THOUGHT LEADERSHIP SERIES
STRATEGIC INSIGHTS

DEFINING A HOLISTIC, OWNER-DRIVEN BIM PROJECT DELIVERY STANDARD AT THE OHIO STATE UNIVERSITY

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With more than 37,000,000 sf, The Ohio State University (OSU) is always looking for ways to improve their planning and operations efforts. Through implementing a BIM Project Delivery Standard the university looked to ”enhance planning and communication resulting in improved quality and speed of decision-making”[1] while also reducing their total cost of ownership.

This case study will outline how an enlightened building owner – The Ohio State University – successfully partnered and collaborated with a BIM-savvy architect and contractor to develop a BIM Project Delivery Standard (BIM PDS), enabling the model to serve as a single-source of truth for relevant spatial and asset information throughout the building lifecycle. This campus-wide BIM Project Delivery Standard defines how all projects over $4 million will be executed and how their deliverables will be formatted. By defining this BIM-enabled process, design and construct team members can understand what relevant 3-D geometry and data will be delivered to the university in a streamlined manner at turnover. This “BIM for lifecycle” approach focuses to reduce the university’s total cost of ownership, while realizing a portion of the 7.1% potential cost avoidance that could be realized through a fully-adopted BIM standard.

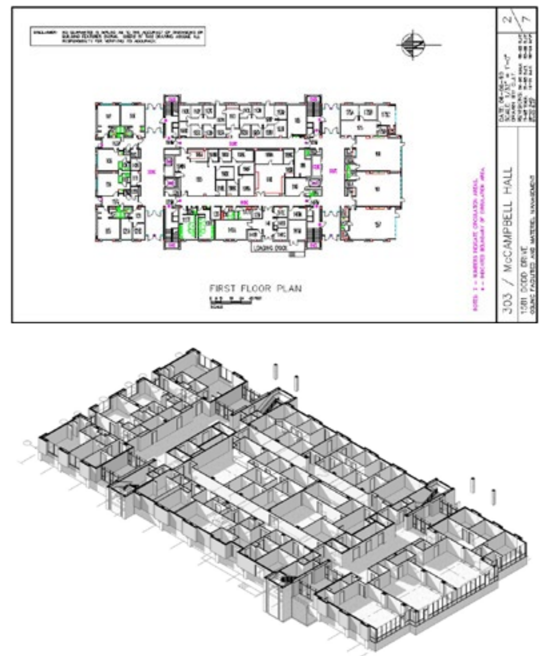


FIGURE 1 CAD to BIM Conversion Example

Why BIM?

The Ohio State University (OSU) is one of the largest public institutions in the United States with over 65,000 students across seven campuses. OSU’s main campus houses over 507 buildings, with a total campus-wide total of 1,345 buildings, covering a total building area of 37,700,000. OSU first started exploring BIM in 2008 after realizing its value to the design and construction community could be applied to their planning, facility management, operation & maintenance initiatives. Further discussions about project delivery and lifecycle approaches created an interesting dialogue between OSU and a design firm and, from there, a trusted partnership evolved.

The initial objective of this strategy, known as the Buckeye BIM Initiative, is to enhance campus planning and communications, resulting in improved quality and speed of decision-making. With partnership and collaboration serving as the cornerstone, the team set forth to work with OSU in determining how to best utilize BIM as an information platform and establish standards and methodologies by which they can manage their diverse and growing building portfolio, campus-wide. A constant dialogue, including honest responses from OSU, assisted with building knowledge to create tailored solutions. The initiative includes two phases – BIM for Existing Buildings and BIM for Design and Construction.

