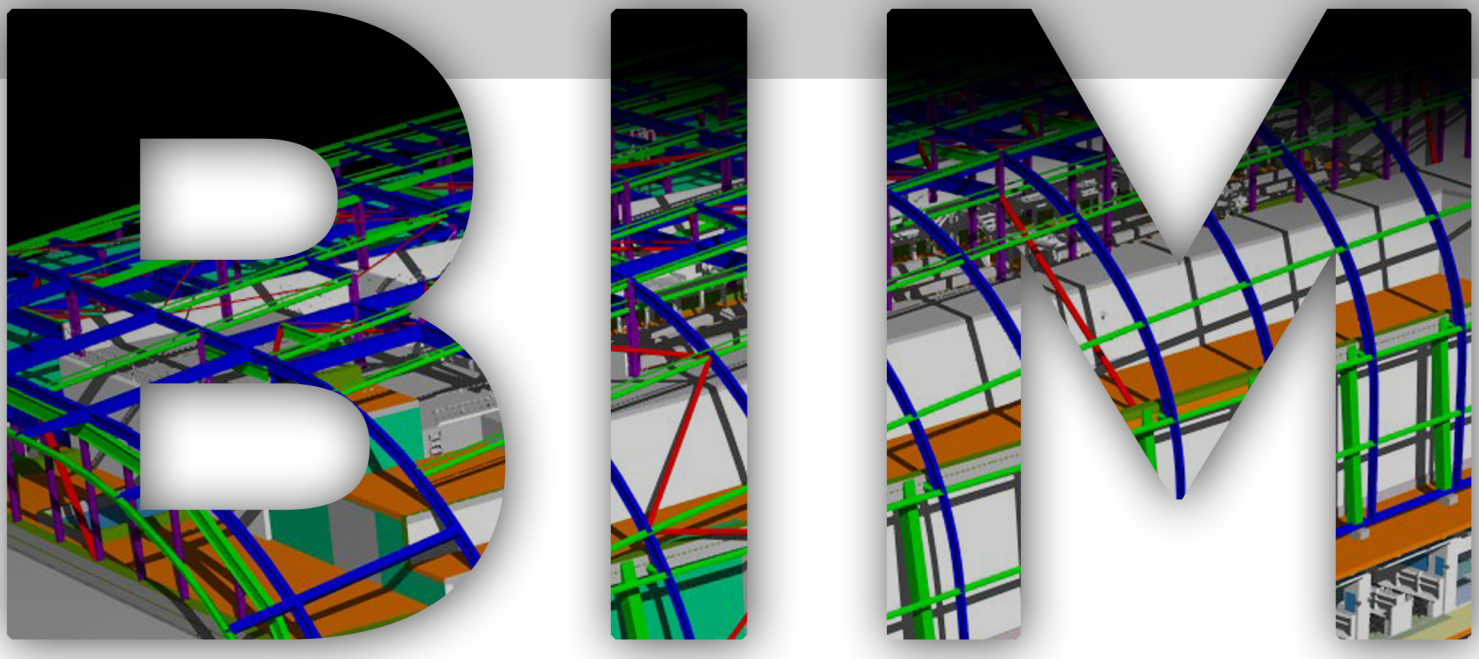
BUILDING INFORMATION MODELING



PLANNING GUIDE FOR FACILITY OWNERS

A BUILDING SMART™ ALLIANCE PROJECT

VERSION 2.0 JUNE 2013

BIM.PSU.EDU

PENN STATE
COMPUTER INTEGRATED CONSTRUCTION

CHARLES PANKOW FOUNDATION

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Executive Summary

In 2009, The Building Information Modeling (BIM) Project Execution Planning Guide was released to support project teams by leading them through a planning process for BIM. A core principle of the planning procedure was to 'Begin with the End in Mind'. This principle, when applied to the Architectural, Engineering, Construction, and Operations (AECO) Industry highlights the need for facility owners to understand and communicate their goals for implementing BIM throughout the lifecycle of the facility so that teams can produce the information during a project that will add value to the owner's business operations. When the BIM Project Execution Planning Guide was released, few owners had outlined their BIM strategy for implementation – both within the operations of their facilities and within the design and construction process. Therefore, this Guide was developed to aid facility owners as they develop strategic, implementation, and procurement plans for BIM integrating in their organizations.

Facility owners should have a different outlook on the value of BIM for their projects. The BIM Project Execution Planning Guide was focused on streamlining the planning and implementation of BIM use within one capital facility or project. The value of BIM tools and processes for owners can be very much attuned to the tools and enabled processes within a given project, or it can differ with a focus on the facility operations and related data after complete. The BIM Planning Guide for Facility Owners seeks to facilitate an owner's review and planning for the proper investment in BIM in line with the specific project focal points or strategic business interests, in addition to improving the value in delivering a single facility.

