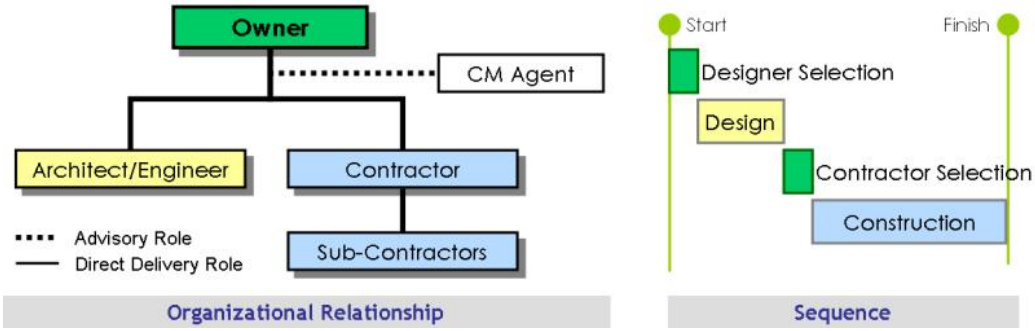
The following give context to the PSU OPP BIM Requirements defined in BIM Addendum. The figures below are not all inclusive, however they provide examples of different types of delivery methods used within the AEC industry. CM Agents may or may be used, timing with which they are acquired can shift while the sequence remains relatively standard for the methodology, and nomenclature is sometimes fluid. Integrated Project Delivery (IPD) has multiple variations, however the general delivery methodology includes early selection of key PDT members with a varying degree of mutual accountability and responsibility to the selected pool of key PDT members.

The BIM addendum also notes that the entity in a "prime" role is responsible for ensuring any subcontracted work effort that relates to the task or deliverable described includes compliance with the BIM addendum. As an example, if the architecture firm having the design contract with PSU subcontracts the MEP work to another design firm, that lead architecture firm remains responsible for ensuring their subcontract includes the associated BIM deliverables. That "design prime contractor" still owns the contractual / agreement responsibility for that task/deliverable, and if not completed by the subcontracted entity the "design prime contractor" is responsible for duplicating the effort at their own expense. In other words, subcontracting work described in the BIM addendum does not preclude the requirement described, nor does it put the burden of enforcing or managing the BIM requirements with that subcontracted entity on PSU.

Another example is common with more integrated delivery methods such as DB. In most DB delivery scenarios, the contractual relationship is between the owner (PSU) and a builder. While the builder is contractually responsible for the design effort, it is unlikely they are performing that work in-house. It is more likely that builder has "partnered" with a design firm and hired them to complete the design requirements. Even though the design firm is completing the work, in this case the "design prime contractor" is the builder since they are the entity legally/contractually responsible to deliver the design related tasks/deliverables to PSU. Conversely, if the entity in a contractual relationship with PSU on a DB was a design firm, they

are the “construction prime contractor” even though that work is subcontracted to one or more builders.

Figure 2: Design-Bid-Build Delivery (DDB) Method (Traditional) (Source [1])



How the BIM Addendum Applies to a DDB (Traditional) Delivery Method?

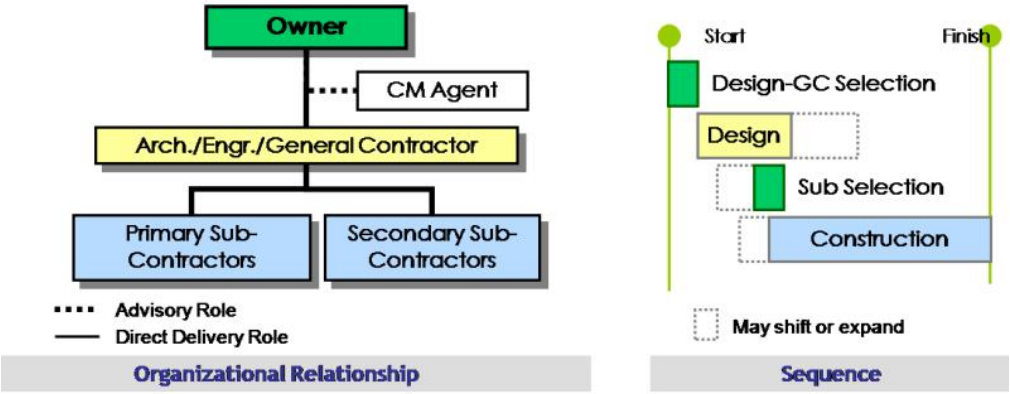
In an acquisition strategy with a traditional DDB delivery methodology approach the BIM addendum supports the following:

“…the prime contractor shall…” means that any prime contractor which has the BIM addendum included in their scope is legally/contractually responsible for the tasks/deliverables defined regardless of whether they are designer, builder or other.

“…the design prime contractor shall…” means that any design entity in a prime contractor relationship with PSU and has the BIM addendum included in their scope is legally/contractually responsible for the tasks/deliverables defined. In a DDB delivery method approach a design firm is most often the entity responsible for design tasks. Therefore the “designer” would be responsible for these tasks/deliverables, while the builder (construction contractor) would not.

“…the construction prime contractor shall…” means that any construction entity (builder) in a prime contractor relationship with PSU and has the BIM addendum included in their scope is legally/contractually responsible for the task/deliverables defined. In a DBB delivery method approach this may be a construction manager, general contractor, or multi-primes responsible for defined aspects of the construction effort. Therefore the “builder” or “construction contractor” would be responsible for these tasks/deliverables, while the designer would not.

Figure 3: Design-Build Delivery Method (Traditional) (Source [1])



How the BIM Addendum Applies to a DB (Traditional) Delivery Method?

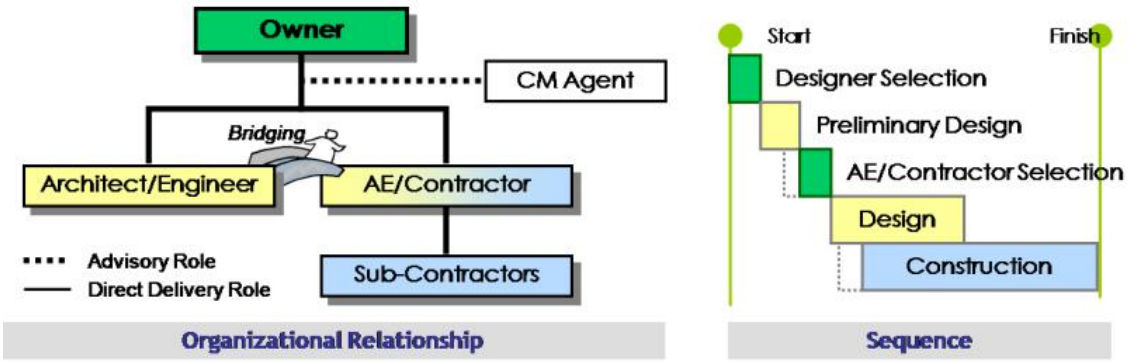
In an acquisition strategy with a traditional DB delivery methodology approach the BIM addendum supports the following:

"…the prime contractor shall…" means that any prime contractor which has the BIM addendum included in their scope is legally/contractually responsible for the tasks/deliverables defined regardless of whether they are designer, builder or other.

"…the design prime contractor shall…" means the entity that holds the contractual agreement with PSU to execute some portion or all of the design. In a DB delivery method approach this is most commonly a builder (construction firm or general contractor or construction manager). While the builder seldom does that design work in-house, they are contractually responsible for the design effort on the project. A design firm is most often the entity executing of the design tasks. It is incumbent upon the builder to ensure they have the BIM requirements in the agreement / subcontract with their respective design partner(s). Therefore the "builder" would be legally/contractually responsible to PSU for these tasks/deliverables, while the "designer" would not.

"…the construction prime contractor shall…" means the entity that holds the contractual agreement with PSU to execute some portion or all of the construction. In a DB delivery method approach this may be a construction manager, general contractor, or multi-primes responsible for defined aspects of the construction effort. Therefore the "builder" or "construction contractor" would be responsible for these tasks/deliverables, while the "designer" would not.

Figure 4: Design-Build Delivery Method (Bridging) (Source [1])

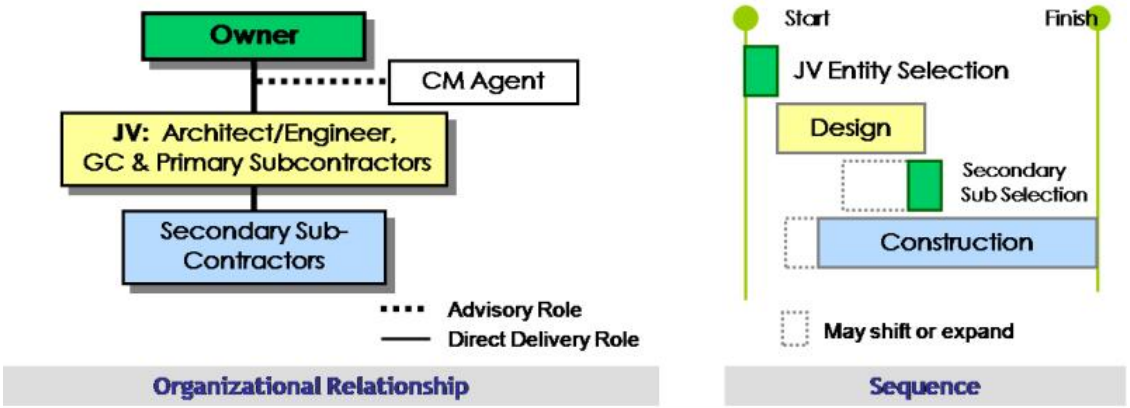


How the BIM Addendum Applies to a DB (Bridging) Delivery Method?

In an acquisition strategy with a bridging DB delivery methodology approach the BIM addendum supports this acquisition strategy in the same way defined in the traditional DB methodology.

In the bridging scenario the original AE team preparing the bridging documents is typically different than the AE team under the DB contract. In this case the AE team developing the bridging documents holds a direct contract with the owner, and therefore for the bridging documents they are the "design prime contractor." While under the DB contract the entity holding the contract (typically a GC, CM, or Joint Venture) is the "design prime contractor," and they ensure they have the BIM requirements included in their subcontract(s) to the AE team finishing the design effort.

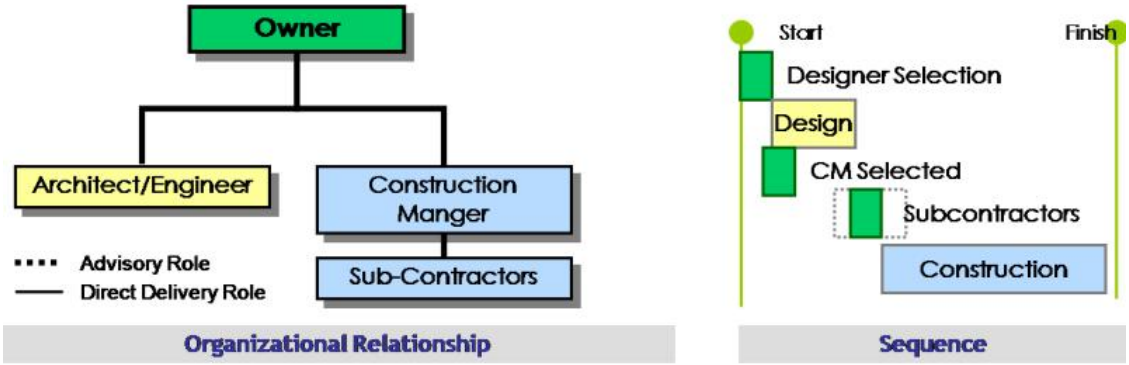
Figure 5: Design-Build Delivery Method (Integrated / Joint Venture) (Source [1])



How the BIM Addendum Applies to a DB (Joint Venture) Delivery Method?

In an acquisition strategy with a Joint Venture DB delivery methodology approach the BIM addendum supports this acquisition strategy in the same way defined in the traditional DB methodology. The Joint Venture (JV) entity has the prime relationship with the owner and thus is responsible for both the design ("design prime contractor") and building ("construction prime contractor") elements of the contract.

Figure 6: Construction Manager at Risk (CMAR) (Source [1])



How the BIM Addendum Applies to a Construction Manager at Risk (CMAR) Delivery Method?

In an acquisition strategy with a CMAR delivery methodology approach the BIM addendum supports this acquisition strategy in the same way defined in the traditional DBB methodology.

While the CMAR has various flavors in today's AEC industry, the basic principles and characteristics are the same. There is a separate design team responsible for the overall design effort, and there is a Construction Manager responsible for the building/construction effort.

"…the prime contractor shall…" means that any prime contractor which has the BIM addendum included in their scope is legally/contractually responsible for the tasks/deliverables defined regardless of whether they are designer, builder or other.

"…the design prime contractor shall…" refers to the entity responsible for some or all of the design effort. In almost all CMAR approaches this is the design team, and not the CMAR (unless the CMAR contractually has some portion of the design responsibility).

"…the construction prime contractor shall…" refers to the entity having responsibility for executing the design and building the project. This means the CMAR has responsibility for these things, while the "designer" does not.

Figure 7: Integrated Project Delivery (IPD) Method (Source TBD)

How the BIM Addendum Applies to an Integrated Project Delivery (IPD) Delivery Method?

In an acquisition strategy with an IPD delivery methodology approach the BIM addendum supports this acquisition strategy in much the same way defined in the traditional DBB methodology.

An IPD delivery methodology inherently has more collaborative sharing and integration of the BIMs and other associated information than the DBB; and from this perspective looks more like the DB in the execution of the BIM requirements. The BxP becomes an even more critical element of the effort to ensure all parties clearly understand who is performing what elements of BIM requirements, when, and how they are being shared.

While the IPD has various flavors in today's AEC industry, the basic principles and characteristics are the same. There is a joint contractual agreement between select PDT members which includes the design, construction, and construction management entities. These agreements may or may not include the owner, and often have some mechanism for pooling the risk so that it is shared in some fashion.

"…the prime contractor shall…" means that any prime contractor which has the BIM addendum included in their scope is legally/contractually responsible for the tasks/deliverables defined regardless of whether they are designer, builder or other.

"…the design prime contractor shall…" refers to the entity responsible for some or all of the design effort. While this can be mix of entities for various elements of the IPD it is most often the AE team having design responsibility. Where there are portions of the design that are to be executed by the builder this language would apply to the builder for the portions of design they are contractually responsible to deliver.

"…the construction prime contractor shall…" refers to the entity having responsibility for executing the design and building the project. These builders (GC, CM, MEP contractors, etc.) who are signatories of the IPD agreement have responsibility for these things, while the "designer" does not.

Figure 8: Design Assist (DA) Method (Source TBD)

How the BIM Addendum Applies to a Design Assist (DA) Delivery Method?

In an acquisition strategy with a DA delivery methodology approach the BIM addendum supports this acquisition strategy in much the same way defined in the traditional DBB methodology.

An DA delivery methodology is intended to be a more collaborative sharing and integration of the BIMs and other associated information than the DBB; and from this perspective looks more like the DB in the execution of the BIM requirements. The BxP becomes an even more critical element of the effort to ensure all parties clearly understand who is performing what elements of BIM requirements, when, and how they are being shared.

While the DA has various flavors in today's AEC industry, the basic principles and characteristics are the same. As in the DBB there is a distinct contract between the owner and the design team, and a distinct contract between the owner and the builder(s). The DA can have significant variations of application. In all cases some portion of the construction team is brought on board prior to design completion (typically through a construction manager) to "assist" in the design development and completion. This DA contractor can act in an advisory role to the design team, however more commonly the DA contractor takes an active role in completing the design. In this later scenario this situation resembles the characteristics of a DB-Bridging methodology. In a DA where some portion of the design is handed off to specific contractors who complete their respective portion of the design, the DA entity assumes the additional role of a "design prime contractor" relative to the BIM Addendum.

This design hand off must coordinate the handoff of the design intent models and final resolution to the Record Model deliverable. This resolution of responsibility is covered in the BIM addendum as it defines the "design prime contractor" role. In a DA scenario we have multiple design prime contractors, and the BIM Addendum addresses required coordination between multiple primes.

As noted in the BIM Addendum the design prime contractor responsible for the majority of the architectural design effort is responsible for coordination of the multiple prime models into the Record Deliverable.

"…the prime contractor shall…" means that any prime contractor which has the BIM addendum included in their scope is legally/contractually responsible for the tasks/deliverables defined regardless of whether they are designer, builder or other.

"…the design prime contractor shall…" refers to the entity responsible for some or all of the design effort. While this can be a mix of entities for various elements of the DA it is most often the AE team having design responsibility and those builder entities performing / completing actual design elements. Where there are portions of the design that are to be executed by the builder this language would apply to the builder for the portions of design they are contractually responsible to deliver.

"…the construction prime contractor shall…" refers to the entity having responsibility for executing the design and building the project. This means the builder (GC, CMAR, etc.) has responsibility for these things, while the "designer" does not.

Procurement Methods

Procurement methods are the process used by the owner, or entity contracting services, to select the team of contractors used in the acquisition of the facility.

Examples include sole source, best value, or low bid.

Contracting Methods

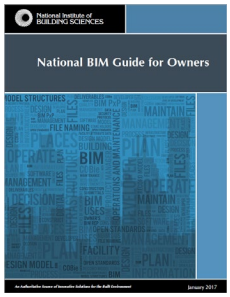
Contracting methods/types are the terms identified that assign financial risk between the owner and the seller of the contracted services. Examples include guaranteed maximum price (GMP), lump sum, or cost-plus fee.

Industry Best Practices

While we list a few general industry best practices here, most of the best practices are dispersed throughout the guide in their relevant sections.

Where they exist, PSU OPP prefers to use industry BIM standards, when they support our identified objectives. This reduces confusion across the PDT, especially for PDT members external to PSU. The following industry standards were used to help develop the PSU OPP BIM Requirements.