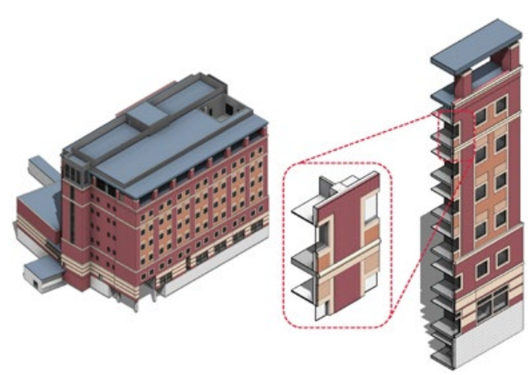


FIGURE 2 As maintained BIM

	Chiller Plant	McCampbell Hall	Kennedy Commons	Total
Project Statistics	Size: 95,737 sf Cost: $77,302,597 Const: $54,784,978 Design: $6,458,966	Size: 104,000 sf Cost: $17,171,045 Const: $13,882,483 Design: $1,363,045	Size: 30,000 sf Cost: $12,539,306 Const: $7,931,390 Design: $1,004,258	Total Size: 229,737 sf Total Cost: $107,012,948
2004 NIST Report **Planning Costs**	A/E: $86,163 CM: $151,264 Owner: $158,923 Total: $396,350	A/E: $93,600 CM: $164,320 Owner: $172,680 Total: $430,560	A/E: $27,000 CM: $47,400 Owner: $49,800 Total: $124,200	Total: $951,110
2007 NIST Report **Design Costs**	Total: $322,948	Total: $68,173	Total: $50,212	Total: $441,333
2007 NIST Report **Trade Package Creation**	Total: $547,849	Total: $138,824	Total: $79,313	Total: $765,986
2007 NIST Report **Coordination**	Total: $3,865,129	Total: $858,552	Total: $626,965	Total: $5,350,646
2004 NIST Report **Recapture of Data**	A/E: $1,915 CM: $20,105 Owner: $16,275 Total: $38,295	A/E: $2,080 CM: $21,840 Owner: $17,680 Total: $41,600	A/E: $600 CM: $6,300 Owner: $5,100 Total: $12,000	Total: $91,895
Total Project Cost Avoidance	$5,170,571	$1,537,709	$892,690	**Total: $7,600,970**
% of Total Project Cost	6.6%	8.9%	7.1%	**Average: 7.1%**
Cost Per Square Foot	$54	$15	$30	**Average: $33**

FIGURE 3 Potential Cost Avoidance Chart from OSU BIM Feasibility Study, 2012

BIM for Existing Buildings: Build – Maintain – Integrate

While creating a process for OSU was a goal, there needed to be a thoughtful approach for future flexibilities, growth and other adaptations, as well. The creation of standards, templates, content, process maps, workflow integrations and training materials/workshops helped transition the university's 2-D AutoCAD drawings to 3-D building information models in Revit (FIGURE 1). As of July 2016, this effort has led to the BIM development for almost 173 buildings totaling 19,645,160 sf.

This initial BIM for Existing Buildings Initiative outlined what an owner's model is and, maybe more importantly, what it isn't. It is not a design or work intent, nor an as-built model. It is an as-maintained model (FIGURE 2) which focuses on a model that is representational, not buildable, and will support the university's planning and operational efforts. This strategic approach also set a goal for future development and model use, creating a successful foundation from current to on-going integration of BIM on campus which continues today.

OSU knew model maintenance would not only be critical to the BIM initiative's success but it would also enable future usefulness by the entire university. The lessons-learned from the existing building model creation allowed for the continued refinement and evolution of modeling standards, and CAD to BIM processes as more were developed. The university also became enlightened about the importance of a consistent modeling approach and how information could be captured and utilized in a new and innovative ways.

This need for consistent approaches became very evident as design and construct communities learned about how OSU was embracing BIM, and looked to receive/share model information. While integrating the design and construct team's models, prior to the BIM Project Delivery Standard's (BIM PDS) existence, OSU quickly realized their efforts would be hindered by lack of consistency and saw an opportunity to standardize their overall framework so model integration could become more fluid, while adapting and establishing a predictability of outcome.

While this maintain/integrate discussion was occurring, a BIM feasibility study (FIGURE 3) was developed to not only reinforce the need for BIM standards but formalize the value and a potential realized return. Leveraging multiple campus renovation and new construction projects, with examples of quantitative and qualitative interoperability cost finding benchmarks, the study reported a potential cost avoidance of 7.1% to the university. [2,3] Set against their $225 million annual construction budget, this metric has the potential to enable a nearly $16 million annual cost avoidance if a BIM standard is fully adopted.

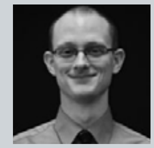
BIM for Design and Construction

With BIM for Existing Buildings serving as a catalyst, CannonDesign submitted and was awarded the BIM standards project with expectations of creating a BIM process, assisting in a holistic BIM approach across campus. This standard's goal is to define how projects will be executed and how deliverables will be formatted for use in facility operations and maintenance.

Setting forth to better understand this sophisticated owner and the wide-range of data needed to oper¬ate and maintain their facilities, the project team developed a multi-stage approach consisting of scope, discover, generate, document, execute and analyze stages (FIGURE 4). The BIM team conducted multi-disciplinary user-group meetings to determine how information is captured, created, shared and managed, and how that differs between department and building types. In addition, persona interviews with individual team members help to better understand their day-to-day needs, challenges faced and opportunities for innovation (FIGURE 5). These meetings enabled the team to completely understand the client – information from focus groups and interviews helped gather significant data and feedback, establishing goals and assumptions for future decision making.

When looking to "follow the data" (FIGURE 6) the consultant teams took advantage of the following questions that, if they couldn't be answered, would remove the specific information from needing to be captured and maintained.

- What data are you going to collect, and how?
- Who is going to use the data?
- How will it be maintained?



Joe Porostosky
Senior Manager, Facilities Information and Technology Services

"Provide leadership over facilities related data systems."

Age: 36

Current Job Experience: 5 Years

Overall Experience: 13 years – IT & Management

Education: MA, Public Policy and Management; BS, Computer and Information Science

Goals: Expand the use of BIM during the entire building lifecycle. Provide easy, powerful access to space data.

Innovation: Leading the Buckeye BIM Initiative, which includes the ongoing BIM for Existing Buildings project to convert all 580 AutoCAD based building plans to Revit based building models. In addition, supporting the development of standards to use BIM for Design and Construction. Leading the effort to combine three disconnected space information systems across the University into one modern, powerful, easy to use solution.

Customer Service: Working to provide a highly integrated, customer focused data and technology environment for all facilities related information in order to improve the quality and speed of decision making by our customers.