This Guide presents a structured approach to effectively plan the integration of BIM within an organization. Three planning procedures are presented:

- STRATEGIC PLANNING to assess existing organizational conditions; align BIM goals and objectives with desired BIM Uses and maturity level; and develop a tran sition plan for BIM implementation;

- IMPLEMENTATION PLANNING to develop the detailed implementation plan within the operations of the organization; and

- PROCUREMENT PLANNING to identify key issues to consider when creating BIM contract requirements.

The BIM Planning Elements

Throughout all stages of this Guide, there are six core "BIM Planning Elements" that must be considered. The BIM Planning Elements are as follows:

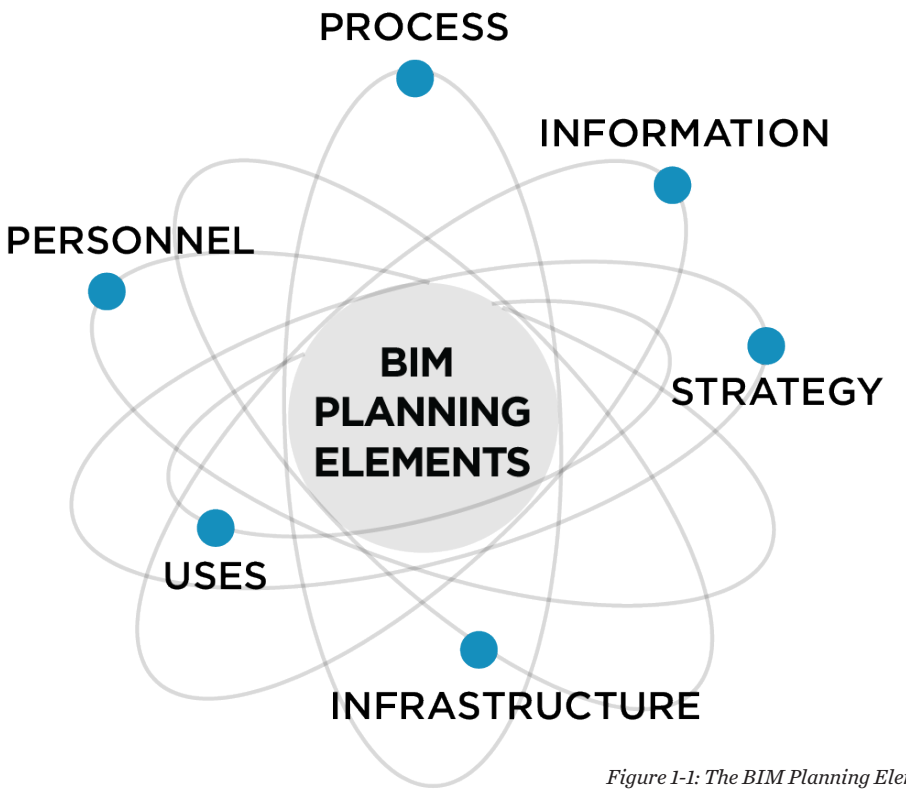

Figure 1-1: The BIM Planning Elements

1. STRATEGY
Defines the BIM goals and objectives; assesses change readiness; and considers management and resource support.

2. BIM USES
Identifies the methods in which BIM will be implemented for generating, processing, communicating, executing, and managing information about the owner's facilities.

3. PROCESS
Describes the means to accomplish the BIM Uses by documenting the current methods, designing new processes leveraging BIM, and developing transition plans

4. INFORMATION
Documents the information needs of the organization, including the model element breakdown, level of development, and facility data.

5. INFRASTRUCTURE
Determines the technology infrastructure to support BIM including computer software, hardware, networks, and physical workspaces.

6. PERSONNEL
Establishes the roles, responsibilities, education, and training of the active participants in the BIM processes established.

Strategic Planning

The Strategic Planning procedure provides steps that an owner can use to plan for BIM at an organizational level. The purpose of this planning procedure is to allow you as an owner to determine your BIM goals and objectives and establish a road map to document how you will accomplish the goals and objectives. The Procedure includes:

1. **ASSESS** the organization's current internal and external level of BIM integration;
2. **ALIGN** the organization's BIM goals by identifying desired levels of maturity for BIM Uses; and
3. **ADVANCE** the BIM maturity level through the development of a defined advancement strategy.