Figure 9: National BIM Guide for Owners



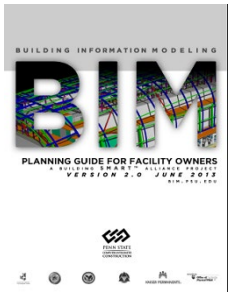
Where practical and applicable, PSU OPP BIM requirements used definitions and concepts that align with the national guide. While it does not get to the granular detail required for daily execution, it provides foundational concepts, standardizes vocabulary, and is a great step towards a national vocabulary and taxonomy related to BIM for the life cycle of infrastructure and facilities assets. **[2]**

Figure 10: BIMFORUM LOD (AIA/AGC)

The PSU BIM Element Matrix (BEM) is based on this document. PSU OPP BIM efforts consider this information critical to the success of many elements of the defined objectives.

http://bimforum.org/lod/ [3]

Figure 11: BIM Planning Guide for Facility Owners



This document represents a collaborative effort of national facilities owners and with information helping owners think through the process of developing an enterprise BIM strategy specific to your organization.

www.bim.psu.edu [4]

Figure 12: Project Execution Planning Guide

This document provided the conceptual structure for the PSU OPP BIM Execution Plan (BxP) template. It provides foundational concepts and considerations to allow the PDT members to use BIM effectively on a project, develop project specific applications, and document those plans for execution.

www.bim.psu.edu [5]

Industry Owner Enterprise Examples

PSU OPP also reviewed other multi-building, multi-campus owners and their approaches. While each owner has specific objectives they are trying to achieve, there are common elements that have provided insights and validation into the PSU OPP approach.

These industry examples include:

- Carolinas Health System [6]
- Department of Defense Military Health System [7]
- Department of Defense USACE [8]
- Department of Veterans Affairs [9]
- Ohio State University [10]
- Western Michigan University [11]

Publication of BIM Standards & Resources

PSU OPP strongly believes in the collaborative benefits to the AEC industry and facility/infrastructure owners of sharing BIM standards and resources. There is far more gained through such collaboration than potentially lost. The collective competition is in the services provided on the campuses and within the facilities used to meet the mission, not in our use of BIM to achieve publicly defined objectives. Through collaboration and sharing of effective use of BIM tools we can advance the AEC industry to our collective benefit.

PSU has a long history of openly and freely sharing our BIM approaches and resources. We continue to do this with our updates, thank those who do the same, and ask others to follow collaborative nature demonstrated by many in the industry.

- PSU OPP resources can be found at: www.bim.opp.psu.edu
- Contact PSU OPP BIMteam at: psubim@psu.edu

Partnerships with Academia

PSU OPP has benefited greatly through our collaborative effort and funding of academic and scholarly research related to BIM and its application. This effort has allowed PSU to blend theoretical and applied research with application in practice. This collaboration has also allowed the research efforts to produce results more easily and rapidly applied to the AEC industry's and owner's management practice.

- PSU Academia resources can be found at: www.bim.psu.edu
- Contact PSU's AE BIM faculty at: cicpennstate@psu.edu

Parameter Association

There are multiple examples and discussions throughout this user guide related to data management and project parameter management. (e.g. see **Revit** Shared Parameter File on page 56)

An overarching data management principal is to store information at the highest level of commonality. As an example, even though the final data deliverable requires each asset to include the project number with which it is associated, you would not want to enter the project number repeatedly within the asset object parameter properties. Additionally, if the field changed you would not want to have to go back and update it in all those data fields. Unless you have different project numbers by phase and you are using phasing in your Revit model, the highest level at which the project number is common is at the project level. Therefore, you would associate the project number at the project parameters level. Because of the associative capabilities of Revit, you would be able export the project number field with each row of assets objectives through multiple processes that are available.

BIM Execution Plan (BxP)

PSU OPP provides a template for the contractors to use. The 2017 BxP template has been published for use.

The 2017 updates resolve many ambiguous elements found in the 2012 template and most importantly aligns with the 2017 BIM Addendum requirements.

2017 template is at: http://psu.box.com/v/BxP

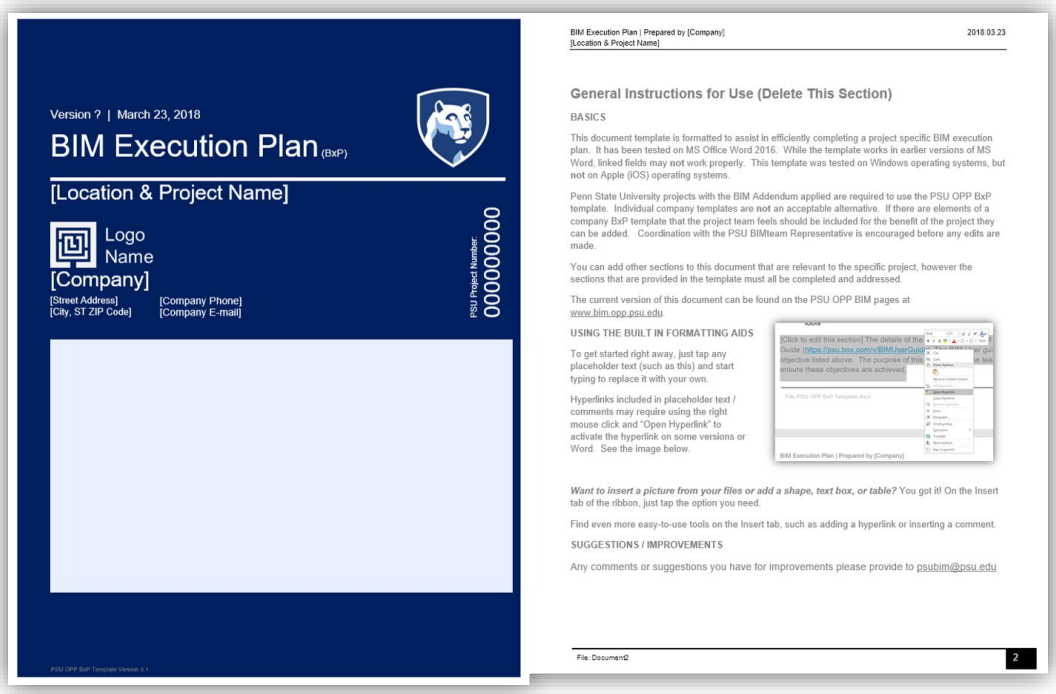
(The current working draft with future updates can be found at: http://psu.box.com/v/BxP-Draft)

COMMUNICATION

The primary purpose of the BxP is to serve as a forcing function for the team to coordinate project specific solutions early ensuring project objectives are met.

COMMUNICATION

Figure 13: 2017 BIM Project Execution Plan Template



Project Specific Solutions

While there are many elements and approaches that may be common from project to project, each project is unique. Therefore, for the project BxP to be valid it must speak to the specific project. BxP's that don't speak to the specific project are of minimal use and demonstrate a general lack of planning and coordination that will negatively affect the specific project and ultimately result in risk to the project delivery team (PDT). **PSU has specifically required the**

project specific BxP to eliminate risk from the project. By signing the design and/or construction contract(s) for the project the prime contractors have agreed reduce this risk through an effective and well thought out project specific BxP.

Preemptive vs Reflective/Reactive

The BIM Addendum specifies the development of the BxP at the very early stages of the contract effort execution. The emphasis on this timeliness is also tied to the invoicing process.

The BxP has value as a preemptive planning and coordination tool. It has no value as a reflective document merely recording the efforts after the fact. Because the primary purpose is to force detailed coordination that proactively ensures the objectives are achieved on each individual project, it inherently means the BxP must be done very early in the project execution efforts.

Joint vs Individual BxP

The BIM addendum requires each prime contractor on a project to deliver a BxP. These are individual BxP's. Prime contractors on a project may request cooperatively to do a joint BxP. This must be approved by the individual project leader.

Joint BxP's are encourage, provided that each team member carries their share of the effort to develop a comprehensive joint BxP. The requirement in the BIM addendum guards PSU against prime contractors requesting a joint BxP and one or more parties not sufficiently contributing their share of the effort to develop an effective project specific BxP.

Living Document

The BxP is a living document and therefore is expected to change over the course of the project execution. The BIM addendum requires each prime contractor on a project to update the BxP as the project evolves. The BIM addendum specifies the expectations for updating the BxP in a timely fashion. The BxP update timeliness is tied to the projects invoicing, so it is incumbent upon the prime contractor's BIM manager to ensure the BxP is updated to avoid invoicing and payment delays.

BxP Section Discussion

Each section of the BxP template is not discussed here, however certain sections are highlighted to help BIM team members to think through the BxP development.

In general instructions are provided in the BxP template itself, and that should be the starting point for the project BxP development.

Note: Any examples presented here may or may not be applicable to your specific project or company approach to achieve the PSU BxP examples. The BxP template should be filled out with relevant information for the specific project.

The contractor (keep in mind that the "contractor" is anyone PSU contracted with to get work completed, so that is both designers and builders) is responsible for completing and updating the BxP during the life of the project.

Enterprise BIM Objectives

The contractor should be able to coherently explain (bullet statements are acceptable) how they are going to use BIM tools to support PSU OPP's objectives. This demonstrates an ability to apply the tools to the project in a way that adds value, rather than just checking a block.

If you need more information / understanding of the BIM Objectives, please refer to **BIM Objectives** section of this document.

Project Specific BIM Visualization Objectives

The use of visualization is one of the key components of any successful BIM application, but what does that specifically mean to the project?

This is something the BIM team should be able to articulate and should be able put in writing. The primary purpose for the team putting it in writing is:

1. Demonstrate you have read the contract and understand the visualization requirements.
2. Demonstrate the team has an actual plan for how they are going to meet the requirements vs ignore them.

BIM Project Uses

This section is self-explanatory; however, it is worth noting that in a BxP that is not joint between the designer and builder, it is expected that each party identify if a BIM use is known or anticipated to be done by another party and who that party is that will be using that BIM application.

This demonstrates an awareness of the fact that you are not working in a vacuum. Your piece is important, and one of the key BIM objectives is to facilitate the exchange of information across the life cycle not just your piece of the effort. If you are not aware of the BIM efforts going on around you, it is difficult to understand how your piece of the effort ties into the bigger picture.

Organizational Chart

Two most commonly used organizational charts are provided. You must either pick one or insert your own.

Organizational Roles and Responsibilities

In general, this defines the organizational roles and responsibilities of various BIM team members and the expected tasks during the various phases of execution and transition to operations.

This section should be updated to appropriately reflect the project effort. Significant changes to the roles and responsibilities should discussed with the PSU BIMTeam Representative ahead of time. These roles and responsibilities are typical of PSU projects and significant variations is not likely to be accepted unless there are very unique circumstances on the specific project.

Asset and Attribute Data Requirements

This is one of the most important elements of the BxP and one of the most incomplete elements turned in, causing BxP rejecting and significant effort of rework (assuming any meaningful effort was demonstrated in the first place).

This section should include the following as a minimum:

1. Some statement that acknowledges an understand of what data is required to be tracked. This information included in the contract addendum for BIM. A link to the data requirements is provided in the addendum.

"The project team will track all data elements identified in the Asset Attribute Matrix (http://psu.box.com/v/BIM-AttributeTypeMatrix) by asset type"

2. Statements about how the data will be tracked.

"The project team will use both Revit and external data management tools to collect, maintain, assemble and deliver the data requirement. Only those parameters identified as being 'required' in the model(s) will be kept in the model. All other required data elements will be maintained externally in Excel and the "Equipment_ID" parameter will be used as the primary linking key for the internal and external data set."

or

"The project team will track all required parameters and data within the BIMs. The design team will create all parameters and populate the data with relevant information. This information will be updated by the construction team members and provided to the design team members for incorporation using Excel spreadsheets."

3. Acknowledgement that there are multiple BIM data deliverables.

"The data deliverables will be iteratively increasing in information (content), and accuracy as the project develops. The team anticipates a minimum of four data deliverables. One data deliverable on or before the midpoint of design. A second data deliverable a design completion. Two additional data deliverables will be completed by the builder at construction midpoint and no later than 60 days prior to substantial completion. This last (fourth) data deliverable will be used by the design team to update the record model data elements for delivery to the owner."

4. An acknowledgement that the data is meant to be shared. Shared across design team members, construction team members, and the owner (the person paying for the work "PSU").

"Data facilitates a broader team understand of project scope and requirements. To this end the team will actively be coordinating with other project team members to share project related data to better facilitate project outcomes/success. This data will be shared via PSU's e-Builder site for the project. Data shared will be annotated to allow the user to understand the degree to which the data is fully developed and can be trusted as final."

5. Who is responsible for managing the data and who can be reached for the various elements of the data?

"ABC will maintain all space related data parameters in the architectural model (POC: BIM Manager). XYZ will maintain all MEP related data parameters in the MEP models (POC: BIM Technical Lead)."

6. Acknowledge that there is a data coordination requirement with the owner (PSU) for certain specified fields.

"Multiple parameters are provided by the Owner (PSU). A consolidated data set will be provided to PSU on e-Builder no later than January 14, 2018. PSU

will fill out the owner provided fields with the relevant information, and when returned to ABC it will be incorporated in appropriate model fields."

7. Acknowledge that the color schema requirements are derived from the parameter data elements required.

"Multiple data elements will be used to develop the required color schema deliverables. These included, but are not limited to 'Room', 'Name', 'Finish_Floor', 'Room_Function_Code' and 'Room_Function_Description'."

8. Acknowledge that the data deliverable is a single consolidated data deliverable. It is not a bunch of disparate excel files PSU needs to clean up on your behalf.

"The data will be collected through various means, and then consolidated into a singular consolidated data deliverable. This data deliverable will a single consolidated Excel Sheet of all required data for all required data."

Project Specific BIM Process

This may be process maps, bullet statements, descriptive text or a combination of these, but it should demonstrate some meaningful process description of how the BIM requirements will be achieved on the project. It should also demonstrate an iterative approach to glean actual value for the project and not just check the box effort on the part of the of the contractor.

BIM Element Matrix (BEM) / LOD Matrix

PSU follows the BIMFORUM LOD matrix and definitions. The team should use provided template to fill out the LOD for the identified elements. If your company has an alternative BEM it uses and wants to use on this project, you should coordinate with the OPP BIMteam Representative ahead of time.

While the project team should update the BEM for the project specifically significant variations (especially those reducing team requirements) should be coordinated ahead of time.

Model Clash/Interference Checks

This section is fundamentally self-explanatory; however, the team should demonstrate a true use of tools to eliminates errors and ensure both design and construction as presented / planned is practical.

Tolerance

While PSU's standard assumes considerable risk on the part of PSU it is often standard practice for designers and builders to use a higher degree of tolerance or clearance standards

either across the project or at specific sections. The intent should be clearly identified in this section.

System/Trade Check Matrix

A basic matrix is presented and can be used. The team should describe how this clash detection will progress throughout the design / construction effort.

"The team will conduct clash detection (interference checks) using Navisworks in accordance with the interference checks matrix below. This will be done on a monthly basis starting January 18, 2019 and continue through CD finalization. The interference checks will be start using a tolerance of 2" and will decrease tolerance to 1" each month in ½" increments. DD interference checks and beyond will use clearance settings incrementally increasing up to 1".

Interference Checks

Design teams CANNOT ignore this requirement or simply push it off to the construction team. Designers are expected to be able to express how they are using BIM tools to ensure their proposed design solutions are viable and physically possible. This is a means or methods of construction determination, but it is a reasonable and practical deconflicting of design elements (e.g. architectural, mechanical, structural, etc.) and a demonstration that the design is accessible from an operational stand point.

Clash/Interference Resolution

Define as a minimum the priority of resolution and who will be coordinating the resolution of conflicts.

"ABC will lead clash resolution efforts. Systems or trades with a lower precedence will typically be required to rework their design or plan to accommodate systems or trades with a higher precedence. The priority of resolution / precedence for corrections is as follows:

System / Trade	***Precedence***
Gravity Fed Systems	*1*
Structural	*2*

System / Trade	*Precedence*
Architectural	*3*
Mechanical Ductwork	*4*
Communication Distribution Trays	*5*
Fire Sprinkler System	*6*

File Naming Convention & Upload Locations

Standardization allows the team to focus on effort that add value and provide meaning.

File naming and file location are a means to effectively and efficienly exchange infomraiton. It enables success.

Abscent of standardization file naming and file turnover only bring frustration, and rob us of time to produce value and find meaning in what we do.

Purpose

The file naming convention applies to all PSU projects whether they apply BIM or not. The BIM requirements do not change those requirements; however, the file naming convention provides multiple benefits to BIM efforts and success of achieving various elements of the defined objectives. The link to the file naming convention is listed in the BIM Addendum.

https://psu.box.com/v/OPPFileNamingStandard

The PSU e-Builder folder description file is at: https://app.e-builder.net/da2/daLanding.aspx?QS=7c8b795d6c484dc780e0f0512d0731e2 (Login Required)

PSU's file naming convention covers many document types, however there are some files specifically that relate to the BIM effort and the integration of objectives across the facility life cycle. These documents are covered in detail in this section (naming, linking to assets, etc.) The PSU "File Data Naming Convention" is used for the following document types see Figure 14.

- Asset Name Plate (ANP)
- Operations & Maintenance Manuals (OMM)
- Approved Submittal (APS)
- Warranty (WTY)

Figure 14: File Data Naming Convention

OMM_00009100_000320400_20150207_00125_142400_ELV-1_Hydrolic Elev Assy_Doc02.pdf

A B C D E F G H I

Label	Description
A	**Document Type (e.g. O&M Manual | 3 characters)**
B	Building Number
C	Project Number (9 Characters: 000000000)
D	Document Date (8 Characters: YYYYMMDDD)
E	DGS Number (Often not applicable)
F	MasterSpec Format Division
G	**Equipment ID (for instance) or Mark (for type) or [Type]—[Instance]**
H	Document / Project Description
I	Additional Meta Data Information (not typically used)

A *Fields used within the BIM process for relating documents to assets*

File Naming Format: elements are separated by "_"

File Naming Convention & Upload Locations

BIM File Naming Convention

There is no mandatory file naming convention, allowing contractors (designers and builders) hired by PSU the flexibility to use internal company or team naming if beneficial to the project. In the absence of any tangible and definable benefit to the project of an alternative BIM file naming convention, the following BIM related file naming is recommended. Whatever the naming convention implemented it **must be defined in the BxP**.

BIM_Company_Subject_Project_Version

- Subject is generally the discipline
- Version may be a submittal or a date

Examples on a project might be as follows (federated model approach):

- BIM_ABC_A_EHalls-Bldg345_SD.rvt
- BIM_ABC_MEP_EHalls-Bldg345_SD.rvt
- BIM_ABC_S_EHalls-Bldg345_SD.rvt
- BIM_ABC_C_EHalls-Bldg345_SD.rvt
- BIM_ABC_C_EHalls-Bldg345_SD.dwg *(linked civil 3D file)*
- BIM_ABC_FP_EHalls-Bldg345_SD.rvt

Or

- BIM_ABC_A_EHalls-Bldg345_190103.rvt
- BIM_ABC_MEP_EHalls-Bldg345_190103.rvt
- BIM_ABC_S_EHalls-Bldg345_190103.rvt
- BIM_ABC_C_EHalls-Bldg345_190103.rvt
- BIM_ABC_C_EHalls-Bldg345_190103.dwg *(linked civil 3D file)*
- BIM_ABC_FP_EHalls-Bldg345_190103.rvt

Where do the files go?