Role Description: Joe's primary responsibility includes leading the Facilities Information and Technology Services team. This includes implementing the components of the Buckeye BIM Initiative, managing staff that maintain the existing floor plans and space data, and managing staff that oversee and implement signage and wayfinding for the Wexner Medical Center. He also acts as a technical advisor/project manager on a number of other facilities related system upgrades and implementations.

Joe Uses the Following Tools: Revit for all converted building models. AutoCAD for existing building floor plans that have not yet been converted to Revit. EvolveFM manages our space data and floor plans in an easy to use web based format.

Joe's Needs: Furthering the use of BIM across the University, especially during design and construction which will facilitate faster integration with the existing environment following handover. Furthering cultural change across the University to enable additional use of BIM data during the building lifecycle.

FIGURE 5 Persona interview example

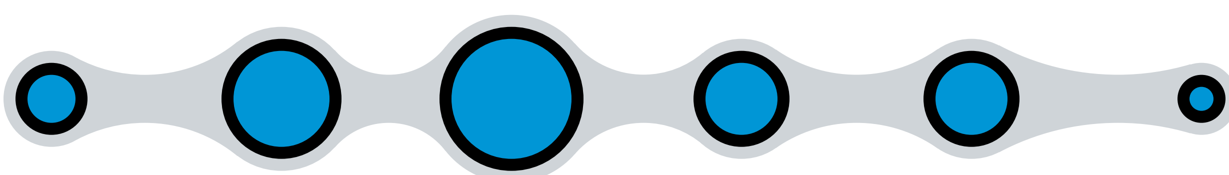


FIGURE 4 BIM project process map

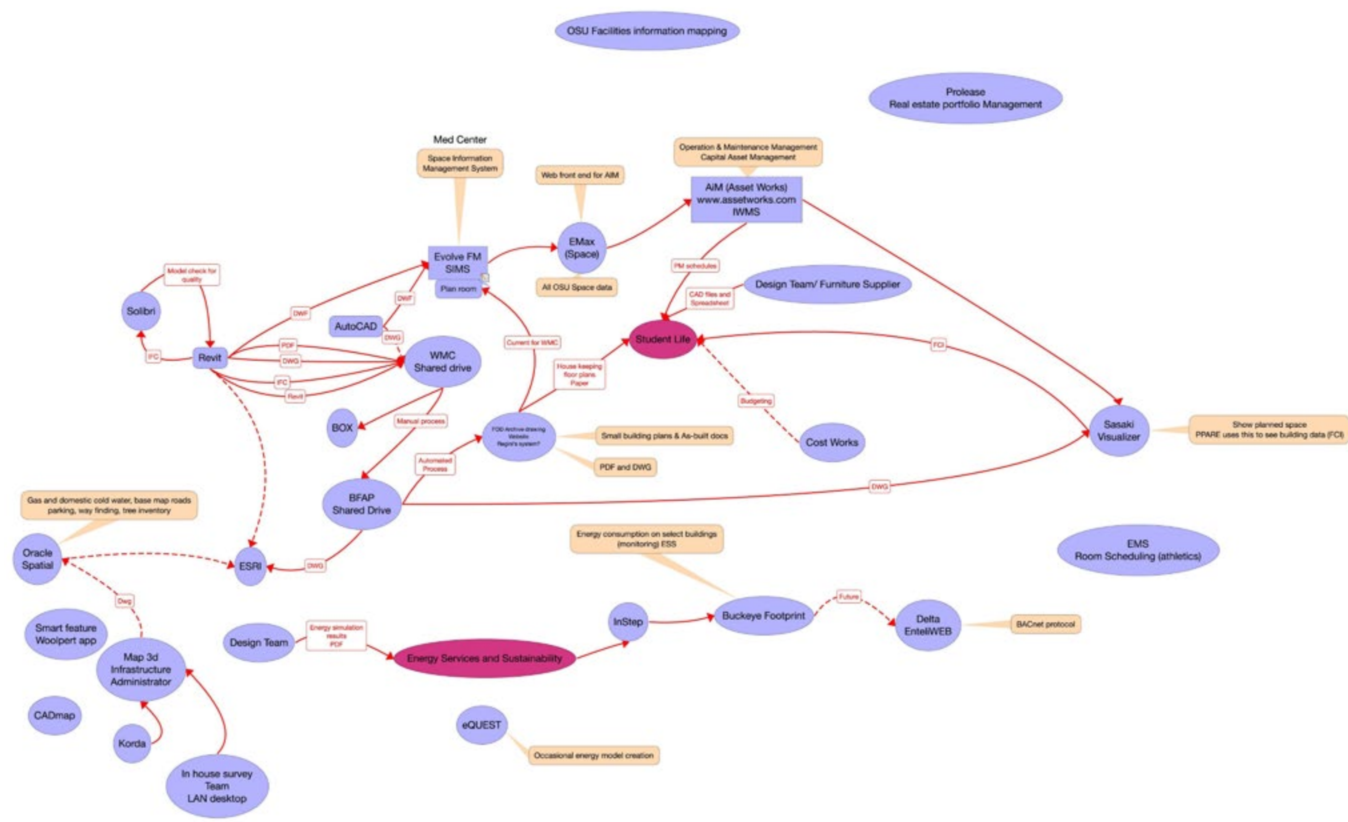


FIGURE 6 Facility information mapping diagram

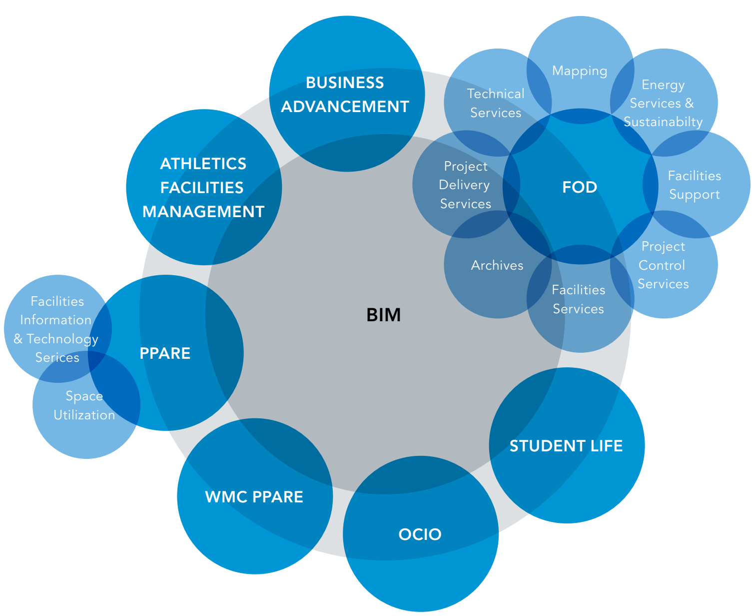


FIGURE 7 BIM stakeholders

The result of this effort was a facility information matrix, which ultimately informs the BIM PDS, defines data and determines where, in the design process, it would be captured and handed over at completion for the university's collective needs.

While this BIM for Design and Construction project develops a high level of consistency in technology, its usage and campus-wide interoperability will enable BIM to serve as a single-source of truth for defined/specific information throughout the building lifecycle. By redefining the contractual obligation for design/construction team members to deliver building information/data in a structured digital format, the university can streamline the turnover process and data integration to new and existing technologies. This overall cultural change will define a commitment to data sharing among the various creators (FIGURE 7), while encouraging communication across departments to foster the currency of spatial and asset information, enabling BIM to help reduce the total cost of operations/ownership.

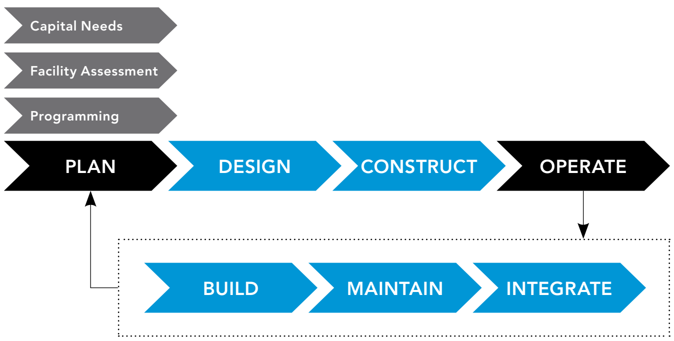