Implementation Planning

After the Strategic Plan has been developed, Implementation Planning can begin. The purpose of this step is to determine and document the detailed guidelines and protocols for implementation. An Implementation Plan will include the following:

1. **PROCESS** maps that clearly define how BIM will be integrated into the organization's practices;
2. **INFORMATION** requirements to support the implementation of BIM;
3. **TECHNOLOGY INFRASTRUCTURE** needed to support the process; and
4. **EDUCATION AND TRAINING** for the personnel who will interact with BIM or resulting data.

Procurement Planning

Prior to the start of a facility project (new construction or renovation); an owner should develop contract requirements for BIM. These contract requirements are necessary to ensure that the owner's BIM needs are met, and the entire project team has a common understanding of the requirements. It also supports the successful implementation of BIM throughout the lifecycle of the facility. With the proper documentation in place at the beginning of the project, the team can plan an effective BIM process for both the project and your needs. Core procurement components include:

1. **TEAM SELECTION CRITERIA** to enable the procurement of qualified items;
2. **CONTRACT REQUIREMENTS** to clearly define the BIM deliverables; and
3. **STANDARD BIM PROJECT EXECUTION PLAN TEMPLATE** to initiate the detailed BIM planning process for a project

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This Guide was authored by a team of individuals within the Computer Integrated Construction (CIC) Research Program at Penn State. This guide was created through a rigorous methodology including content analysis of available industry and research documents, industry interviews, workshops, and observational case studies. Prior to public dissemination, an expert advisory board has reviewed the BIM Planning Guide for Facility Owners. Principal authors of the Guide include:

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/// Getting Started

This section of the Guide is intended to quickly provide an overview of BIM along with several important items that you should know before beginning to use the remainder of the Guide.

What is Building Information Modeling?

For the purposes of developing this Guide, we will use the definition of BIM from the U.S. National Building Information Modeling Standard (NBIMS-US) which states that Building Information Modeling is the act of creating an electronic model of a facility for the purpose of visualization, engineering analysis, conflict analysis, code criteria checking, cost engineering, as-built product, budgeting and many other purposes...

While the model is an important component of BIM, many now view BIM as more of a process change than a new technology. The model may serve as a knowledge resource to for all project participants, but BIM is a process that enhances collaboration resulting in improved information management and an overall leaner process.

The Value of BIM for Owners

BIM adoption is rapidly gaining speed within the Architectural, Engineering, Construction, and Operations (AECO) Industry. Project teams are shifting their standard practices toward the use of intelligent, parametric 3D models, which can more easily be modified, coordinated, and maintained throughout the lifecycle of a building. According to the 2012 BIM Smart Market Report, industry-wide adoption of BIM surged from 28% in 2007 to 71% in 2012. Almost two-thirds (62%) of all BIM users perceived a positive return on investment. Firms that were most

engaged with BIM enjoyed far larger increases in benefits. The primary benefits of BIM for owners are a reduction of document errors and emissions, rework, construction cost, project duration, and claims and litigation.
A large majority of owners believe that BIM use is expanding and that owners are driving this change. In 2007, Stanford University's Center for Integrated Facilities Engineering (CIFE) showed that BIM provided a 40% reduction of unbudgeted changes; provided cost estimates within 3% of the traditional estimates; contract savings of up to 10% with the use of clash detection; and reduced project time by up to 7%. Some of these figures may be disputed, but what cannot be argued is the trend. Adoption rates and positive benefits continue to grow. It is clear that owners are recognizing the value of BIM to improving their capital facility projects, and ultimately, their organization.

How to Use this Guide

This Guide has been developed for facility owner organizations, along with designers, contractors, operators, and consultants who advise owners. We assume that the reader has a fundamental understanding of BIM concepts. For those readers who are not familiar with BIM, it is recommended, that you review BIM literature such as BIG BIM little bim by Jernigan (2008), the BIM Handbook by Eastman et al. (2011), or other BIM resources from the GSA, US Department of Veterans Affairs, US Army Corp of Engineers, and others.

This Guide is not intended to convince an organization to use BIM, but rather how to implement it. If the organization has determined that BIM can add value to the organization, this Guide will lead them through the steps to integrate BIM into the organization. However, if the organization is unsure about implementing BIM, it may be necessary to further research the benefits and risks of BIM to make a business case for implementing BIM.

While the Guide is written for facility owners who operate and maintain facilities, it is important to note that implementing BIM for non-owner organizations is very similar. Therefore, this Guide is an excellent resource for any organization wishing to integrate BIM into their core operational processes.
The Guide contains three primary procedures:

- The Strategic Planning procedure (Chapter 2);
- The Implementation Planning procedure (Chapter 3); and
- The Procurement Planning procedure (Chapter 4).