The BIM requirements follow the PSU project closeout process. Projects will generally use one of two approved document/file delivery methods (PSU BOX or PSU e-Builder). This process applies to all projects whether the BIM Addendum applies or not. This approach provides benefits to the PDT in achieving the BIM objectives and various elements defined in the BIM Addendum.

PSU BOX File Location

Specifically, the location for the electronic deliverables is using the PSU BOX project specific closeout folder set created by the PSU Work Control Division (WCD).

PSU e-Builder File Location

Specifically, the location for the electronic deliverables is using the PSU e-Builder project specific closeout folder set created by the PSU Work Control Division (WCD).

Type vs Instance File Naming Considerations

The team MUST think through and define how file naming for the APS, ANP, OMM, WTY documents will be handled for the project and its relationship to the "Equipment_ID" attribute field related to the project assets.

This decision has huge impacts downstream at project turnover! It CANNOT be a deferred discussion and decision. *Many teams have struggled and failed at document turnover, document association, and linking because this was not thought through properly.*

See section Type vs Instance Data Deliverables *on page 70 for discussion related to data management implications.*

In most cases OMM and APS documents are submitted by type, while asset name plate (ANP) are by instance. If not thought through properly this can cause consternation downstream during project turnover as the team tries to figure out how to resolve this problem in linking / associating documents with individual assets in the model.

Some common examples that arise are seen when looking at pumps, fans, lights, etc. In the case of a pump you typically would have a unique name plate for each instance of a pump while you have one O&M Manual for each type of pump (and there may be 20 instances of the same type of pump). These cases arise most commonly when you have a "Mark" and "Type Mark" that are used on assets where you want to identify both types and instances.

Example:

Pump Types A, B, C have 10, 15, and 20 instances respectively. So, you might have a Type Mark A and Mark of P001 for pump type A instance 1. The "Equipment_ID" attribute might be P001, PMPA, or more appropriately to handle both type and instance is Pump-A--P001.

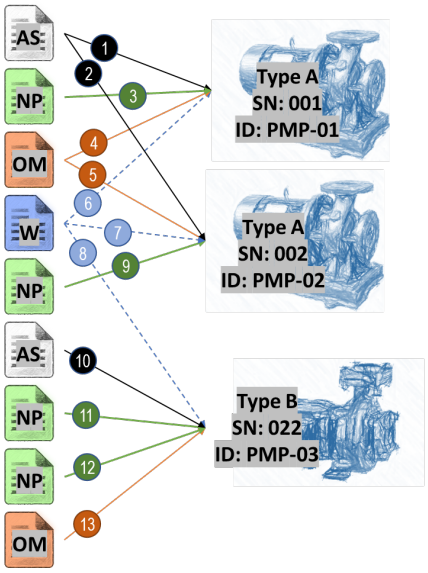
Each "Equipment_ID" instance would follow as Pump-A--P002, Pump-A--P003… Pump-A--P010, Pump-B--P016… Pump-B--P031, etc.

In this case the dilemma that arises is that you need a file naming approach and "Equipment_ID" attribute approach that can support both instances and type association. This means that you have both a one to one (one file name to one Equipment_ID") and one to many

(one file name to many “Equipment_ID” attributes in the model data set). This is depicted in Figure 15 below.

Figure 15: Type and Instance File Naming Dilemma (Source [12])

Mixture of One-to-Many, One-to-One, Many-to-One, etc. (Documents to Assets) – Most Common Situation



Description:

- One Warranty Document for Multiple Pumps (Types and Instances| One-to-Many)
- One OM Manual for Multiple Pumps (Instances | One-to-Many)
- One or multiple Name Plate (picture) for Each Pump (Instance | One-to-One)
- One Approved Submittal for Multiple Pumps (Types | One-to-One or Many-to-Many)

Document	Line	Asset Type	Instance	Description
Approved Submittal (AS) 1	1, 2	Pump A	PMP-01, PMP-02	One-to-Many
Name Plate (NP) Picture 1	3	Pump A	PMP-01	One-to-One
OM Manual (OM) 1	4, 5	Pump A	PMP-01, PMP-02	One-to-Many
Warranty (W) Document 1	6, 7, 8	Pump A Pump B	PMP-01, PMP-02, PMP-03	One-to-Many
Name Plate (NP) Picture 2	9	Pump A	PMP-02	One-to-Many
Approved Submittal (AS) 2	10	Pump B	PMP-03	One-to-One
Name Plate (NP) 3	11	Pump B	PMP-03	Many-to-One
Name Plate (NP) 4	12	Pump B	PMP-03	
OM Manual (OM) 2	13	Pump B	PMP-03	One-to-One

The solution lies in a coordinated file naming plan and “Equipment_ID” attribute management plan.

There are other tools that can be used to relate documents to assets, however they each have their own complexity and limitations. PSU uses the file naming approach in order to address the broadest user base and skills, to integrate to multiple applications, and to limit the use of third-party proprietary software.

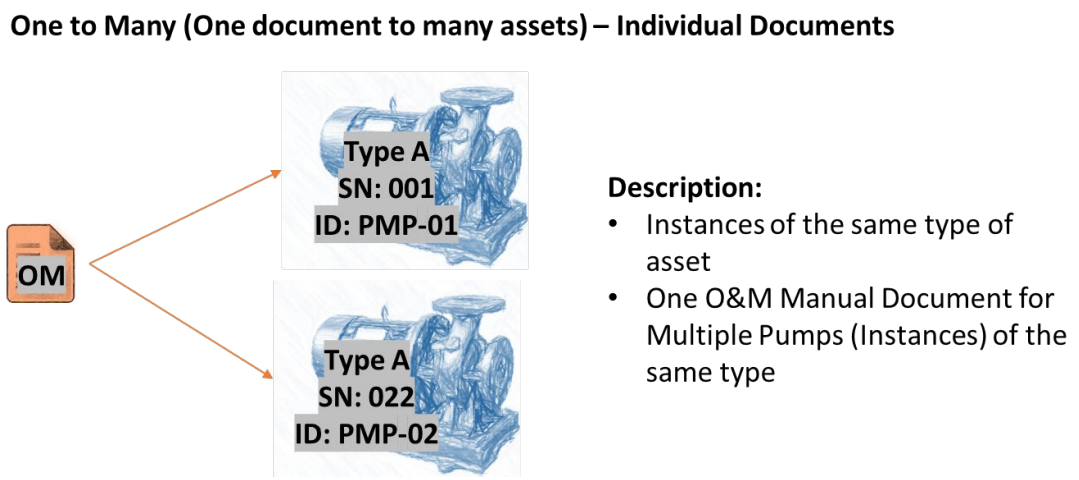
To address the complexities of each scenario we will break down each of the various documents to asset relationships depicted above.

- In the context of an ANP an **instance relationship** is needed for each asset.
- In the context of an OMM a **type relationship** is needed for each asset.
- In the context of the WTY a **type relationship** is needed for each asset of that given type (e.g. all pumps). Note that this approach (one document to multiple types of assets) is not recommended and takes special coordination to apply successfully.
- In the context of the APS a **type relationship** is needed for each asset.

One-to-Many (Single Type)

In the scenario where you have one document to many types of assets (see Figure 16) the following approach should be used in the naming convention of the “Equipment_ID” section and parameter.

Figure 16: One-to-Many (Same Type) (Source [12])



In this scenario you could just use the type identification of “Pump A” in the “Equipment_ID” if you had no other documents that need to be identified by the instance of the pump. This would be uncommon, and typically you would have other documents (such as the asset name plate picture) that require an instance association. To solve this, you would do the following:

Asset Parameter & File Name	Entry
Pump Equipment_ID Parameters of the respective pump(s)	Pump-A--PMP-001 Pump-A--PMP-002
OM Manual File Name (Equipment_ID section of the file name)	_Pump-A_
Example File Name: **OMM**_00009100_000320400_20150207__142400_**Pump-A_**Circulating Pump.pdf	

In the file naming because there is no “--" (double dash) in the “Equipment_ID” section of the file name it is presumed to be a Type only association.

See the **One-to-One (Instance)** and **Many-to-One (Instance)** sections of this document for instructions on how to handle the file naming for documents that require an instance relationship.

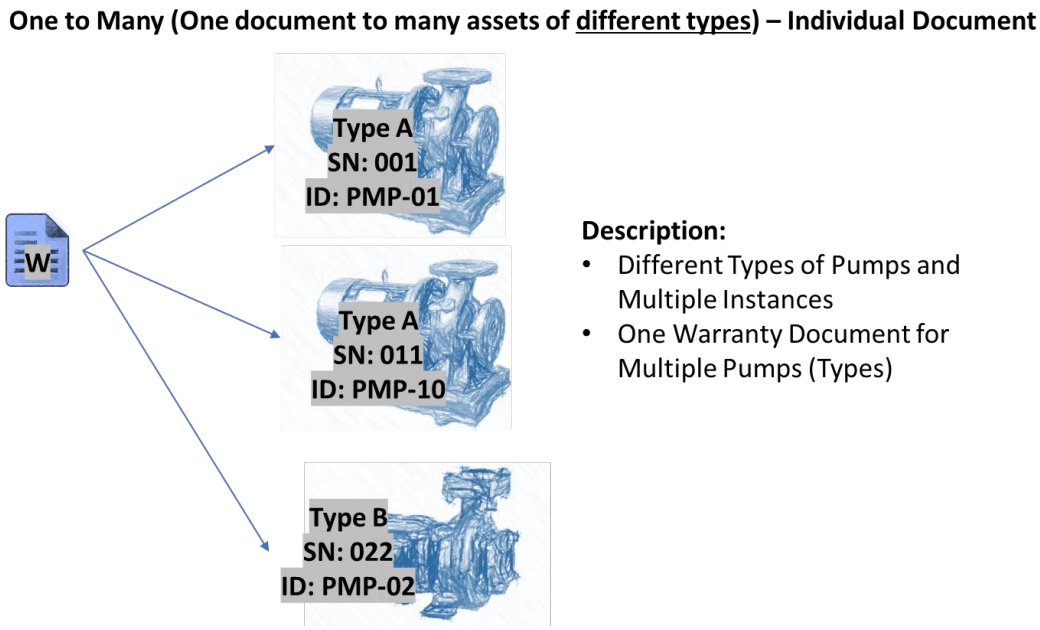
One-to-Many (Multiple Types)

It is possible to use this naming convention approach for the a one-to-many (Multiple Types), see Figure 17. *An example of this scenario is in* Figure 15 *lines 6, 7, and 8. If you want to associate one document with multiple types of things special coordination must be made with the PSU OPP Document Center and PSU BIMteam.*

While possible, it is recommended that a unique file be created for each type (assuming multiple types exist)..

A one-to-many different/multiple types scenario is possible, but not recommended. This approach typically is not compatible with operational management of the assets over the life of the facility.

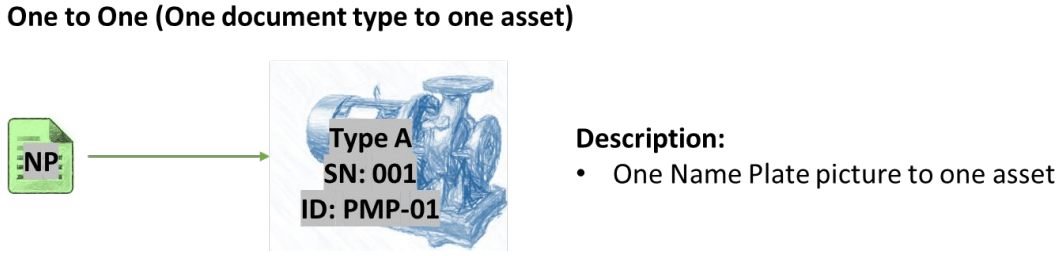
Figure 17: One-to-Many (Multiple Types) (Source [12])



One-to-One (Instance)

In the scenario where you have one document to one asset (see Figure 18) the following approach should be used in the naming convention of the “Equipment_ID” section and parameter.

Figure 18: One-to-One (Instance) (Source [12])



In this scenario you include both the type and instance information on the file naming "Equipment_ID" section.

Asset Parameter & File Name	Entry
Pump Equipment_ID Parameters of the respective pump(s)	Pump-A--PMP-001
Name Plate picture File Name (Equipment_ID section of the file name)	_Pump-A--PMP-001_
Name Plate picture file name after all required fields	Nothing is added.
Example File Name: **ANP**_00009100_000320400_20150207__142400**_Pump-A--PMP-001_**Circulating Pump.pdf	

Alternative Instance Approach

In cases where there is one document to one asset relationship for ALL documents associated with an asset you can use an alternative approach. This is atypical and not recommended as it typically adds more confusion for the team than it solves.

If your instance identifier is unique across all assets AND you have no need to associate documents by type you could use the instance identification ("Mark") without a type. See the following example.

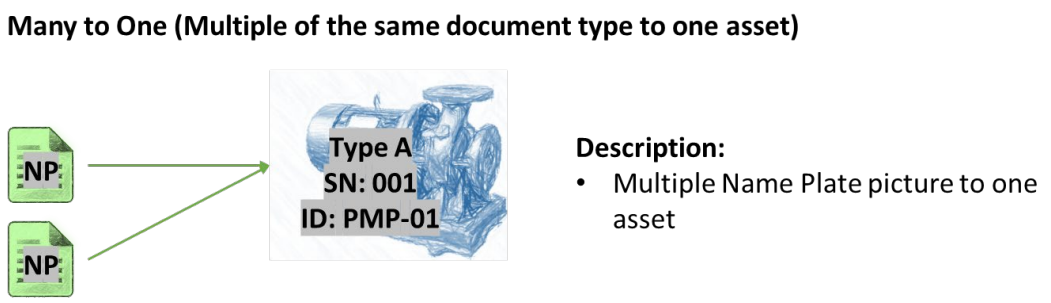
Asset Parameter & File Name	Entry
Pump Equipment_ID Parameters of the respective pump(s)	PMP-001

Asset Parameter & File Name	Entry
Name Plate picture File Name (Equipment_ID section of the file name)	_PMP-001_ *(only if unique across all assets and there is no need for a type association of documents)*
Name Plate picture file name after all required fields	Nothing is added.
Example File Name: **ANP**_00009100_000320400_20150207__142400**_PMP-001_**Circulating Pump.pdf	

Many-to-One (Instance)

In the scenario where you have one document to many types of assets (see Figure 19) the following approach should be used in the naming convention of the “Equipment_ID” section and parameter.

Figure 19: Many-to-One (Instance) (Source [12])



In this scenario you are tying a file back to a specific instance of an asset and you have multiple files of the same type of file (e.g. name plate picture) so the file name text would be the same without adding something unique on the ed of the file. In this scenario you include both the asset type and instance in the “Equipment_ID” portion of the file name, plus you need to add something unique on the end of the file name requirements. See the following table for examples of how to address this scenario.

Asset Parameter & File Name	Entry
Pump Equipment_ID Parameters of the respective pumps	Pump-A--PMP-001

File Naming Convention & Upload Locations

Asset Parameter & File Name	Entry
Name Plate picture File Name (Equipment_ID section of the file name)	_Pump-A--PMP-001_
Name Plate picture file name after all required fields	_001.jpg _002.jpg
Example File Name(s): (respectively) **ANP**_00009100_000320400_20150207__142400**_Pump-A--PMP-001_**Circulating Pump**_001**.jpg **ANP**_00009100_000320400_20150207__142400**_Pump-A--PMP-001_**Circulating Pump**_002**.jpg	

Best Practice Solution

Continuing with the earlier pump example the following application would be applied.

The BIM parameter ("Equipment_ID") for each of the three pumps would be:

- Pump-A--PMP-001
- Pump-A--PMP-002
- Pump-B--PMP-003

The file names for the respective OMM, APS, ANP, WTY documents would be:

O&M Manuals

- **OMM**_00009100_000320400_20150207__142400**_Pump-A_**Circulating Pump.pdf
- **OMM**_00009100_000320400_20150207__142400**_Pump-B_**Circulating Pump.pdf

Approved Submittals

- **APS**_00009100_000320400_20150207__142400**_Pump-A_**Circulating Pump.pdf
- **APS**_00009100_000320400_20150207__142400**_Pump-B_**Circulating Pump.pdf

Warranty Documents

- **WTY**_00009100_000320400_20150207__142400**_Pump-A_**Circulating Pump.pdf
- **WTY**_00009100_000320400_20150207__142400**_Pump-B_**Circulating Pump.pdf

Name Plate Pictures

- **ANP**_00009100_000320400_20150207__142400**_Pump-A--PMP-001_**Circulating Pump**_001**.jpg
- **ANP**_00009100_000320400_20150207__142400**_Pump-A--PMP-001_**Circulating Pump**_002**.jpg
- **ANP**_00009100_000320400_20150207__142400**_Pump-A--PMP-002_**Circulating Pump.jpg
- **ANP**_00009100_000320400_20150207__142400**_Pump-B--PMP-003_**Circulating Pump.pdf

Examples by File Type

The following is not meant to be all inclusive, however it is fairly comprehensive relative to the deliverables defined in the BIM Requirements. While every effort is made to keep this section updated, it is reflecting approaches to standards established by other divisions within OPP, and as such there may be some time lags in synchronizing the images with those updates.

It is our intent to reference the closeout and file naming convention policy when formally published by OPP. Our primary goal in this section is to help take some of the guessing out of the process related to specific BIM requirement deliverables on a project.

NOTE: It is important to note that "_" is used to differentiate meta data elements within the file name. There are two critical points here: (1) even if you don't provide information on a piece of the name you must use the correct number of "_" between the parts of the name, and (2) you cannot use "_" within the parts of the field. As an example:

OMM_142400_ELV-1	is NOT correct because the "_" between elements/parts is missing from the file naming convention
OMM_____142400_ELV-1	is correct because it used all the "_" between one meta data part and the next

OMM_____142400_ELV_1_Hydrolic Elev	is NOT correct because a "_" was used in the text of the Equipment ID / Mark section
OMM_____142400_ELV-1_Hydrolic Elev	is correct
OMM_____142400_ELV 1_Hydrolic Elev	is correct

Operations & Maintenance Manuals (OMM)

These are the electronic copies of the OM manuals required by the project. PSU OPP's WCD has expressed that (1) all OM manuals be electronic and (2) that OM manuals should be individual files for each unique type of asset. This specifically is being interpreted as a unique file for each asset having a different asset type, manufacture, and model.