FIGURE 8 Plan, design, construct, operate

The following key outcomes from the discovery and generate phases helped drive the BIM PDS development:

- Further the university's cultural change, to enabling utilizing BIM data throughout the building lifecycle
- Explore how BIM can reduce the total cost of operations and ownership
- Improve the quality and speed of decision-making
- Enable the BIM to serve as a single-source of truth for defined/specific information
- Define a commitment to data sharing among all data creators, while encouraging communication across departments to foster the currency of spatial and asset information
- Define how BIM can drive more efficient and collaborative project delivery methods
- Leverage structured data to streamline the turnover process and data integration into new and existing technologies
- Integrate BIM and GIS
- Enable the BIM to be utilized for energy and sustainability projects to increase efficiency generating savings
- Redefine the contractual obligation for design/ construction team members to deliver building information/data in a digital format

With these details defined, the team worked to create a standard that would "begin with the end in mind;" focusing on end-results while outlining an efficient plan within a BIM-enabled collaborative project delivery environment. Aiding in this delivery the BIM PDS does not prescribe a process that requires specific technologies and individual responsibilities. Rather, it outlines a descriptive framework to execute the project so design and construct teams work in a consistent manner to drive consistent, high-quality and well-structured project deliverables and outcomes (FIGURE 8). This was an important process evolution that moved away from blanket statements like "BIM to be used by all disciplines" or "BIM to be turned over at the project completion," statements too often requested by owners.

Embodying these defined outcomes and needed data, the university launched the BIM Project Delivery Standard in January 2015 and project teams are now expected to follow it on all projects over $4 million in accordance with the university's procurement policies. Project teams are also expected to address the university's response for qualifications and proposals, including BIM experience within a collaborative project delivery environment and approach to implementing BIM during design and construct phases of the project continuum.