The Guide is written in the sequential order of the steps and procedures that are necessary to implement BIM. However, each organization will be at a different stage of BIM implementation, and it may be beneficial to focus on a specific procedure based upon the organization's current level of BIM implementation/maturity. We suggest that you to first read each chapter and then target areas that provide the most value to your current level of BIM implementation.

The appendices provide additional resources for implementing the procedures documented in this Guide. Additional templates and resources are also available at the project website (http://bim.psu.edu). Throughout the Guide, case study examples are provided to illustrate the content discussed. Those examples were developed from case studies and input provided by the supporting organizations.

/// Strategic Planning for BIM Implementation

An organization should conduct a strategic planning process to establish BIM objectives and set the direction to focus future implementation efforts The planning activities help an organization to set the goals and objectives, while directing the means and methods for achieving them.

While organizations might be looking for sources that provide a "one solution fits all approach" to plan for the implementation of BIM, it is important to understand that no two organizations are alike. Keeping that constraint in mind, the BIM Strategic Planning Procedure can be separated into three primary steps: 1) Assessment, 2) Alignment, and 3) Advancement. Templates have been created to support each of these steps and to document the relevant information. These templates are included in the appendices and are also located at http://bim.psu.edu.

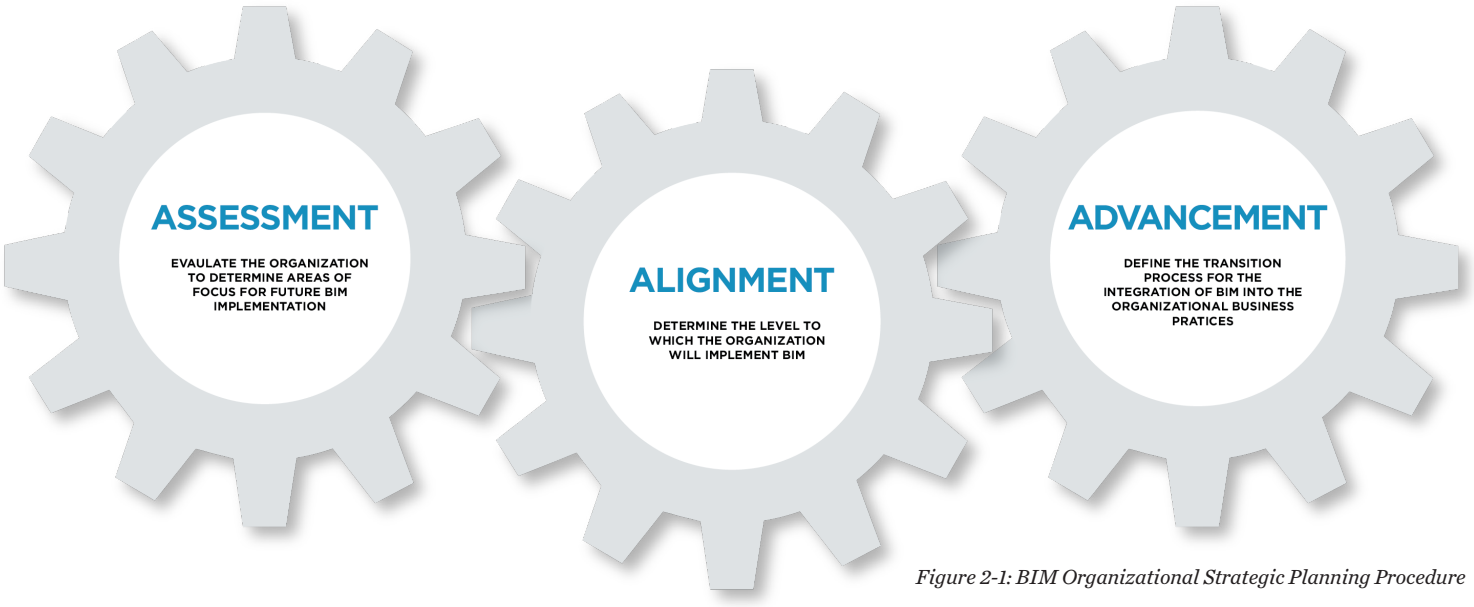

Figure 2-1: BIM Organizational Strategic Planning Procedure

The Need for a Strategic Plan for BIM Integration

Strategic Planning helps ensure an organization is ready for the implementation of a new process or technology with planned resources. If implemented correctly, it can promote collaboration within an organization and greatly reduce the chances of failure. Several benefits gained through creating a BIM strategic plan include the development of:

- A clear understanding of the organizational goals and BIM objectives in a given time frame;
- The effective allocation of organizational resources for key BIM competencies and priorities;
- The provision of a benchmark from which progress in each of the competency categories can be measured at milestones to assess transitions; and
- The promotion of teamwork and an integrated perspective for planning with multiple opinions from different individuals within an organization.