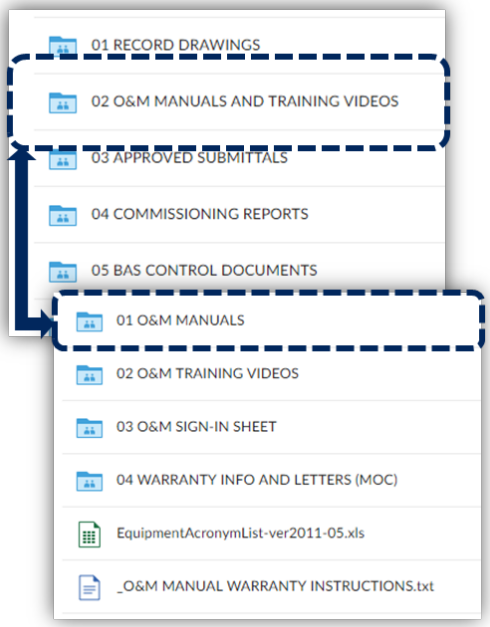
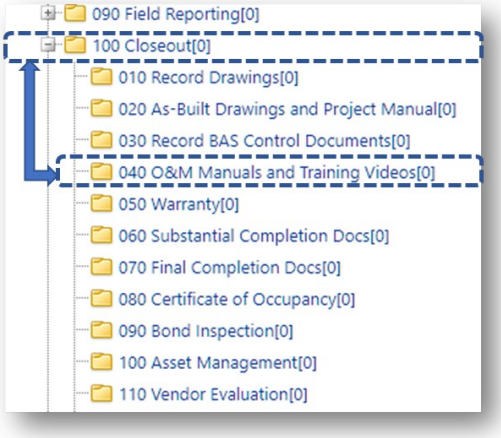
Assets that have a unique combination of asset type, manufacture, and model would be consider an "instance" of an asset. They would have a unique OM manual document and would use the "Equipment_ID" field identification as the "Equipment ID NCS" in the file naming convention.

Assets without a serial number, a common serial number, or agreed to by PSU as being grouped would be considered as a "type" OM manual. OM manuals for a "type" of asset

would use the “Mark” field identification as the “Equipment ID NCS” in the file naming convention. (see Figure 14)

OM Manuals are placed in the project close out folder as show in Figure 20 for the respective project.

Figure 20: OM Manual Closeout Folder Location

Projects using PSU BOX	Projects using PSU e-Builder
	

Approved Submittals (APS)

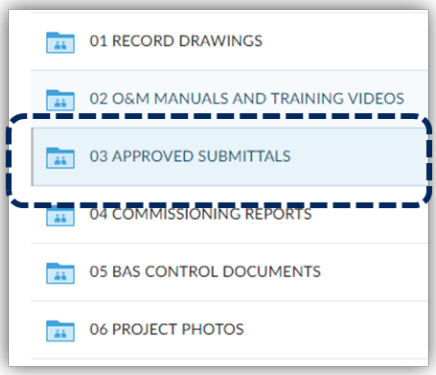
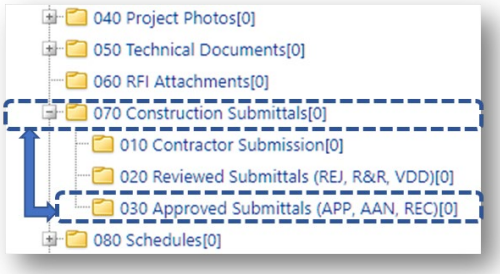
These are the electronic copies of the Approved Submittals (APS) required by the project. PSU OPP's WCD has expressed that (1) all AS be electronic and (2) that APS should be individual files for each unique type of asset. This specifically is being interpreted as a unique file for each asset having a different asset type, manufacture, and model.

Assets that have a unique combination of asset type, manufacture, and model would be consider an "instance" of an asset. They would have a unique APS document and would use the "Equipment_ID" field identification as the "Equipment ID NCS" in the file naming convention.

Assets without a serial number, a common serial number, or agreed to by PSU as being grouped would be considered as a "type" APS. APS for a "type" of asset would use the "Mark" field identification as the "Equipment ID NCS" in the file naming convention.

AS are placed in the project close out folder as show in Figure 21 for the respective project.

Figure 21: AS Closeout Folder Location

Projects using PSU BOX	Projects using PSU e-Builder
	

Asset Name Plate (ANP) Pictures

These are the electronic copies of the equipment name plate (ANP) picture required by the project. PSU OPP's WCD has expressed that (1) all ANP pictures be electronic, (2) that ANP should be individual files for each unique type of asset, (3) the ANP information should be legible, and (4) whenever possible should be straight-on (i.e. not an angled photo shot). This specifically is being interpreted as a unique file for each asset having a different asset type,

manufacture, model, and serial number. Figure 23 shows examples of acceptable equipment name plate pictures.

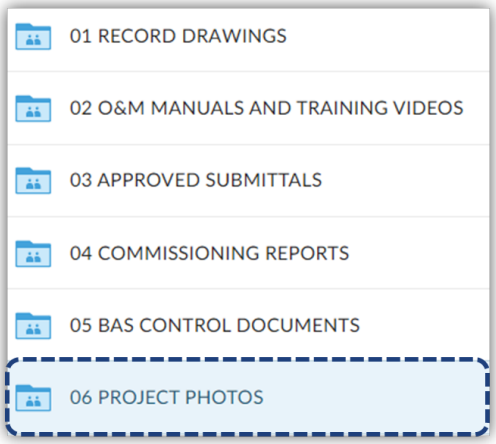
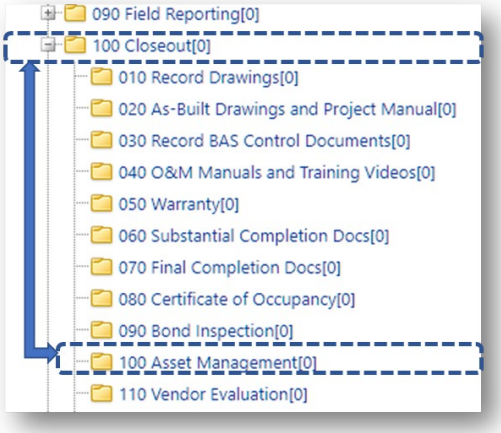
Name plate pictures MUST be legible! *The purpose of the picture is to allow PSU to read the name plate information related to a specific piece of equipment. If you can get both the Name Plate and the PSU Barcode in the same picture that is ideal.*

Assets that have a unique combination of asset type, manufacture, model, and serial number would be consider an "instance" of an asset. They would have a unique NP document and would use the "Equipment_ID" field identification as the "Equipment ID NCS" in the file naming convention.

Assets without a serial number, a common serial number, or agreed to by PSU as being grouped would be considered as a "type" NP. NP for a "type" of asset would use the "Mark" field identification as the "Equipment ID NCS" in the file naming convention.

NP are placed in the project close out folder as show in Figure 22 for the respective project.

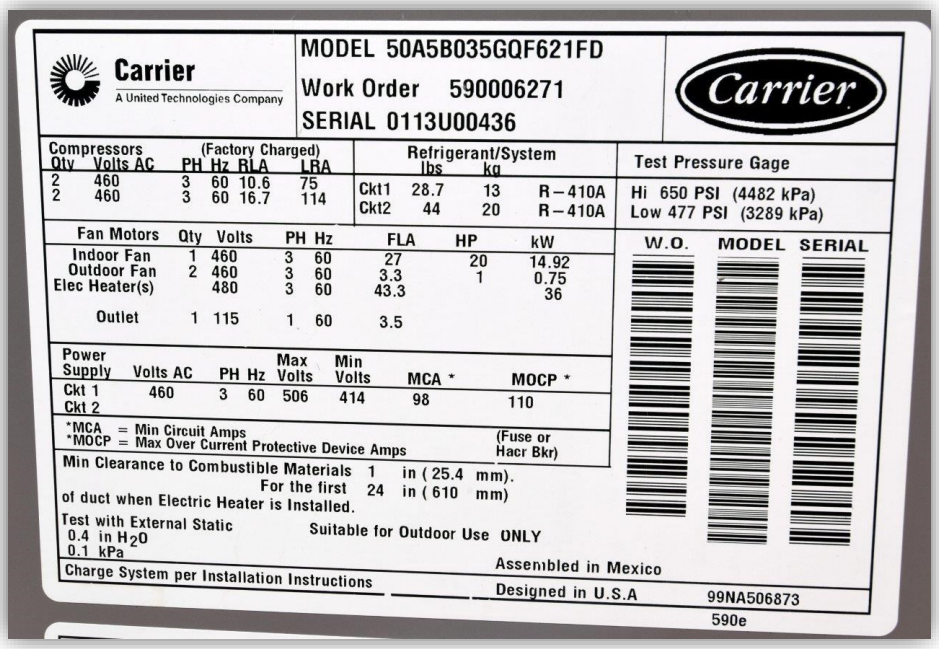
Figure 22: NP Closeout Folder Location

Projects using PSU BOX	Projects using PSU e-Builder
	

Name Plate Examples

Figure 23: Name Plate Examples (Good)

File Naming Convention & Upload Locations

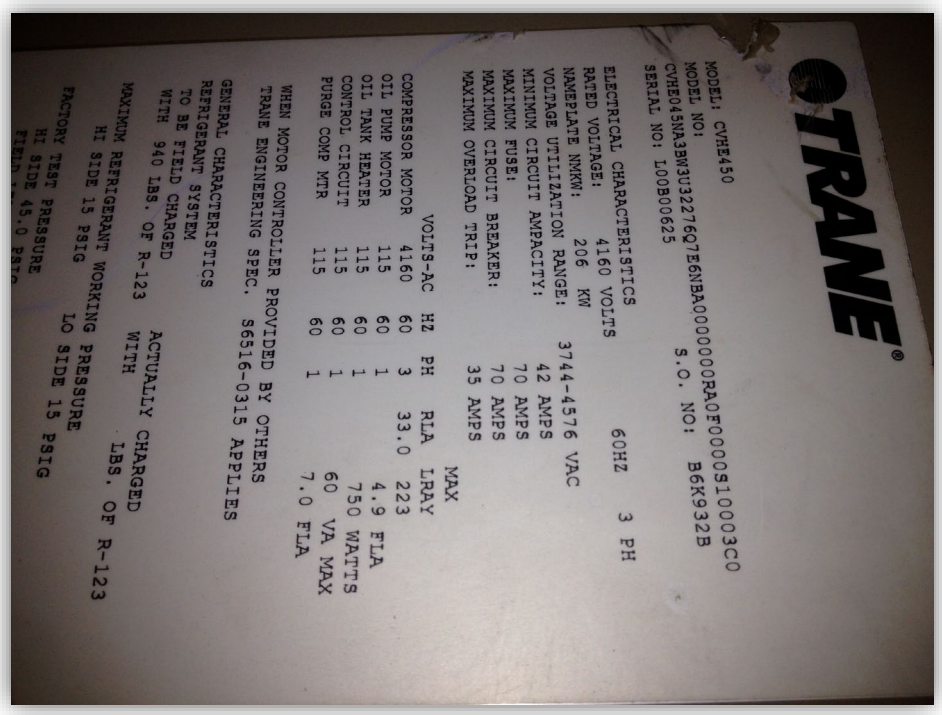


Name plate photos that do are not legible, cut off, or are not related to the specific piece of equipment are NOT acceptable. Figure 24: Name Plate Examples (Unacceptable)Figure 24 show example of name plate pictures that are not acceptable.

Figure 24: Name Plate Examples (Unacceptable)

File Naming Convention & Upload Locations

BAD: Illegible Text



BAD: Rotated Sideways, Angled vs Direct On, Cut off Data Set (incomplete)

BAD: Data illegible

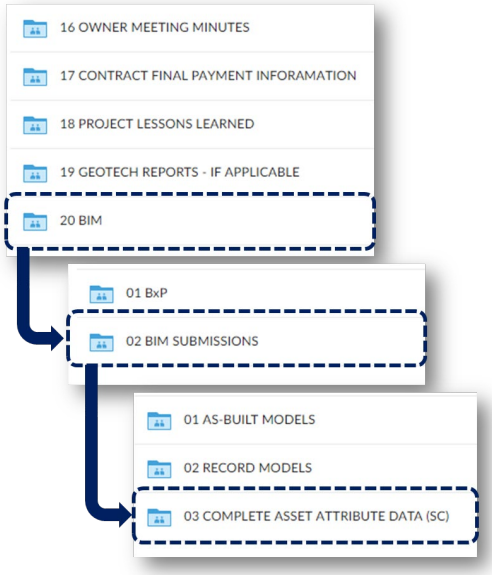
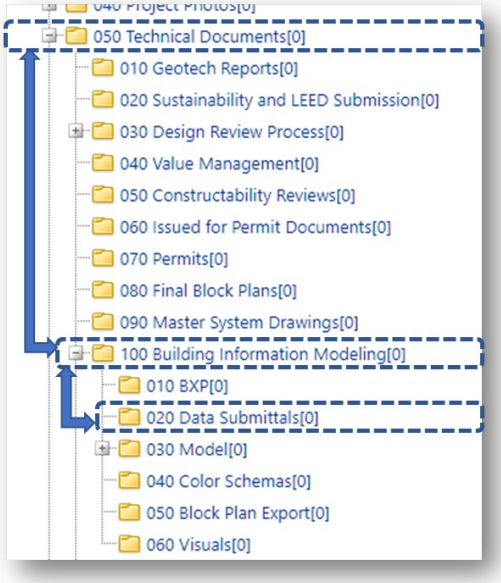
File Naming Convention & Upload Locations

Data File Location

The data file deliverables have no specified naming convention; however, it is recommended that a name be given that readily identifies the file and the as of date of the information enclosed. An example might be “Data Deliverable – MOC – 180327.xlsx”

Data Deliverables are placed in the project close out folder as show in Figure 25 for the respective project.

Figure 25: Data File Closeout Folder Location

Projects using PSU BOX	Projects using PSU e-Builder
	

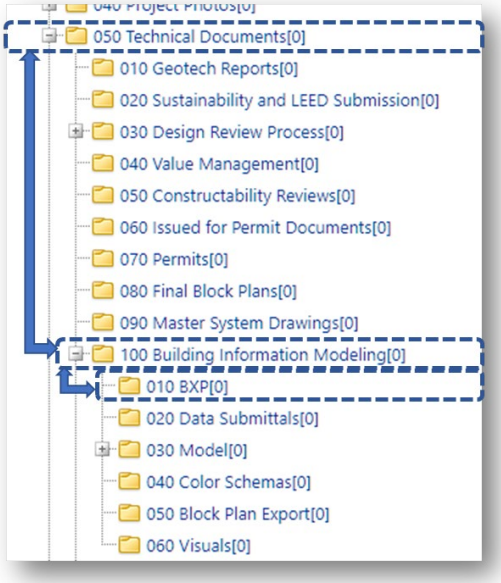
File Naming Convention & Upload Locations

BxP File Location

The BxP has no specified naming convention, however it is recommended that a name be given that readily identifies the file and the as of date of the information enclosed. An example might be “BxP - Mueller Lab - 180327-1100.docx”

The BxP is placed in the project close out folder as show in Figure 26 for the respective project.

Figure 26: BxP Closeout Folder Location

Projects using PSU BOX	Projects using PSU e-Builder
	

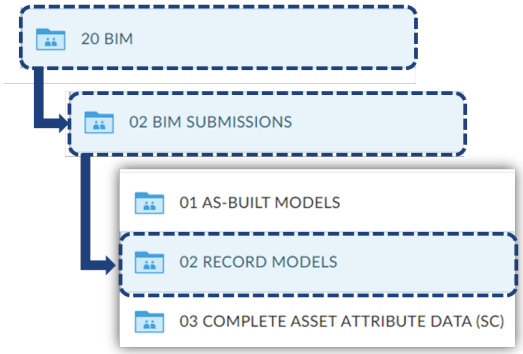
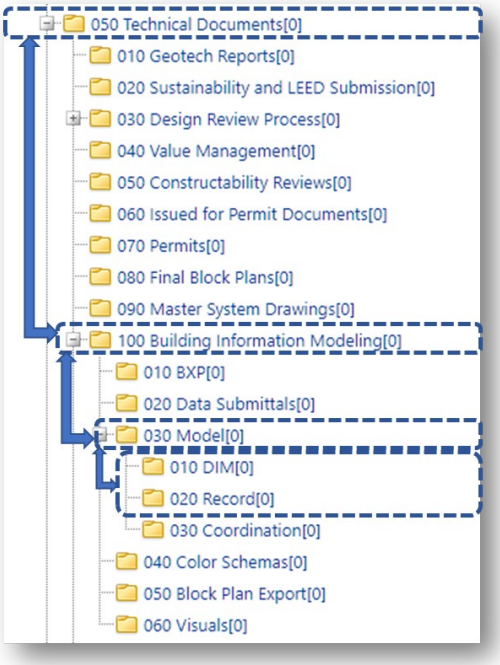
File Naming Convention & Upload Locations

Revit Model Files (DIM and Record) Location

The Design Intent Models (DIMs) and Record Models has no specified naming convention, however it is recommended that a name be given that readily identifies the file and the as of date of the information enclosed. An example might be “Mueller Lab - A - 180327-1100.rvt” and “Mueller Lab - S - 180327-1100.rvt”

The models are placed in the project close out folder as show in Figure 27 for the respective project.

Figure 27: Revit Model Files (DIM and Record) Closeout Folder Location

Projects using PSU BOX	Projects using PSU e-Builder
	

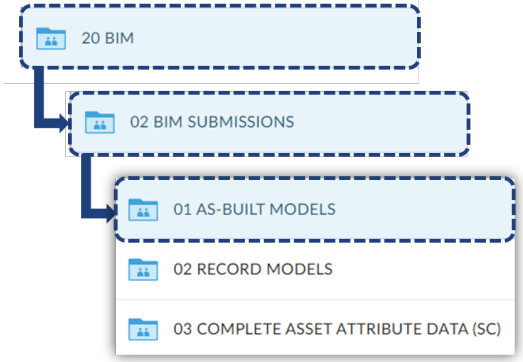
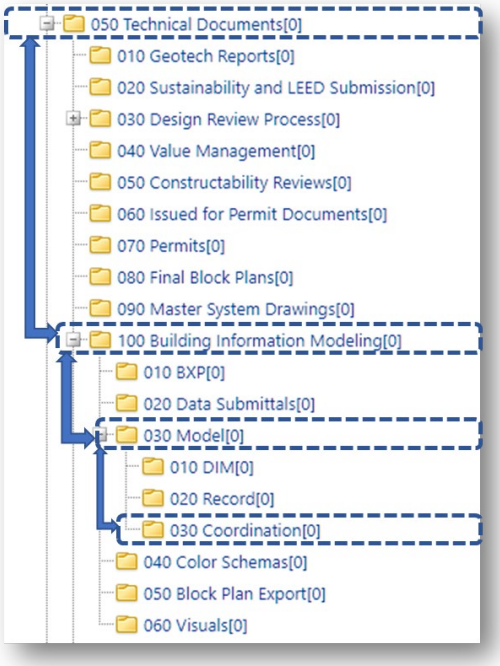
File Naming Convention & Upload Locations

Coordination Model Files Location

The Coordination Model and its respective source files have no specified naming convention; however, it is recommended that a name be given that readily identifies the file and the as of date of the information enclosed. An example might be “Mueller Lab - A - 180327-1100.nwd” “Mueller Lab - A - 180327-1100.rvt”, “Mueller Lab - S - 180327-1100.rvt”, and “Mueller Lab - C - 180327-1100.dwg”

The coordination file and its respective source files are placed in the project close out folder as show in Figure 28 for the respective project.