Defining a BIM Project Delivery Standard*

As the next steps in OSU's evolving BIM initiatives, the BIM Project Delivery Standard, were developed with two distinct components: the standard and the execution plan. The execution plan enables design and construct team members to document the people, process and technologies that will be implemented to ensure adherence to the standard (a reference to understand what relevant 3-D geometry and data shall be delivered). These deliverables, including the execution plan, are also one of four key components:

1. BIM Execution Plan
2. Conformed Design Intent Models
3. Record Construction Models
4. COBie Worksheet

*Go to https://fod.osu.edu/sites/default/files/ohio-state_bim_pds.pdf to download the BIM Project Delivery Standard.

The BIM Execution Plan (BIM EP)

In addition to outlining typical project information (scope, schedule and milestones) the BIM Execution Plan expands the conversation to include people, process and technology to ensure adherence to the BIM PDS. With people being one of the most important aspect, the BIM project participants (FIGURE 9) create a structure and hierarchy of responsibilities for the project team. Not only is it critical to establish design, construct and discipline model manager roles, but it was also important for the university to promote and evolve these roles by educating and elevating the university project manager's traditional role and creating a new supporting BIM savvy position – the university model manager.

The BIM EP process allows design and construct team member to outline how they intend to leverage the different BIM Use Cases (FIGURE 10) to execute and benefit their specific project. Supporting those Use Cases teams, will also outline important topics like BIM meeting procedures, model collaboration, transmission and permitted use strategies and, most importantly, model development and ownership in the model element table which provide a project specific evolution to meeting the model's minimum level of development (LOD) for BIM deliverables.

Lastly, the technology component addresses what software model element authors will use to accomplish their BIM Use Cases, which is a critical step ensuring the design and construct team can collaborate around these tools successfully and in an interoperable format from the project outset.

As mentioned, this BIM Execution Plan is the first activity the project team will embark on to strategize how they will meet their model- and data-based deliverables. In describing the evolution, the BIM PDS outlines a series of key elements that work toward a successful project delivery and the alignment of expectations from the outset.

The initial pages of the BIM PDS describe a series of BIM Use Cases which are specific BIM-enabled goals, opportunities and/or processes where BIM can be taken advantage of to complete a project-specific task throughout the Plan > Design > Construct > Operate continuum of a facility's lifecycle.

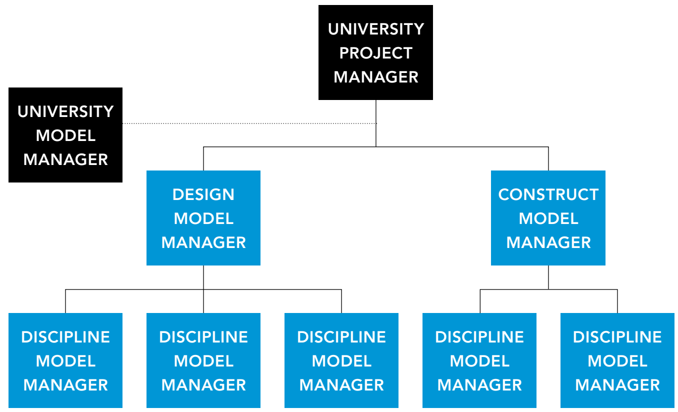


FIGURE 9 BIM project participants

Plan (University/Internal Use Case)

- Programming/Planning - Facility Condition Index - Capital Needs

Design

- Model Authoring – Design Intent BIMs
- Existing Conditions Documentation/Modeling
- Program of Requirements (PoR) Validation
- Site Design
- Model Reviews
- Sustainability (Energy Modeling, Simulation and Performance)
- Design Simulation/Analysis
- Clash Prevention
- Conformed Design Intent BIMs

Construct

- Model Authoring – Trade Coordination BIMs
- Model Authoring – Shop/Fabrication BIMs
- Clash Detection
- Model-based Scheduling (Sequencing/Simulation)
- Model-based Estimating (Quantification/Cost Estimating)
- Site Analysis Planning
- Record Construction BIMs

Design

- Asset/Maintenance Management
- Space Management
- Building Systems/Energy Management
- Geographic Information System
- Document Management (Archives)