Figure 28: Coordination Model Files Closeout Folder Location

Projects using PSU BOX	Projects using PSU e-Builder
	

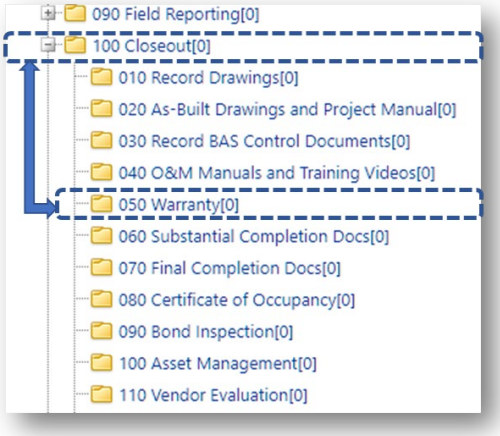
File Naming Convention & Upload Locations

Warranty Files Location

The asset warranty files are documents that certify the warranty start and stop for the respective assets.

The warranty files are placed in the project close out folder as show in Figure 29 for the respective project.

Figure 29: Warranty Files Closeout Folder Location

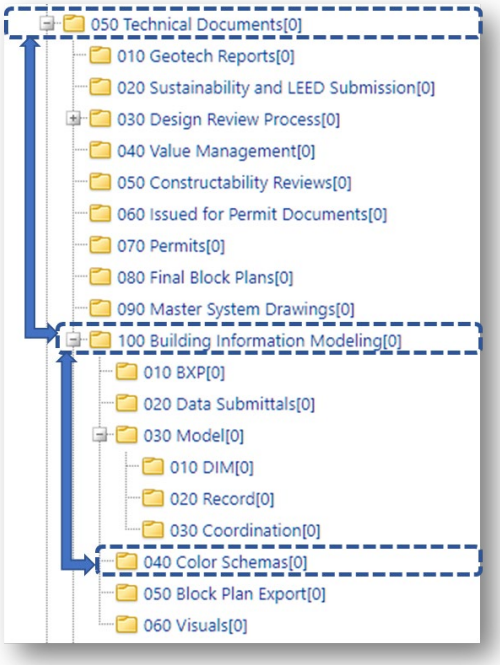
Projects using PSU BOX	Projects using PSU e-Builder
	

Color Schema Documents Location

The color schema documents identify various data attributes on a plan view document.

These files are placed in the project close out folder as show in Figure 30 for the respective project.

Figure 30: Color Schema Documents Folder Location

Projects using PSU BOX	Projects using PSU e-Builder
	

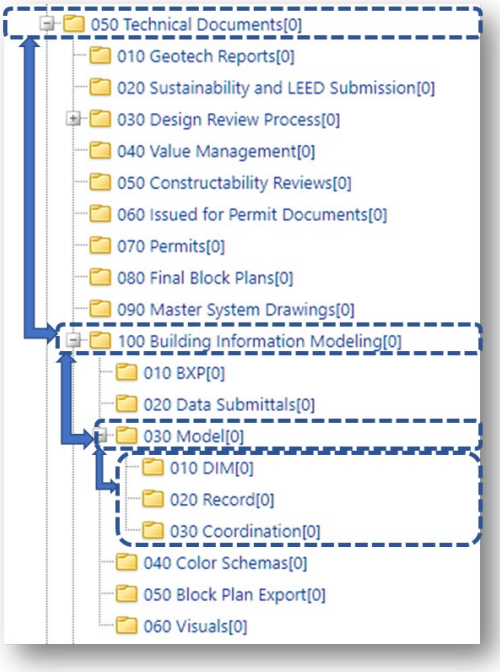
Clash/Interference Report Location

The clash/interference reports are the results of clash and interference resolution efforts conducted on a project.

These files are placed in the project close out folder as show in Figure 31 for the respective project. They are placed in the appropriate folder for the stage of the project effort. Typically

clash detection reports for design stage are placed in the “DIM’ related folder and ‘Coordination’ related folder for those conducted relative to construction coordination.

Figure 31: Clash/Interference Report Folder Location

Projects using PSU BOX	Projects using PSU e-Builder
	

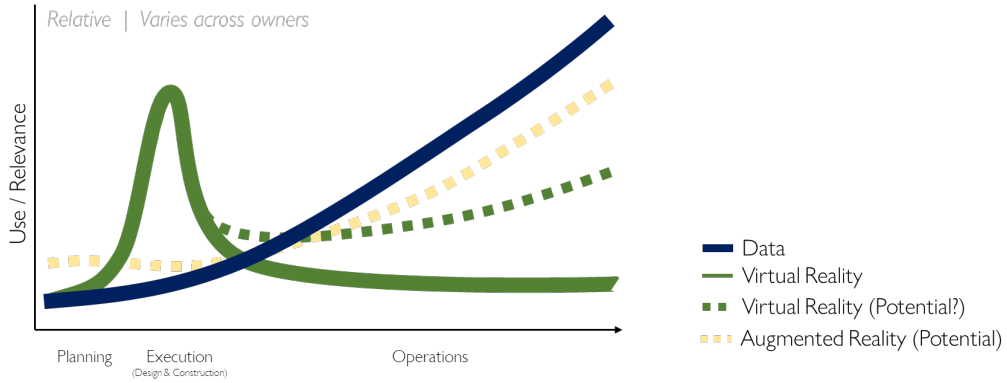
BIM Information

There are two main pillars of information exchange that make up the PSU OPP BIM objectives, visual and data. (See **Visualization** on page 60 and **Data Management** on page 67.)

Both yield significant value to the various members of the project delivery team (PDT). The intrinsic value of BIM visual components and data vary over time and based on use (see Figure 33). PSU OPP's current BIM objectives focus on the virtual visualization benefits of BIM tools during the execution phase and rely on the actual visualization of the built environment during operations, therefore the visual benefits of BIM diminish significantly post construction. However, the value of the data associated and gleaned from the model increase significantly as project moves into the operational phase of the life cycle.

Figure 32: BIM Information (Visual and Data Driven) (Source: [13])

Figure 33: BIM Information Value Across the Lifecycle (Source: [14])



Often much energy is focused on the management of data during the execution phase of the project, while the relevance of that data to operations is marginalized. The PSU OPP BIM requirements consider the relation of that data to the broader lifecycle perspective from a time (Figure 34) and cost (Figure 35) perspective.

Figure 34: Facility Lifecycle Perspective Relative to Time (Source: [15])

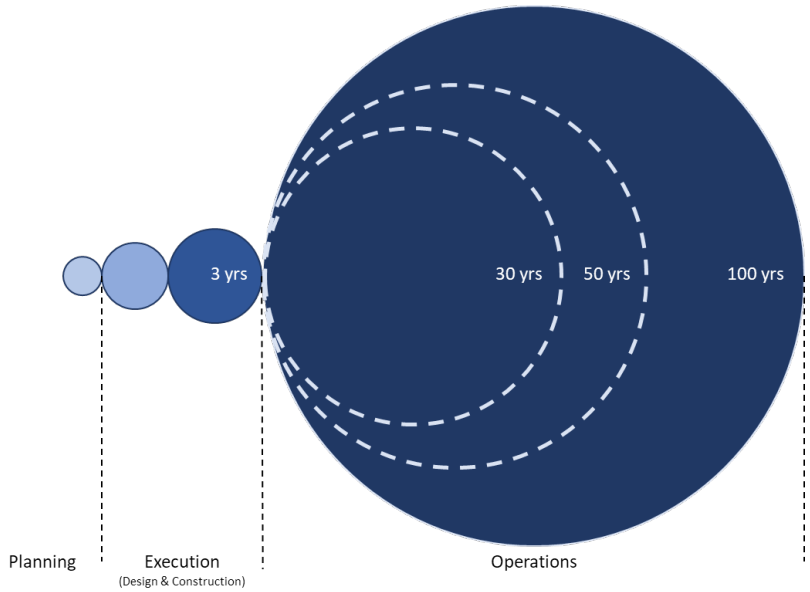
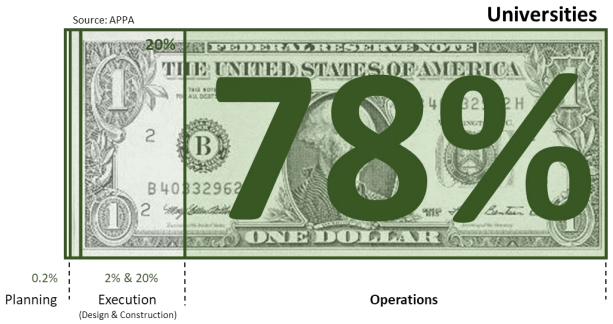


Figure 35: Facility Lifecycle Perspective Relative to Cost (Source: Adapted from [16, 17])



Revit Shared Parameter File

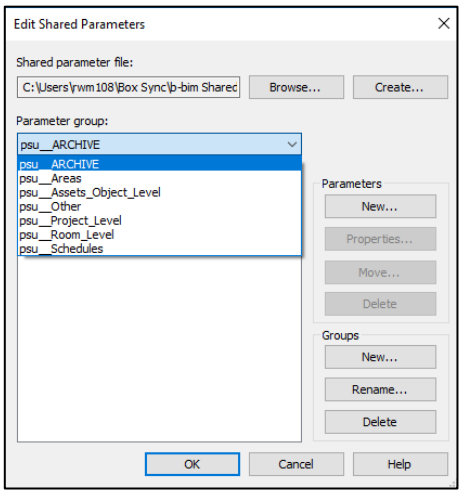
PSU OPP has provided a shared parameter file that aligns with the defined project, area, room, and object level attributes.

Since PSU OPP specifies Revit as the BIM tool, where ever an existing “out of the box” parameter exists it was used. Some exceptions to this exist at the project level where those “out of the box” parameters are typically used by designers and builders for tracking data that does not align with PSU’s intended use (e.g. the “Project Number” field is often used by the design firm for their internal project number, which is different than the PSU project number). Where an “out of the box” parameter does not exist in Revit the PSU defined attribute is given the “psu__” prefix as the formal parameter name. As an example, the object attribute “Actuated” has the parameter name “psu__Actuate” within Revit and the shared parameter file.

The parameters are grouped by intended usage within the Revit file. The following shared parameter groupings are used:

- psu__Project_Level (parameters that are associated at the project level)
- psu__Areas (parameters that are associated with areas)
- psu__Room_Level (parameters that are associated at the room level)
- psu__Assets_Object_Level (parameters that are associated at the object level)
- psu__Other (parameters that are associated with multiple levels)
- psu__Schedules (parameters that are specific to projects)
- psu__ARCHIVE (is meant for holding parameters that are archived and no longer used over time)

Figure 36: PSU OPP Shared Parameter Groups (Source [18])



Changing / Repurposing Parameters

Parameters should **NEVER** be repurposed on a project beyond their defined use. The exchange of data on a specific project is import, but it also ties into a broader enterprise integration of data that PSU OPP is building. Each parameter has a specific definition and a unique GUID associated with it. That GUID facilitates the linking of information across multiple data sets to the parameter and definition of what that data field represents.

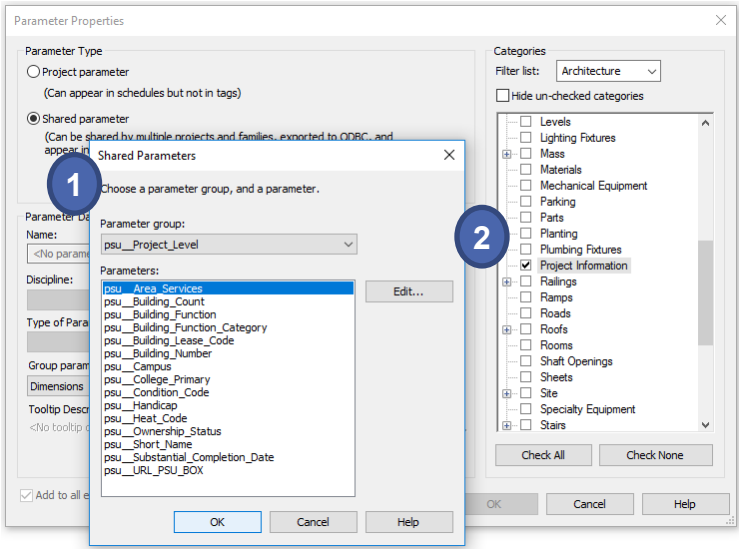
If an existing parameter is no longer needed as defined it should be archived. This retires the GUID without confusing the meaning of the data from one project to another and inadvertently causing conflicts in the PSU OPP enterprise data systems.

Using the Shared Parameter File

The shared parameter file is a Revit compatible configuration text file for shared parameters. There are multiple advantages to using share parameter files. When the shared parameter file is brought into your Revit project you can associate the parameters with various elements of the Revit file. While you can technically associate the parameter with any or multiple categories of elements in Revit, as described earlier the parameters are categorized by intended use within the model.

As an example, if you do not already have the shared parameters associated with your Revit project, you can set up the “psu__Project_Level” parameters with the “Project Information” category in Revit. (see Figure 37 and Figure 38)

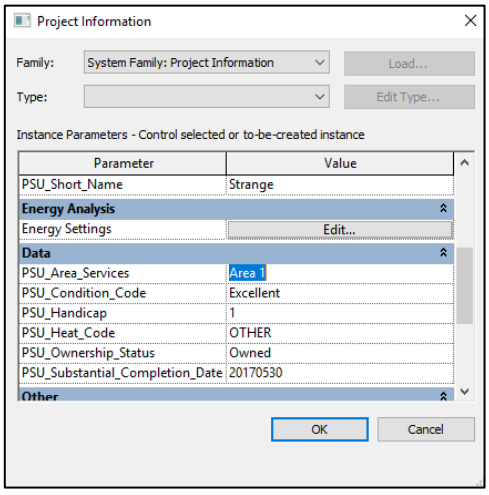
Figure 37: Associating Project Level Shared Parameter with the Project Information Category (Source: [18])



1 The psu_Project_Level group is selected
2 The parameter will be associated with the Project Information category

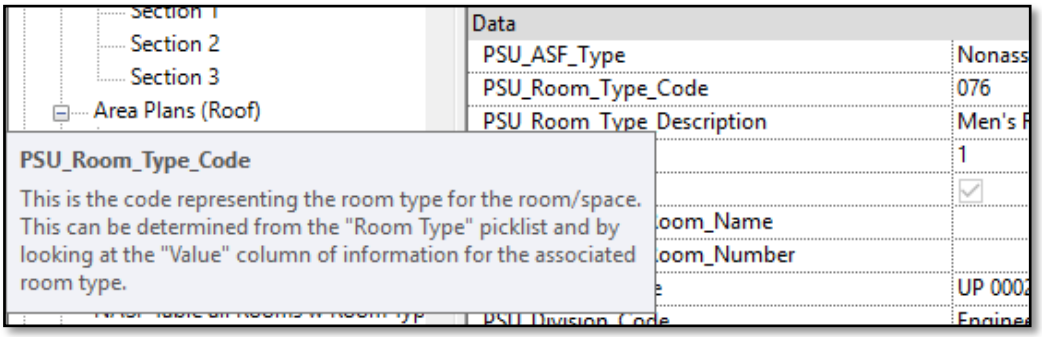
Once established in your project and associated with the Project Information category you will see the parameter available for use in your project information. Project level information is particularly important, because it allows you to associate this parameter with all areas, rooms, and objects within that project. So, for project level information you would be able associate the information with all exported assets by filling it out once rather than within each asset property set.

Figure 38: Parameter associated with the Project Information (Source: [18])



Note that the shared parameter file also has the advantage of providing the same description for the parameter as defined in the PSU OPP attribute definition table when hovered over in Revit properties. (see Figure 39)

Figure 39: Shared Parameter Definitions (Source: [18])



Visualization

Visualization is a key component of the AEC industry and critical to allow all parties to conceptualize the same understanding of the project intent, provide spatial awareness and context, and understand various environmental relationships. Additionally, PSU use visualization to enhance marketing related to potential donors, fundraising, and recruitment.

Methods

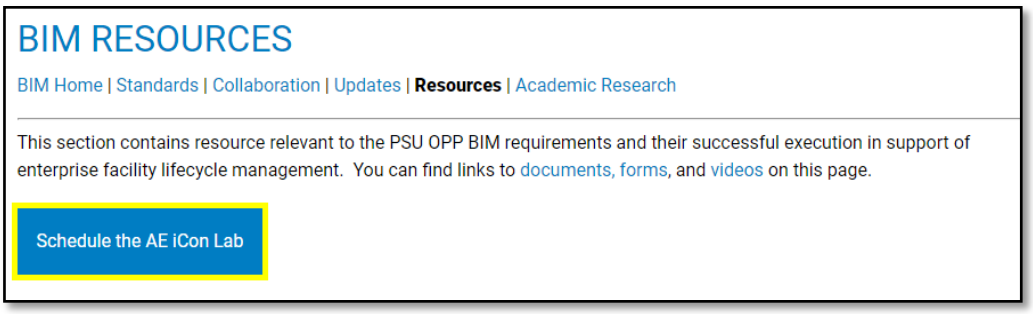
There are multiple methods to get the visual information across. The BIM Addendum provides the following types of methods.

- Static Renderings
- Static Pre-recorded animation fly throughs
- Dynamic Navigation (Desk side)
- Dynamic Partial Immersion (PSU AE ICON Lab)
- Dynamic Full Immersion (VR Head Mounted Displays a.k.a Goggles)
- Dynamic Full Immersion (PSU ARL CAVE)
- Dynamic Augmented Reality

Scheduling the PSU AE iCon Lab

The iCon lab must be scheduled in advance of the meeting and use. The use of the lab must be schedule with the PSU Department of Architectural Engineering (AE). Scheduling is available through email coordination. A template email is available on the www.bim.opp.psu.edu website (see “Resources”).

Figure 40: Scheduling the AE iCon Lab (Source: OPP BIM Pages)



Typical Costs Associated with the iCon Lab

The typical cost of using the PSU AE Department iCon Lab is $3500 per 1.5 days of use support. This includes loading the model(s) to be used in the meeting ahead of meeting, an

individual to drive the model during the meeting (typically an AE graduate student), and the meeting time itself.

These funds are used to refresh hardware and software in the iCon lab by the AE department.

Note that if the project does not have the required funding, the AE department, on a case by case basis, may make exceptions to the associated fee. Exceptions should be handled by directly contacting the AE department CIC Director.

Quality

Visualization comes in degrees of realism. In many cases the benefits gained from photorealistic rendering does not justify the current costs of developing them. Lesser degrees of realism or rendering granularity and accuracy often provide enough to allow the team to fully understand the situation, glean the information needed, and provide decisions. The BIM Addendum provides the following types of quality related to realism in increasing order of accuracy and cost to develop.

- Geometrical realism (material and color not accurate)
- Relative realism (colors relatively accurate, but material/texture not accurate)
- Photo Realistic

Visualization Support of PSU Project Approval Process

The project design deliverables requirement includes various visual deliverables associated with the project approval process. While not part of the BIM addendum this requirement is typically derived in part or in whole from the project BIM(s).

These requirements are part of certain projects and occur during the schematic (or its equivalent) phase of a project design. The contractual requirements can be found at: https://wikispaces.psu.edu/display/OPPDCS/01+01+00+PROJECT+DOCUMENT+FORMAT#id-010100PROJECTDOCUMENTFORMAT-010102OwnerReview. It is recommended that you refer to this link for details of the current requirement.

*Note that there is also a data requirement associated with the PSU Project Approval Process. (See **Project Approval** Data Requirements on page 68)*

Visualization Support for Project Approval – Summary

The following images demonstrate 2D and 3D visualizations needed to support the PSU project approval process. These support the project approval processes that are facilitated using various visual representations and aids. These generally include the following:

- Site Plans (e.g. Figure 41, Figure 42)
- Floor Plans (e.g. Figure 43)
- Static Renderings – Interior and Exterior (e.g. Figure 44, Figure 45)

The samples below are a representation of previous projects visualizations aids that have been effective in the approval process. These visualizations are meant to help senior decision makers understand the basics of the project, the scope, the mission support, and the benefits/impact to Penn State.

Each project will be unique, however the themes presented in the following images can be used to understand reasonable expectations.

Figure 41: Project Site Context Plan (Source: [19])

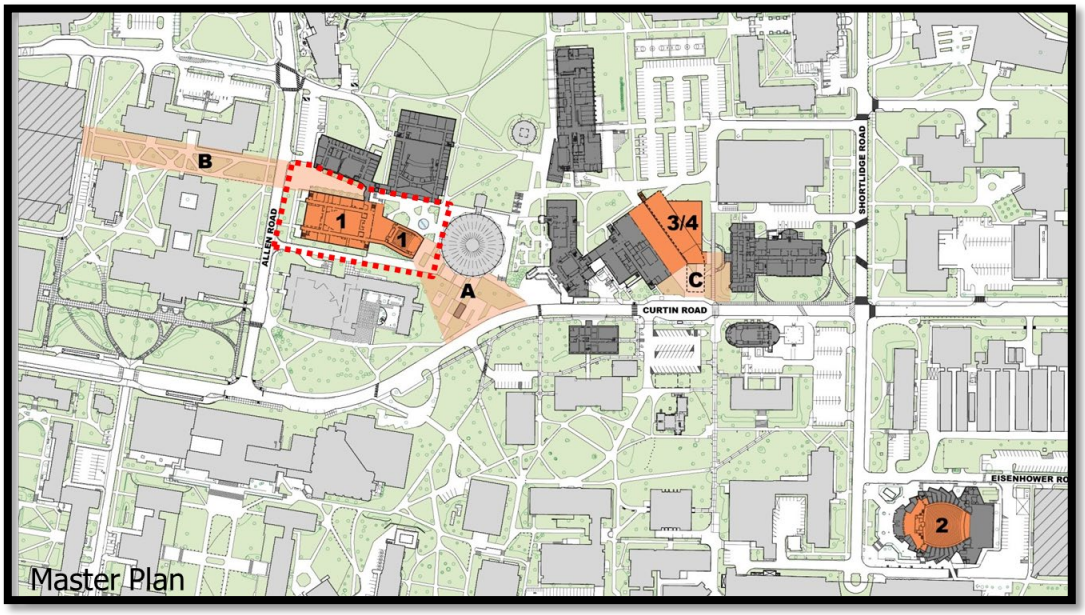


Figure 42: Project Site Plan Visualization (Source: [19])

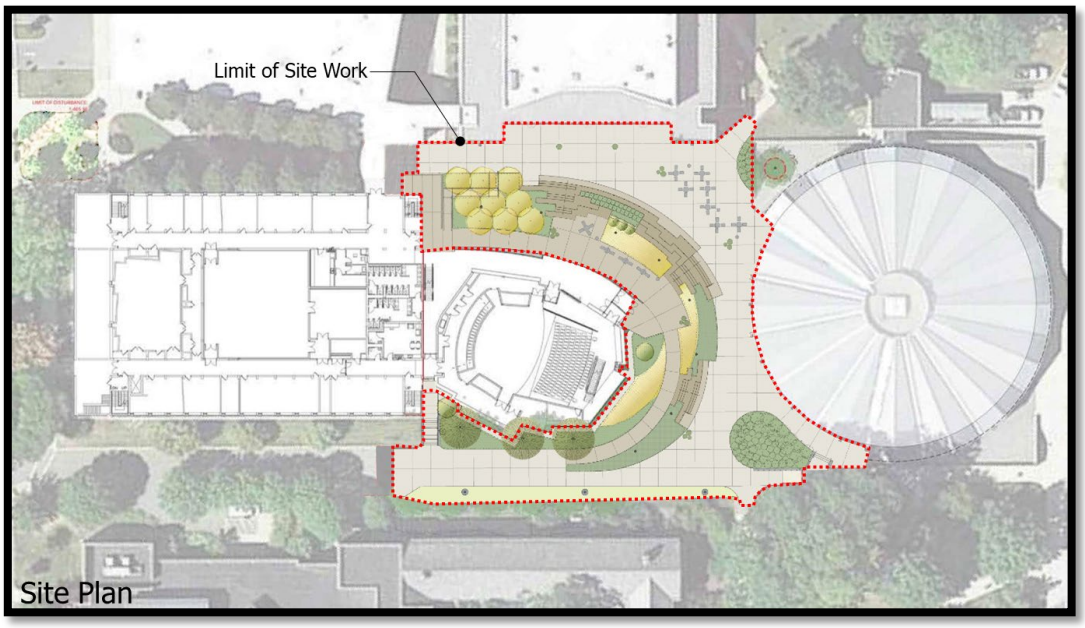
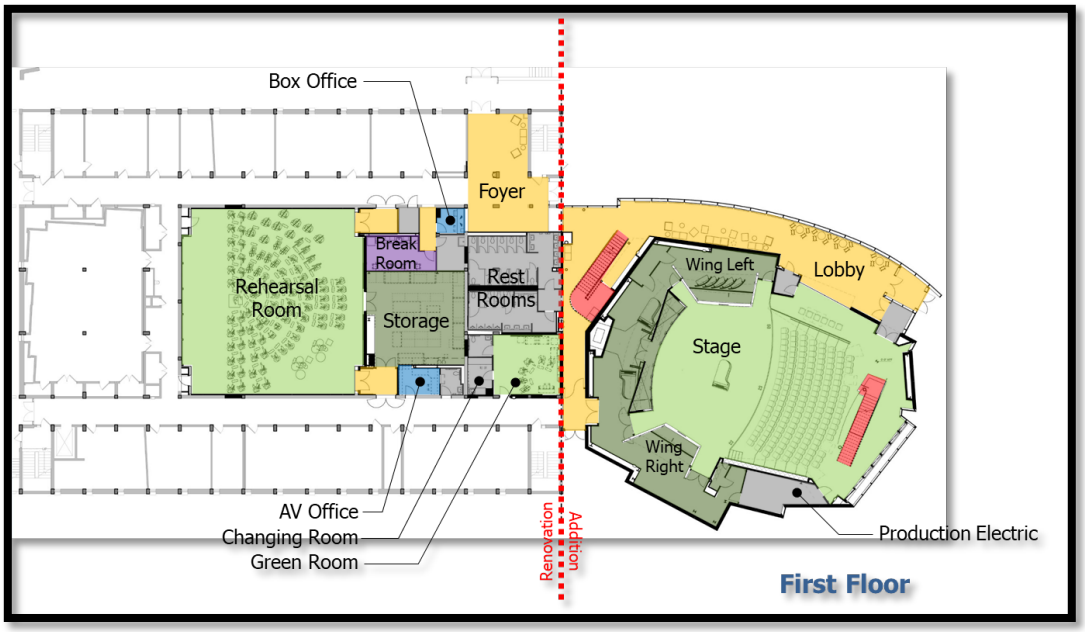


Figure 43: Project Major Components & Demarcation between New (Addition) and Renovation (Source: [19])



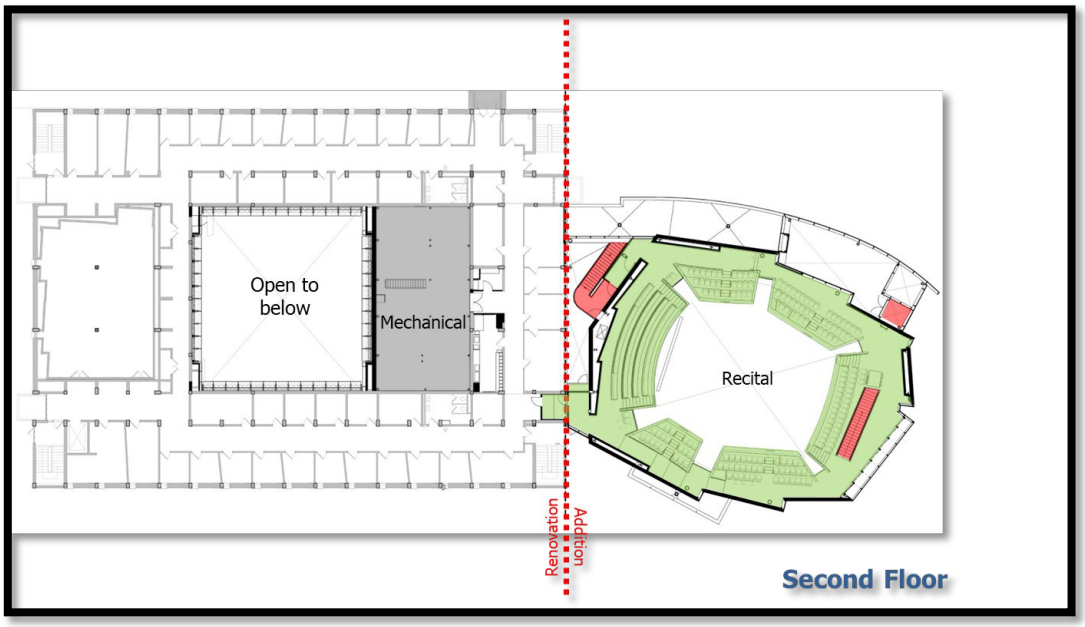


Figure 44: Project Static Renderings Interior Significant Spaces (Source: [19])

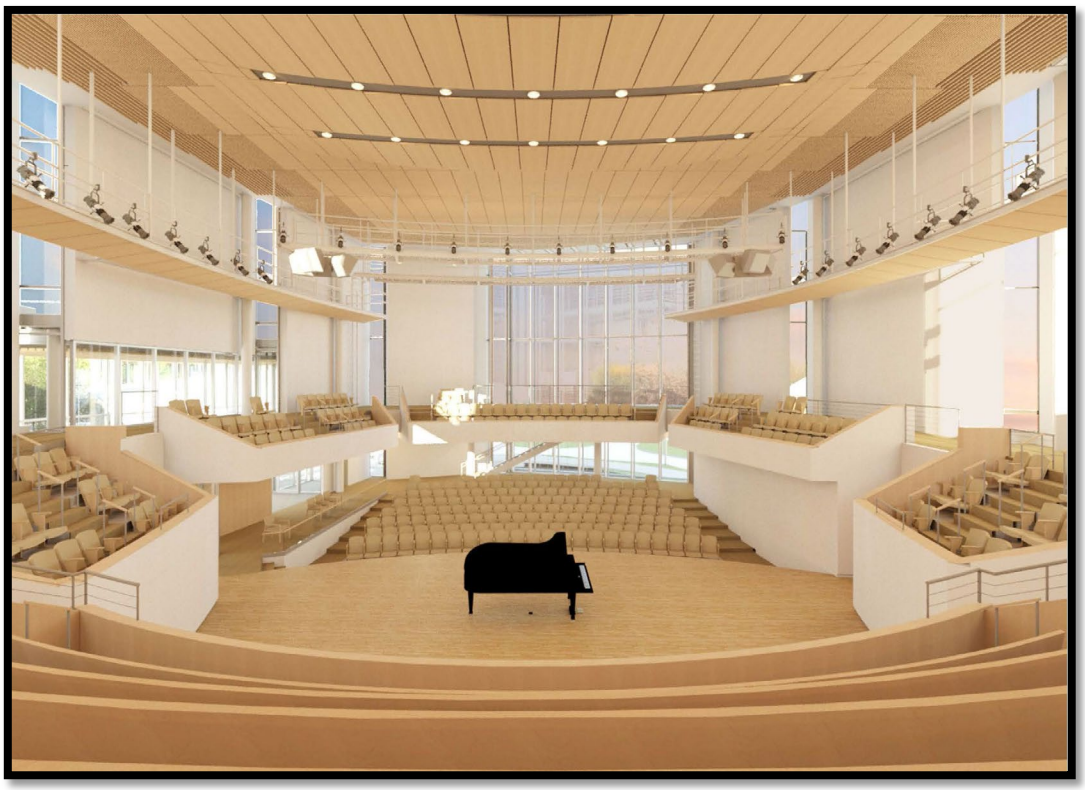


Figure 45: Project Static Renderings Exterior Significant Views (Source: [19])

Data Management

Data which is the foundation of accurate information about a project is one of two key pillars of "I" (Information) in the BIM. This section details various aspects of the data related requirements with the BIM addendum.

There are benefits of the data across all aspects of the lifecycle to include more effective sharing of common data during the execution (design and construction) phase of a project. Additionally, there are considerable operational information needed that is often generated and tracked during execution. The BIM addendum requirements specify data management requirements that integrate many of PSU's project related data needs, the formatting for that data, and the means of handoff to PSU.

Considerable effort by PSU OPP was made to (1) clarify the data requirements, and (2) consolidate the requirements. Changes occur over time related leadership priority shifts, regulatory requirements, industry process improvement, and lessons learned. However, the effort in the updates brings together many data requirements that need to be met during execution and transitioning the project effectively from execution (design and construction) to operations.

Data Requirements

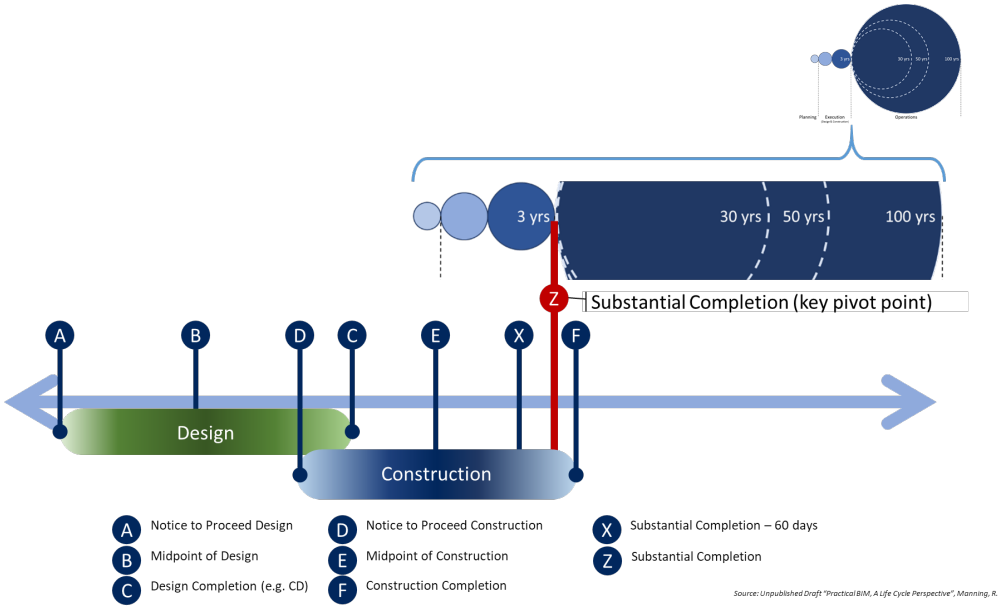
PSU has multiple data requirements when bringing an individual project into the operational enterprise. These data requirements, and their respective deliverables, are defined in the BIM addendum. They support many different systems across PSU. The requirement is established to provide a consistent deliverable with simple format requirements. These data requirements represent some of the most important elements of the project deliverable to allow effective operational success (see the discussion in the **BIM Information** and **BIM Objectives** sections for insight into the importance of asset information to the overall facilities life cycle).

The data requirements are not a singular event at the end of the of the project. Project data supports many parties (both internal and external to PSU) across the project life cycle. Figure 46 provides an overview of some key points in the project to which the data requirements are tied. The BIM addendum requirements include incremental data collection efforts that achieve to basic functions of (1) ensuring the team is effectively progressing through interim data deliverables towards (2) final data deliverables that occur at key points during the execution effort.

A key component of the data effort is appropriate quality control (QC) and quality assurance (QA). Details on the QC/QA approach, process and expectations are further discussed in the

Project Quality Control & Quality Assurance section of this document. The BIM addendum defines the QC/QA requirements for the project data deliverables.

Figure 46: Project Data Deliverables Across the Project Life Cycle (Source: [12])



Interim Data Deliverables

Interim data deliverables are essentially progress checks to ensure the team is on track to meet specified final data deliverables with the appropriate accuracy and on time. Interim data deliverables are not expected to be complete or without error. However, they are expected to demonstrate a progressive effort that will result in a success final data deliverable.

Final Data Deliverables

Final data deliverables are data deliverables that occur at key points of the project and will be used to facilitate PSU loading of operational data bases, provide key snapshots in time related the project status, and inform PSU operational planning and programmatic funding requests.