FIGURE 10 BIM use cases

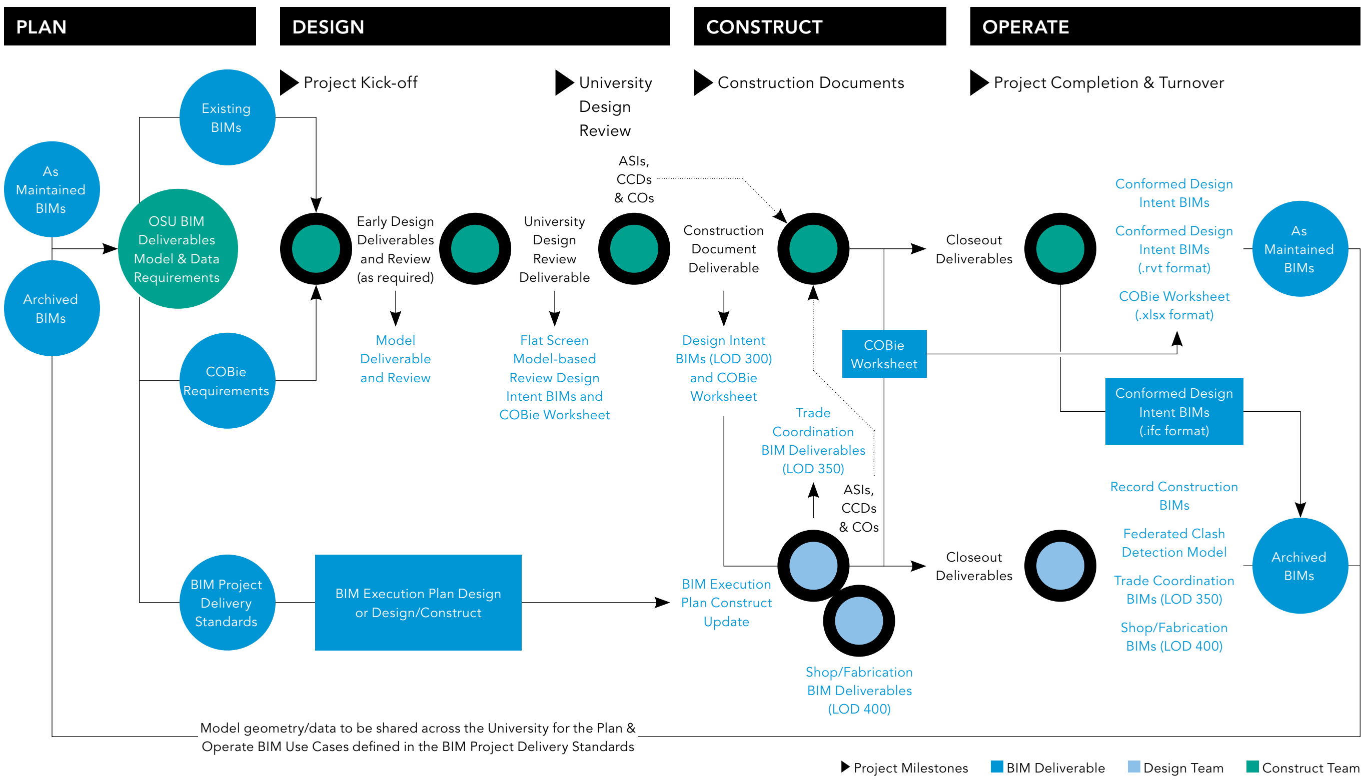


FIGURE 11 BIM project delivery standard process map

While outlining a range of potential uses the document focuses on the development and evolution of model-based deliverables which ultimately play a key role in the university's lifecycle approach.

The Conformed Design Intent BIMs will be delivered in an .RVT format and represents the conformance of the multiple design intent models with all the information that is released throughout the bidding and construction processes. The standardization of this particular model will become the as-maintained model that is taken advantage of by integrating into an ever-growing database of existing building models for use throughout the facility's lifecycle.

Fundamental LOD Definitions	
LOD 100	The Model Element may be graphically represented in the Model with a symbol or other generic representation, but does not satisfy the requirements for LOD 200. Information related to the Model Element (i.e. cost per square foot, tonnage of HVAC, etc.) can be derived from other Model Elements.
LOD 200	The Model Element is graphically represented within the Model as a generic system, object, or assembly with approximate quantities, sizes, shape, location, and orientation. Non-graphic information may also be attached to the Model Element.
LOD 300	The Model Element is graphically represented within the Model as a specific system, object, or assembly in terms of quantity, size, shape, location, and orientation. Non-graphic information may also be attached to the Model Element.
LOD 350	The Model Element is graphically represented within the Model as a specific system, object, or assembly in terms of quantity, size, shape, orientation, and interfaces with other building systems. Non-graphic information may also be attached to the Model Element.
LOD 400	The Model Element is graphically represented within the Model as a specific system, object, or assembly in terms of size, shape, location, quantity, and orientation with detailing, fabrication, assembly, and installation information. Non-graphic information may also be attached to the Model Element.
LOD 500	The Model Element is a field verified representation in terms of size, shape, location, quantity, and orientation. Non-graphic information may also be attached to the Model Elements.

FIGURE 12 Fundamental LOD Definition [4]

LOD Matrix of BIM Deliverables					
		Design Intent BIM (CDs)		Conformed Design Intent BIM	
		LOD	COBie	LOD	COBie
D: SERVICES					
D30	**HVAC**				
D3010	Facility Fuel Systems	300		300	
D3020	Heating Systems	300	X	500	X
D3030	Cooling Systems	300	X	500	X
D3050	Facility HVAC Distribution Systems	300	X	500	X
D3060	Ventilation	300	X	500	X
D3070	Special Purpose HVAC Systems	300		300	
D40	**Fire Protection**				
D4010	Fire Suppression	300	X	500	X
D4030	Fire Protection Specialties	300	X	500	X

FIGURE 13 LOD matrix of BIM deliverables [5]

FIGURE 12

Additionally, the evolution of the model authoring – trade coordination and shop/fabrication BIMs will be critical to a successful construction process, serving as the foundation for the record construction BIM Use Case. This other project deliverable will record and document all revisions including but not limited to design alterations and/or field modifications that have occurred throughout the course of the construct process.

Continuing the strategy of the PDS being descriptive, not prescriptive, the BIM Process Delivery Map (FIGURE 11) was developed focusing on project delivery and information turnover while engaging the project team in collaborative BIM-enabled environment. It also defines a process that is flexible enough for different-sized projects and delivery models highlighting the design and construct process rather than the individuals (architect, engineer, contractor or trade contractor) or project phases (SD-DD-CD).

With a process strategy defined to implement the BIM Use Cases and project deliverables, teams also need to understand the expectations for development of model elements and structure to the data associated. To accomplish this, the university has built the BIM PDS around industry standards like the BIMForum's Level of Development (LOD) Specification (FIGURE 12) and the Construction Operations Building Information Exchange (COBie). For OSU, it was important to not only speak a common language with design and construct team members but leverage an established industry vocabulary.

Leveraging the BIMForum's LOD Specification as a framework for defining the progression of model components, assemblies and systems throughout the design and construct process will enable models to meet their prescribed reliability as defined by the project's BIM Use Cases and final project deliverables. The standard's LOD matrix of BIM Deliverables (FIGURE 13) defines the relevant model element geometry to be included along with the minimum non-graphic information (parametric data) to facilitate on-going use of the BIMs by OSU. While the university describes what is to be included in the project deliverables (Design Intent BIMs and Conformed Design Intent BIMs) the standard allows for a flexible and scalable framework to outline how requirements are achieved and who the responsible model element author will be which will be documented in the BIM Execution Plan.

Another important element of the project BIM deliverables is the evolution of the model to the Conformed Design Intent BIMs Use Case which will ultimately become the "as-maintained" models once turned over to the university. Expanding on the existing fundamental LOD definitions the university has expanded on what LOD 500 means beyond the model elements need to be a "field verified representation in terms of size, shape, location, quantity and orientation." OSU defines that "the progression of model elements to this state will originate from the LOD 300 components, assemblies and systems developed for the Design Intent Models created by design teams as illustrated in the BIM Project Delivery Standards Process Map of the BIM PDS." While the BIMForum LOD Specification defines the minimum geometric requirements the model quality section of the BIM PDS outlines the minimum accuracy and tolerances for the BIM-based model deliverables. Subsequent sections provide additional model development and quality requirements for components, systems and assemblies, as well as outlining the specific requirements for the spatial elements.

While the LOD matrix of BIM deliverables addresses the geometric and model-based components of the project deliverables there is a significant focus on the capturing data about the building which is defined in the non-graphic building information section of the BIM PDS. Capturing this facility information/data via the COBie worksheet deliverable will provide the needed interoperability to share information across campus which will be critically important to the application of the BIMs by the university during the operation and plan phases of their facility's lifecycle.

Creating an information hierarchy from a macro to micro level (campus to asset) the information originally gathered in the Facility Information Matrix (FIM) during the team's effort to follow the data during the generate phase of our work. Organized as property, building, floor, room and asset parameters in the FIM the standard provides information on which building components, assemblies and systems will have information attached to them via the COBie worksheets as well as when that data is expected to be populated and where it should reside, in either the BIMs or COBie worksheet (FIGURE 14).

Parameter	One University Review	Design Intent BIM (CDs)	Conformed Design Intent BIM
Property			
Campus Name*	X	X	X
Building			
Building Number*	X	X	X
Building Name*	X	X	X
OSU Project Number*	X	X	X
OSU Utility Project Number*	X	X	X
Address*	X	X	X
City*	X	X	X
State*	X	X	X
Zip*	X	X	X
County*	X	X	X
Gross Area	X	X	X
GPS X Coordinate	X	X	X
GPS Y Coordinate	X	X	X
GPS Z Coordinates	X	X	X
Floor			
Floor Name*	X	X	X
Floor Number*	X	X	X
Floor Gross Area	X	X	X
Room			
Room Number*	X	X	X
Space ID*	X	X	X
Area*	X	X	X
Wall Finishes*		X	X
Ceiling Finishes*		X	X
Floor Finishes*		X	X
Asset			
Asset Tag*		X	X
Asset Description*		X	X
Asset Type*		X	X
Contractor			X
Replacement Tag			X
Serial Number			X
Manufacturer*		X	X
Model Number*		X	X
Model Name*		X	X
Warranty State Date			X
Warranty End Date			X
Kilowatts*		X	X
Volts*		X	X
Phase*		X	X
O&M Documentation			X

FIGURE 14 Facility Information Matrix (FIM)