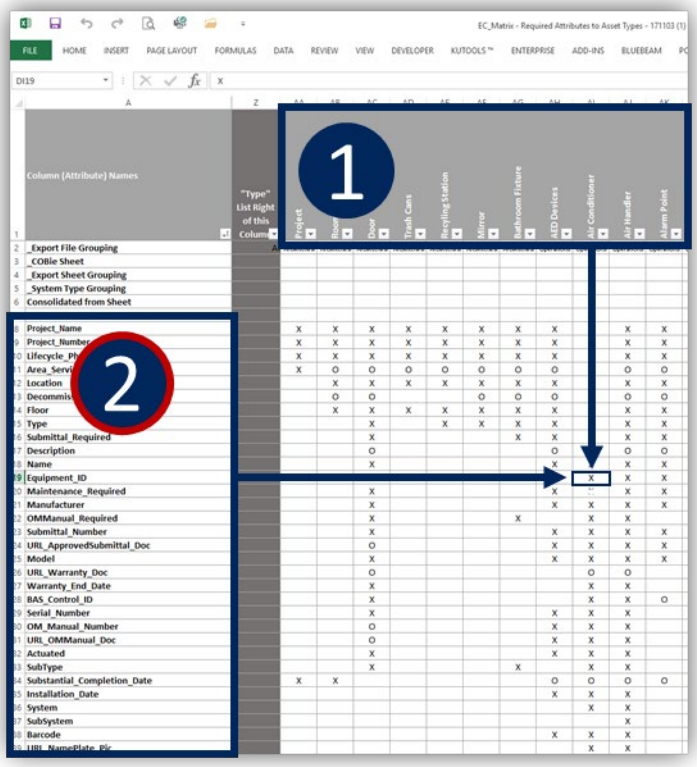
Project Approval Data Requirements

Some projects require senior leadership approval. These projects have both visual and project data requirements. Most of the project data requirement is derivable from the project BIM(s). The project BIM team should be cognizant of these requirements to facilitate needed support to the design and PSU project manager. These data requirements are defined in the same document used to define the **Visualization Support of PSU Project Approval** Process (see page 61).

Asset Attribute Matrix File

The “Matrix” identifies the types of assets PSU needs information on and the information about those types of assets that is needed. This is most simply summarized as ❶ assets and ❷ information about assets. Depending on the physical location or the project and database receiving project data the terminology can vary, so for simplification ❶ “types” and “sub-types” to group the assets is used; and ❷ “attributes” is used to define the information about those assets that is being collected. (See Figure 47) As an example if the data is going into Maximo the equivalent of “type” is “classification” and “information” or “attributes” related to the asset is “specifications.” To relieve the contractors from needing tracking specific terminology for each system PSU uses, the BIM requirements use a common vocabulary regardless of database system (in most cases it is multiple database systems).

Figure 47: Asset Attribute Matrix (Source: [12])



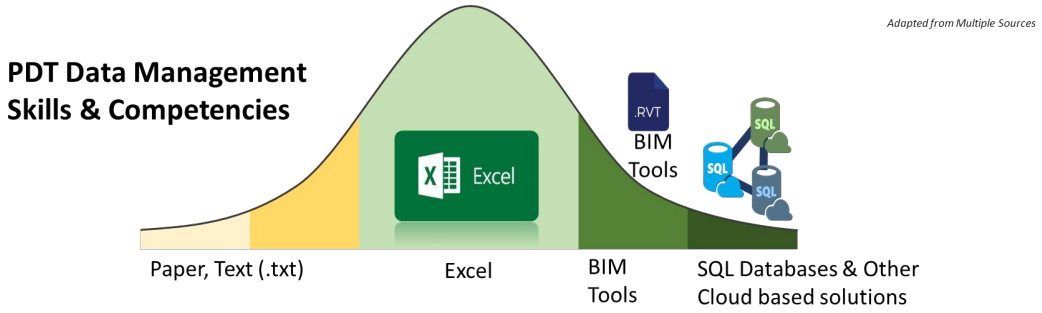
The assets can be grouped into two types of categories (1) space and (2) equipment. Both the building/structure itself and the individual pieces of equipment in the building/structure are assets to PSU. Much of the focus is on equipment, but there are elements (such as “rooms”) that are also considered assets as part of the physical building/structure.

The use of excel as a basis for simple data format exchange allows many diverse applications and approaches from all PDT members involved across multiple projects.

ExcelConsolidor © Matrix Format

The Matrix is formatted as a configuration file for use with ExcelConsolidator © (www.excelconsolidator.com). This allows multiple data exchanges using Microsoft Excel ©, and supports the consolidation of individual Excel files into a singular Excel sheet meeting the PSU data deliverable format requirements. There are many different tools that can be used, however PSU uses to address the reality that while a wide spectrum of data management skills exists, most PDT members (internal and external) involved in the process fall in the Excel © skills set. (see Figure 48)

Figure 48: Typical Data Management Tool Skills (Source: [12])



Building solutions that effectively and efficiently work around Excel provide the wideness net for common solutions and processes for both BIM and Non-BIM projects. More importantly maximize buy-in / adoption and enterprise success. This allows a broader spectrum of vendors/contractors (designers, builders, consultants, suppliers, etc.) to understand and succeed. At the same time, we are working to pull the AEC industry into more advanced data management awareness and skill sets.

Type vs Instance Data Deliverables

In most cases, assets are provided in the required data deliverable on a per instance basis. There are exceptions when an asset can be provided as a type with the “Count” parameter representing the total assets of that type.

Note:

1. *It is strongly recommended that you review your list of asset types that you intend to provide in the data deliverable is reviewed early with the PSU BIMteam representative.*
2. *Asset types that will be delivered in the data deliverable as a type should be identified specifically by type in the BxP for the project.*

Rules of Thumb for Asset Type Delivery Instead of Instance

You can always provide assets by instance even if the information is identical for all related attributes associated with the asset type.

Asset data is delivered as a row of data. So, if a specific asset type has 15 attributes, then those 15 attributes must be the same exact information to report it as a single line of data (type vs instance). In rare cases (example lighting fixtures) where a single unique field (e.g. location) exists it can be generalized or concatenated to deliver the asset as a "type" (single row of data). If the data is being derived from the model to establish the count in the first place, it often is easier to just provide the data as an instance.

The following are general rules of thumb that can be used to consider which assets can be delivered as a type with the appropriate count versus by instance. If any of these characteristics are not met, it should be assumed that the asset is delivered as an instance. The following characteristics generally apply:

1. They are the same manufacture and model,
2. They do not have unique serial numbers that are being tracked.
3. They do not have unique barcodes that are being tracked (by default assets that require a PSU barcode must be reported/tracked by instance),
4. They do not have individual approved submittals (AS) or OM manuals for the instance of that asset type (meaning it is the same type, but within that type there are unique AS or OM documents associated with certain instances of that type),
5. The asset location (example Room 101) is not relevant to the asset from a maintenance or tracking perspective,
6. The instances of that type of asset do not have unique BAS control point IDs (assuming a BAS control ID attribute applies to that asset).

Examples:

- Lighting fixture types can be reported as a type with a total count.
- Lavatory Fixtures can be by types provided they meet the above rules.

Parent / Child Asset Relationship

The BIM Addendum requirements and associated asset attribute requirements provide for two ways to address assets with components that are themselves an asset type (e.g. fans, motors). These types of relationships are referred to as a parent/child relationship.

- Scenario one is where the parent and child asset are reported as one row of data with the parent asset (example FCU) being the "Equipment_ID" for the asset, and the component (e.g. fan and/or motor) information being attribute fields of that parent asset.
- Scenario two is where the parent asset is report as a individual asset (read as row of data) and the component (child) asset is also reported as an individual asset. This child asset uses the "Associated_Asset" attribute to identify the parent asset. As an example, if the "Equipment_ID" for AHU number 1 is "AHU-01", and there are two fans each with their own motor, then you would report five assets (read as rows of data). The fans would be listed separately (again read as rows of data) with the "Associated_Asset" attribute being "AHU-01" as the parent. Likewise, the fans' (e.g. FAN-01, FAN-01) "Equipment_ID" would be used when listing the motors as individual assets and identifying their "Associated_Asset" parent.

The parent/child approach allows the asset information to be reported as individual lines of data while identifying the parent asset (or associate asset). This approach accommodates situations where there is not a "one to one" relationship of assets. Some assets when listed individually (e.g. motor) will always have parent, while others (e.g. fan) may have a parent or it may not.

Barcode vs Tags vs QR Codes vs Equipment_ID vs Asset ID

Barcodes and tags are used to identify various assets. The following provides a basic differentiation between barcodes and tags. It is important to understand that barcodes, tags, Asset ID, and "Equipment_ID" are not necessarily the same (almost always are not the same).

Equipment_ID

The "Equipment_ID" is established in the design process. If the "Equipment_ID" is intended to match either (or both) the barcode or equipment tag, this coordination needs to occur very early in the design process and should be defined in the BxP so BIM PDT members understand the expectation for data coronation. The barcode is typically randomly assigned (unless QR codes are used).

The "Equipment_ID" is used in the BIM process to uniquely identify the objects using the parameter. It used as a primary key and provides a means to link internal BIM assets and external associated data for the object. The proper use of this parameter allows type, instance or combinations of type and instance information association when used properly. It is also used by PSU OPP as means to associate selected documents with the assets (see the **File Naming Convention & Upload Locations** section on page 30).

Asset ID

The asset identification (Asset ID) number is a unique number or alpha-numeric ID that is used by PSU OPP to identify the asset in the CMMS (e.g. Maximo). While the "Equipment_ID" and

"Asset ID" can match, they often do not and are used for different purposes. The Asset ID is typically identified or assigned downstream of the design process and towards the end of the construction process.

The Asset ID typically is the number or alphanumeric shown used on the barcode or QR code.

Barcodes

The asset matrix identifies assets that require barcodes. "Barcodes" is the field used to represent the unique machine-readable alpha-numeric identification. PSU OPP barcodes are most commonly a machine-readable numeric sticker that is affixed to the individual piece of equipment and represent an "instance". (see Figure 49) Barcodes are typically supplied by PSU OPP to the contractor to affix to the respective assets (aka pieces of equipment) and recorded with the asset data requirement.

Figure 49: PSU OPP Barcode (Source: NA)

Note: Typically, assets that are children of a parent asset don't have a separate PSU OPP barcode. Consult PSU operations if you are unclear wither a barcode is required for a child component.

Tags (Equipment, Valve, etc.)

Tags required by PSU OPP come in various forms. They can be manufacturer applied tags, custom label tags affixed to the asset (see Figure 50), or chain and tags (see Figure 51) attached to valves, traps, etc.

There are no known enterprise wide tagging requirements for PSU OPP. Tagging requirements by contractors is project specific.

Steam trap tags are attached by PSU OPP.

Figure 50: Panel Tag (Source: NA)

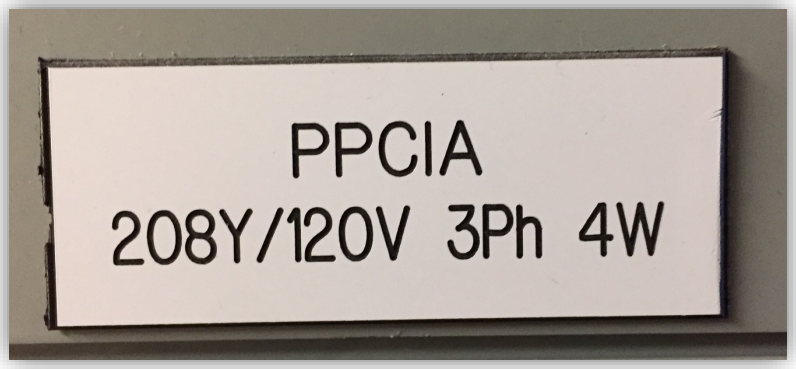


Figure 51: Valve Tag (Source: NA)

Figure 52: Steam Trap Tag (Source: NA)

QR Codes

PSU OPP is currently testing the implementation of QR codes. There are no established enterprise requirements for QR codes on projects. If QR codes are being applied to a specific project this adds an additional layer of data awareness and management as the QR codes are often unique to a specific asset. In such cases the QR code must be affixed to the correct instance of the asset and the data associated may be much more detailed. Figure 53 show one generic example of a QR code.

It is also important to note that the QR codes that PSU OPP is testing include a passive RFID component which will include some basic information that is readable by an active RFID reader in near proximity to the tag. PDT members need to be aware of these capabilities if applied as data synchronization between visible QR code, RFID embedded data, and BIM or data deliverable is critical.

Figure 53: QR Codes (Source: NA)

If QR codes are being used on a project the BxP should clearly identify how the management of the associated data, tracking and integration with the model will be handled.

Data Synchronization

A primary benefit of BIM is the ability to synchronize data across the various PDT members and the project life cycle stages. It is important to understand this intent and ensure proper measures are taken to achieve data synchronization.

Data synchronization means that the information associated or identifying various elements of the design and physical project and its respective assets matches. Multiple studies indicate the amount of waste incurred by a project due to erroneous or conflicting data. Proper data management will significantly reduce or eliminate these costly errors and confusion.

Deliverables

This section provides insights and examples of what “good” looks like relative to the stated deliverables, their respective due dates, and insights as to why PSU cares about the deliverable.

Link to Invoicing

PSU has had some historical problems with deliverable completeness, accuracy, and timeliness. To solve this problem two things have been done (1) PSU has better defined the requirements and their due dates, and (2) we have tied certain deliverables to the invoicing process.

The BIM requirement linkage to invoicing does not affect the total amount payable on the contract. If a contractor performs the work and provides the deliverables in the time frame that was contractually agreed to in the contract award, BIM will have no effect on the project payments. However, if the contractor does not complete the specified BIM deliverables in the time frames required to the level of quality specified it will delay payment. This is because the invoice will not be accepted due to incompleteness of or non-compliance of the work required up to that point.

Keep in mind the earlier discussion about the **BIM Objectives** (see page 5) and why PSU is specifying BIM requirements in the first place. It is tied directly to objectives that affect PSU’s ability to successfully manage the facility life cycle.

Record Model(s)

Record model(s) are a primary deliverable. They typically are incremental updates to the final DIM by the design team during the construction effort based on feedback from the field, change orders, etc. reflecting as-built conditions at the designated LOD for the record model elements.

The Record Model(s) are typically one of the last BIM deliverables. They are used by the owner for follow on projects and operational management objectives.

Except for certain portions of civil design, these models are in Revit. Refer to the BIM Addendum for specific contractual deliverables and time lines.

Coordination Model (CM) or Construction Coordination Model (CCM)

Coordination models are very important to the construction process to validated anticipated means and methods, trade sequencing and eliminate risks associated with construction, ensure the design intent is built and maintability is both feasible and practical.

These models are the Navisworks files and associated source files. PSU requires two specific Navisworks file formats be delivered **with all associated source files**. NWC files formats are not required.

- **NWD** file format is a self-sufficient file that represents a snapshot of the CM at a given point in time.
- **NWF** file is the 'editable' Navisworks file and requires either the NWC or source files to be of practical use.

Source files are any files in their native format that are used in Navisworks. This can include Revit, other BIM formatted files (e.g. Tekla) various 3D CAD formats, point clouds, etc. that are used as part of the construction coordination process (clash detection, trade sequencing, estimating, etc.) in Navisworks.

Refer to the BIM Addendum for specific contractual deliverables and time lines.

Data Set

The PSU OPP BIM Addendum has specific requirements for the data deliverable. It is not a singular deliverable or effort. Rather it is a data deliverable that occurs multiple times throughout the life of execution (design and construction) and is incrementally more accurate in its data and data quality.

This is one of most important long-term deliverables. The data and its accuracy allow execution and operational team members to comprehend, plan, coordinate, and execute more effectively during the design and construction phase, as well as transition to and during operation of the facility/assets.

Refer to the BIM Addendum for specific contractual deliverables and time lines.

The data deliverable is a **single consolidated set of data in Excel**. The failure of the designer and builder to execute this deliverable properly sets the owner (PSU) up for operational failure of the significant investment. PSU seeks partners who set us up for operational success.

Project Quality Control & Quality Assurance

The goal is to have correct information and deliverables to support the broader facility life cycle management requirements.

This section briefly describes the approach taken with the BIM program to quality control (QC) and quality assurance (QA). Fundamentally the QC of the work product and associated deliverables is the responsibility of the prime contractor contractually responsible to PSU for the deliverable. QC represents an effort to ensure 100% of the deliverable meets all specifications and requirements. QA is something that may be employed by the prime contractor, however it is fundamentally an effort by PSU, or PSU's expressed representative, to spot check the deliverables for compliance with all specifications and requirements. This QA process typically represents an incremental approach starting with a basic sample set from the total/complete set.

Quality Control (QC)

The prime contractor will typically have a QC process defined for the overall project. Presumably this QC plan includes how deliverables will be checked for compliance to include the BIM defined deliverables.

The BIM Addendum identifies specific QC requirements and it is reasonable to expect that the prime contractor can verbally express how those QC efforts are being performed. Additionally, it reasonable for the PSU Project Manager or BIM Team Representative to ask for a basic visual demonstration of those QC efforts periodically throughout the project. This is especially likely if a QC concern arises during the execution of the project.

Quality Assurance (QA)

PSU will conduct various QA efforts throughout the course of the project to ensure compliance with the BIM requirements. We do not attempt to define all QA efforts that might be used on the project, however we are providing the following to help both internal and external team members understand some of the QA approaches that PSU may employ on a project.

QC/QA Tools

Multiple QC/QA tools exist to ensure compliance of the model and the data deliverable. The following list provides some tools available. This list is not all inclusive, nor does it cover all the QC/QA that may be required as "good practice" for a specific project.

Revit Model Checker (PSU OPP Template)

PSU has provided a template configuration file that should be used when check Revit models for compliance with the PSU OPP standards. This file addresses both required and optional attribute (parameters) for various project, room, and object level elements.

The model checker is a free plugin provided by Autodesk for Revit. The plug in is available at: http://www.biminteroperabilitytools.com/modelchecker/. Once installed it can be found on the "Add-Ins" tab of Revit (see Figure 54). The PSU OPP Model Checker Configuration is found under the "Samples" (see Figure 56). The model checker will produce a report (see Figure 56) to assist the modeler in determining where they have errors that should be corrected.

Figure 54: Revit Model Checker (Source: [18])

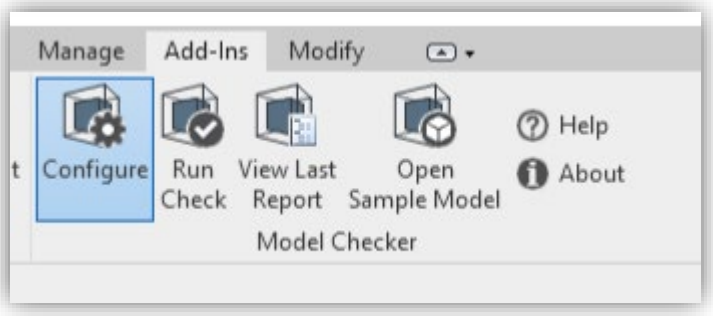


Figure 55: Revit Model Checker PSU Configuration File (Source: [18])

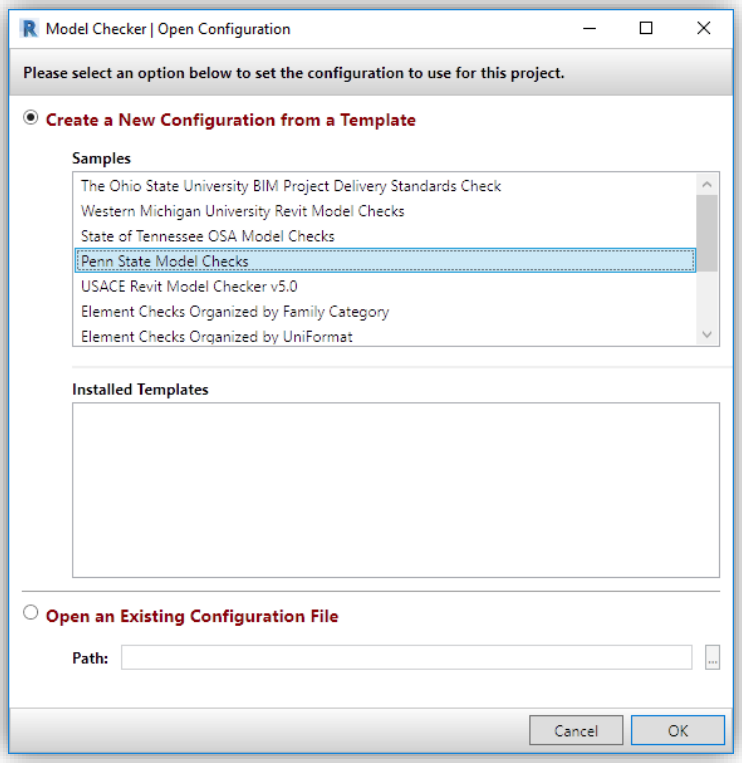
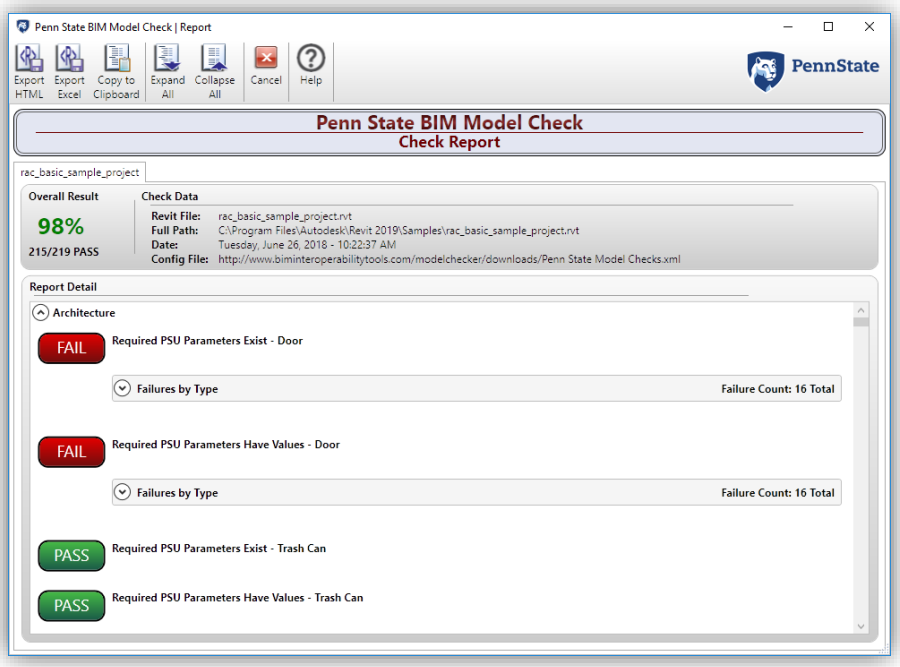


Figure 56: Revit Model Checker Report Results (Source: [18])



"it isn't that they cannot find the solution. It is that they cannot see the problem.

G.K. Chesterton

Clash Detection / Interference Checks

Clash detection and interreference checking are used interchangeably for the purposes of this discussion. There are three basic types of clashes referred to in the PSU OPP efforts:

- **Hard clashes**
- **Soft Clashes**
- **Workflow (or 4D) clashes.**

Hard clashes are often of the most concern, followed by maintenance accessibility soft clashes. The resolution of maintenance accessibility soft clashes is expected on all designs and is not considered an optional clash resolution effort.

Hard Clashes

Hard clashes are defined as two or more physical objects occupying the same space. [20]

Soft Clashes

Soft clashes exist when a physical object does not have the geometric tolerances or "buffer" that is required. Soft clashes can include a physical object occupying the required buffer zone of another physical object or multiple buffer zones intersecting. [20]

For the purposes of PSU requirements soft clashes most often occur when the required maintenance accessibility zones are intersected or the tolerance of 1" is exceeded.

Workflow or 4D Clashes

Workflow clashes, often considered 4D (3D + time), are sequence interference of material movement or trades in the same physical space at the same time when it is not practical, or it is inefficient.

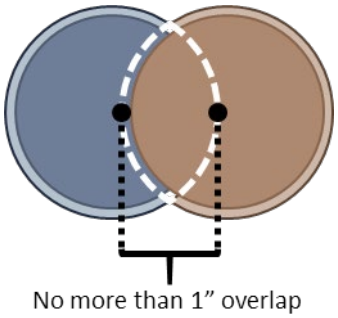
Tolerance

Specifying a tolerance minimum is another way to express the risk PSU is willing to assume or not assume on a project.

A minimum tolerance of 1" is a relatively high-risk threshold. Often designers and builders will apply more stringent tolerances to all or portions of the project. This is acceptable and advisable based on common industry standards of practice or means and methods practice.

"Tolerance" can have different meanings in various software or company nomenclature. As a means of establishing a common vocabulary on PSU projects, "tolerance" is defined as an intersection (overlap) of elements that does not exceed the "tolerance" specified. [20] [12]

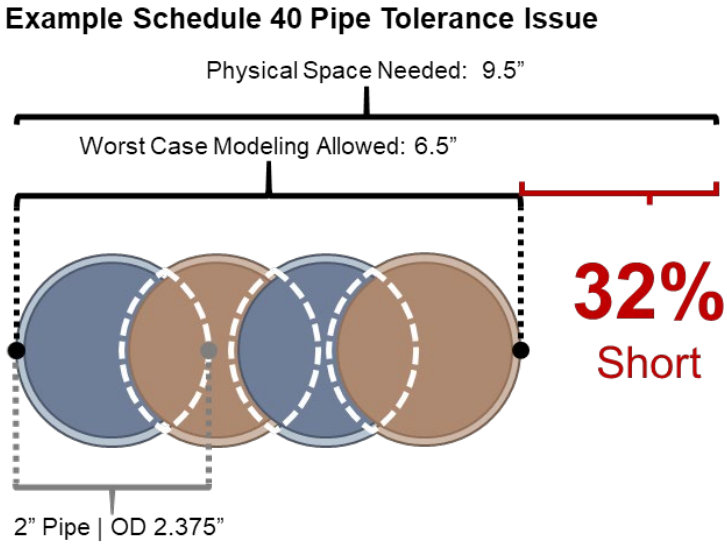
Figure 57: Tolerance Graphic (Source: [12])



Tolerance Risk Assumed

It is important to understand the risk assumed in using tolerance. The risk assumed by using tolerance is small when looking at singular instances as noted in Figure 57 above, however when multiplied across multiple instances it provides a clearer understanding of the accepted risk potential. As seen in Figure 58 the risk assumed using tolerance across multiple instances can be significant and can have serious cost impacts if it occurs in a constrained space (e.g. constrained utility shafts, mechanical rooms with tight equipment buffer or access).

Figure 58: Tolerance Risk Across Multiple Instances (Source: [12])



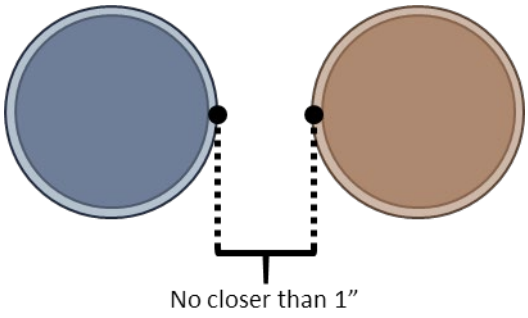
Clearance

Specifying a clearance minimum is another way to specify risk.

“Clearance” can have different meanings in various software or company nomenclature. As a means of establishing a common vocabulary on PSU projects, “clearance” is defined as a

separation between objects or other modeled elements (example buffer zones) that is no closer than the specified clearance. [12]

Figure 59: Clearance Graphic (Source: [12])



Application in Design and Construction

The construction coordination models (CCMs) and design intent models (DIMs) vary in granularity of detail. This should be spelled out in the LOD matrix for the project.

Clash detection is expected and REQUIRED contractually for all PSU BIM projects with the BIM Addendum applied.

Design

This requirement is to ensure that DIMs are deconflicted to extent that components and objects are modeled (e.g. walls, structural elements, mechanical systems, equipment, etc.) The BIM Addendum defines the minimum requirements (e.g. the contractor responsible for design must run and deconflict their design prior to construction drawings or its equivalent).

Construction

It is also REQUIRED as part of the construction effort at least prior to construction. This is commonly done initially holistically for the entire project, and then in more detailed sequenced efforts that tie to stages of the construction as details are developed and coordinated such as:

- Overall building/project clash detection
- Access tolerances and standoff distances
- Main vertical and horizontal chases / utility shafts and distribution runs
- Horizontal trade sequencing and associated building attributes

Clash Detection / Interference Checks

Defining the Clash Detection / Interference Effort

The designer and builders are required to define the clash detection plan as part of their BxP development. More monitoring by PSU project management is required to ensure prime contractors are enforcing, conducting, and resolving the issues found in a timely fashion.

Contact Information

Russ Manning
VDC Engineer
Tel 814.863.3301
Fax NA
rwm108@psu.edu

Saratu Terreno
Post-Doctoral Researcher
Tel 814.863.4563
Fax NA
snt120@psu.edu

Sam Bertolonio
Manager, Design Services
Tel 814.863.2176
Fax NA
sjb106@psu.edu

BIMTeam General Email
psubim@psu.edu

Company Information

Design Services | BIMteam
113 Physical Plant
University Park, 16802
Tel 814.863.3301
Fax NA
www.bim.opp.psu.edu

Common Definitions

The following definitions are used through the PSU BIM Requirements. They are provided here to help ensure commonality of vocabulary and clarify intended use.

The column with a 💬 indicates whether the term is defined explicitly in the BIM Addendum. It predominately used by the BIMteam to ensure the specific definitions listed in the BIM Addendum match the guide. It is not meant to indicate any other differentiation.

Definition	💬
Acquisition Strategy means the combined approach for execution of the specific project. This includes the delivery methodology, procurement methodology, and contract type.	**Yes**
BIM Manager means the individual assigned by the prime contractor to coordinate, manage, and ensure all BIM requirements are met as prescribed in the time frames specified.	**Yes**
cDays means the number of calendar days.	**Yes**
Commissioning (Cx) Agent (CxA) Prime Contractor means the prime contractor responsible for Cx on the project.	**Yes**
Construction Prime Contractor means the prime contractor responsible for the construction effort on the project.	**Yes**
Contract Type means the terms identified that assign financial risk between the owner and the seller of the contracted services. Examples include guaranteed maximum price (GMP), lump sum, or cost-plus fee.	**Yes**
Construction Coordination Model (CCM) see coordination model.	**No**
Coordination Model (CM) means the Navisworks file used to coordinate construction trades and all associated source files in their original format at the agreed upon level of development and level of information.	**Yes**
Delivery Method means the methodology by which the project participant relationships are structured and the sequence in which they are acquired in the overall acquisition strategy. Examples include design-bid-build, design-build, and construction manager at risk.	**Yes**
Design Intent Model(s) means the design team that captures the intended design. This/these model(s) include(s) all accurate and relevant geometry and facility information required to design the facility.	**Yes**
Design Prime Contractor means the prime contractor responsible for the design effort on the project.	**Yes**

Definition	
Level of Development (LOD) means the degree to which an element's geometry has been thought through and the degree to which the user of that geometry may rely on it when using the model. This varies from the National BIM guide specifically to differentiate between geometry only versus geometry and information (data). See LOI for data/information description.	**Yes**
Level of Information (LOI) means the level of data / information required for a specific element and the degree to which a user may rely upon it.	**Yes**
Means and Methods Model means a model used for coordination and planning of the construction which is representative of the means and methods to be used for the project. For the purposes of the BIM addendum requirements all means and methods model(s) are inherently part of, and reflected within, the coordination model and its source files.	**Yes**
Prime Contractor means the person or entity having a direct contractual relationship with PSU under this contract award. This term universally refers to but is not limited to design professionals ("designers"), builders (general contractors, construction contractors, construction managers, construction management agents acting in a CMAR role, etc.), construction management agents (acting solely in an owner agent construction management role), consultants, or vendors.	**Yes**
Procurement Method means the process used by the owner, or entity contracting services, to select the team of contractors used in the acquisition of the facility. Examples include sole source, best value, or low bid.	**Yes**
Record Model means the source Revit model(s) that reflects as-built conditions at the prescribed level of development and level of information. This model is a level of detail and information prescribed by the owner with the intent of use to facilitate common facility operations and modifications / adaptations over the life of the building. It is intended to be used as a lightweight model with enough geometric detail to enable multiple enterprise operations efforts. Typically, the design intent model is used as the baseline and then updated incrementally to incorporate all the changes during construction. It is differentiated from the coordination model it two primary ways: (1) the record model is completely in Revit, and (2) it most often contains more data and less complex geometry than the coordination model.	**Yes**

List of Acronyms

The following lists acronyms used throughout this report / study.

Acronym	Description
AAALAC	Association for Assessment and Accreditation of Laboratory Animal Care
AC	Air Conditioning
ACF	Animal Care Facility
Admin	Administration
AHJ	Authority Having Jurisdiction
BSL	Biological Safety Level
BSL2	Biological Safety Level 2 (refers to a laboratory type as defined by the CDC and USDA)
BSL3	Biological Safety Level 3 (refers to a laboratory type as defined by the CDC and USDA)
DC	Design & Construction part of OPP
DS	Design Services part of OPP's DC division
DX	Direct Exchange (refers to a type of air conditioning system in HVAC)
EA	Environmental Analysis
EA$	Economic Analysis
FIS	Facility Information System (Penn State's space management system)
FTE	Full Time Equivalents (The fraction of man hours earned by some effort relative to that of the man hours of a full-time employee for one year.)

List of Acronyms

Acronym	Description
GSF	Gross Square Feet
HVAC	Heating Ventilation and Air Conditioning
IES	Illumination Engineering Society
NSF	Net Square Feet
OPP	Office of the Physical Plant
PDT	Project Delivery Team
PSU	Pennsylvania State University
SF	Square Feet
UPS	Uninterrupted Power Supply
WCD	Work Control Division

History

The following highlights the history of this document. Dates listed in the future should be interpreted as planned and estimated.

Date	Event
17.11.27	Draft Published
18.02.28	Updated Draft

Section	Updates
Acquisition Strategies	Added graphics and more examples
Best Practices	Added examples
Clash Detection	Added section

18.03.30 Updated Draft (version 1.0.1)

Section	Updates
Acquisition Strategies	Added graphics and more examples
BxP	Added detail and 2017 Draft link
Clash Detection	Added detail and graphics
Definitions	Added cross reference column to BIM Addendum definitions to ensure sync'd.
File Naming Convention	Added graphics for locations
History	Corrected errors
Multiple Sections	Corrected grammatical and spelling errors; Added cross references; Updated references; Updated document tables

History

Date	Event
18.05.31	Updated Draft (version 1.0.2)

Section	Updates
Acquisition Strategies	Add more examples
BxP	Updated Links
Data Management	Added type vs instance reporting, and parent/child management discussion
Delivery Schedule	Develop draft – data, schedules, timeline, color schemes, block diagrams for FIS
General Updates	Update various tables and schedules throughout
Visualization	Provided more information detailing scheduling of the iCon Lab and example of renderings typically needed to support the PSU project approval process

18.06.22 Updated Draft (version 1.0.3)

Section	Updates
Multiple	Grammatical and formatting cleanup
Clash Detection	Additional discussion and insights added
Data Management	Additional discussion and insights added
File Upload	Clarifications made, added information and graphics for DIMs, Record and Coordination Models
Visualization	Additional information related to project approval process support requirements
Document Index	Significant cleanup and additions for better referencing of document

18.09.27 Updated Draft (version 1.0.4)

Section	Updates
Data Management	Examples of Name Plate Pictures

History

Date	Event	
19.01.24	Updated Draft (version 1.0.5)	
	Section	**Updates**
	Best Practices	Add examples
	File Naming Convention	Added more descriptions and examples; added graphics for locations in PSU e-Builder
	Clash Detection	Added details related to meeting requirements
19.03.18	Published (version 1.0.6)	
	Section	**Updates**
	BIM Objectives	Updated BIM Objective cross-walk to OPP goals
	BxP	Add samples of data approach descriptions
	Deliverables	Added discussion related to RM, CCM, and data deliverable
	File Naming Convention	Added more descriptions; added graphics for locations in PSU e-Builder
	General Clean Up	Added descript
19.04.30	Published (version 2) – ANTICIPATED EFFORT	
	Section	**Updates**
	Acquisition Strategies	Add more graphics
	Best Practices	Add more examples
	BxP	Add samples of data approach descriptions
	Data Management	Add examples
	Delivery Schedule	TBD
	Visualization	Add more detail

List of Figures and Tables

The following is a list of figures and tables through the user guide.

Figures

List of Figures and Tables

Tables

Citations / References

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Index of Terms

There is a lot of information in this document, so we have tried to make it a little easier to find information related to some common terms used in the BIM Requirements and this user guide.

Index of Terms

Attachments

There are no attachments to this document.