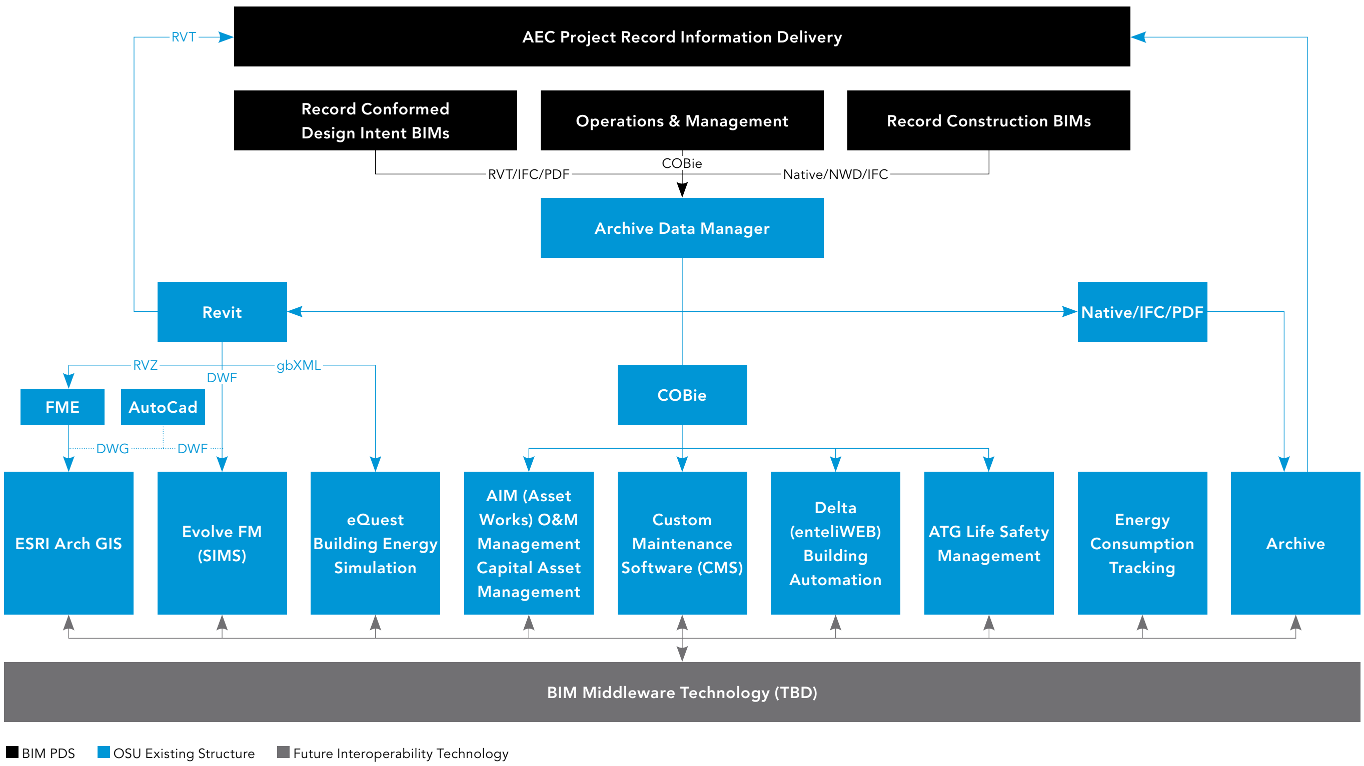


FIGURE 15 Post-BIM process and technology map

By documenting these outcomes, the BIM Project Delivery Standard successfully defines how project will be executed and how deliverables will be formatted. This continued evolution of the Buckeye BIM Initiative has proven extremely successful and has become widely adopted on campus. The BIM Project Delivery Standard has been fully integrated in to the university's Building Design Standards, RFQ & RFP text, overall contract language and is being leveraged on multiple projects. Setting the foundation for the future growth, the university will continue to work toward driving a high level of consistency in technology, its usage and campus-wide interoperability providing the opportunity for BIM to serve as a single-source of truth for defined/specific information throughout the building lifecycle (**FIGURE 15**).

Conclusion

While these items alone cannot generate the potential cost avoidance of a fully adopted BIM standard as outlined in the BIM feasibility study, the university is continuously focusing on how BIM can reduce the total cost of operations/ownership on campus by furthering the cultural change. In support of this integration and continuous improvement goals that have been set for the BIM Project Delivery Standard our project team provided the university a series of recommendations that became known as BIM Implementation Strategy.

The BIM Implementation Strategy outlines a strategy (people, process and technology) to effectively implement this change and drive the commitment to data sharing among the various data creators, while encouraging communication across departments to foster the currency of spatial and asset information, facilitating a BIM-enabled environment to help reduce the total cost of operations and ownership for Ohio State University.

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About the Author

Brian Skripac is CannonDesign's BIM and Digital Practice leader who continually drives innovation by merging technology and practice. He has 20 years of industry experience, with the last 10 focusing on the integration of BIM to transform the design and project delivery process. Brian has successfully developed and managed BIM-enabled delivery systems for large efforts in Design-Led Construction. In addition, he focuses on the use of BIM to capture and structure relevant facility data, implementing the value BIM brings to facility owners from an interoperable lifecycle management strategy. A thought-leader in this field, he is an advisory group member and past-chair of the AIA National Technology in Architectural Practice Knowledge Community and serves on the BIMForum committee responsible for authoring the LOD Specification.

About CannonDesign

CannonDesign is an integrated, global design firm that unites a dynamic team of strategists, futurists, researchers, architects, engineers and industry specialists, driven by a singular goal — to help solve our client's and society's greatest challenges.

Contact Information

For more information please visit cannondesign.com.