Like any new process, BIM implementation within an organization has a learning curve associated with it. This is of importance for organizations with relatively low or no experience with BIM, as a lack of familiarity can carry risks throughout the stages of implementation. With more detailed planning, an organization will be able to achieve improved clarity of the process, which will reduce risks and increase the overall value of implementation.

The BIM Planning Committee

A BIM Planning Committee should be assembled prior to the start of Strategic Planning. The team members should include individuals who have background knowledge and experience with BIM and its processes, and should represent a diverse group of members from across the organization. In cases where the organization cannot compile a Planning Committee with previous BIM experience, it may be advantageous to seek assistance from third party BIM implementers. The Planning Committee should include the following:

BIM Champion: A person who is technically skilled and motivated to guide an organization to improve their processes by advocating adoption, managing resistance to change, and ensuring implementation of a new technology or process, should be selected to lead the BIM initiative. The BIM Champion should have the ability to direct funds and staffing as necessary to support the BIM efforts. It is important that an individual with authority, leadership, and motivation is selected to champion this process.

Executive Representation: Without the involvement of

high-level executives, it is most likely that the planning team will not be able to gain the necessary resources to plan and implement the recommendations that are developed. By including executives, key decisions to proceed are more easily facilitated.

Middle Management Representation: The middle managers are responsible for operating their departments and achieving goals set by the planning process. They are responsible for the daily operations of their division by monitoring and delegating work to the technical workforce. These managers should be involved in the core planning necessary to manage resistance to change that may occur throughout the BIM implementation phase.

Technical Workforce Representation: The technical workforce includes personnel who are directly involved with the technology and processes that drive the implementation of BIM on a daily basis. They are the most experienced employees in terms of the operations, and they implement and use technologies to improve processes within the organization. They are likely to be the most affected by any BIM adoption process. Being responsible for the standard workflows that are subject to change due to integrating BIM, they are also the most likely to resist the change. Involving the workforce in planning can be quite beneficial to the committee since their involvement can help foster acceptance of the new processes and provide insight to the challenges in modifying processes.

When assembling the BIM Planning Committee, considerations should be given to involving personnel with specific responsibilities and capabilities including:

- An individual(s) who can champion the planning throughout the organization;
- Decision makers who have authority to grant access to resources required by the team (e.g., time, funding, personnel, and infrastructure);
- Individuals who might be directly affected by the adoption or change;
- Motivated individuals who can contribute to the process and are supportive of improving the process through change;
- Implementers of the BIM process; and
- Individuals who will be able to monitor progress and manage the process change

Establish BIM Planning Committee Mission

The BIM Planning Committee Mission states the purpose for the existence of the BIM effort. A mission statement for the BIM Planning Committee stems from an understanding of a number of items including: the type of the organization; the mission and vision of the organization; the facilities group(s) that support the organization; and the challenges faced by these operating units.

The scope and focus of a committee's Mission Statement can vary based on the expertise and level of understanding of the committee. The committee's statement generally explains their existence to achieve the organizational mission and vision with the use of BIM, or extend into details by mentioning an improvement in a specific process or technology for the organization.

/// CASE STUDY EXAMPLE: BIM Planning Committee Mission Statements

Kaiser Permanente's National Facilities Services (NFS) BIM Work Team's mission statement establishes its function as gathering information and helping the NFS BIM Strategy for planning the adoption and implementation of BIM for Kaiser Permanente. The mission reads "to gather information from across the NFS enterprise, report findings, deliver recommendations for the NFS BIM Strategy, and identify work tracks/action plans to execute on the strategy". It goes further to elaborate its purpose to "Define the role of BIM in the Healthcare Facility Life Cycle Management (FLCM) and to establish the Healthcare BIM Consortium (HBC) and industry partners."

The Healthcare BIM Consortium (HBC), a collaboration of healthcare owners, software vendors, designers and builders has a more specified BIM Mission. The consortium exists to "seek solutions for interoperability to support the Facility Life Cycle Management (FLCM)."

The BIM Planning Elements

Throughout all steps of Strategic Planning, there are six core elements, referred to as the "BIM Planning Elements" that must be assessed. The BIM Planning Elements are:

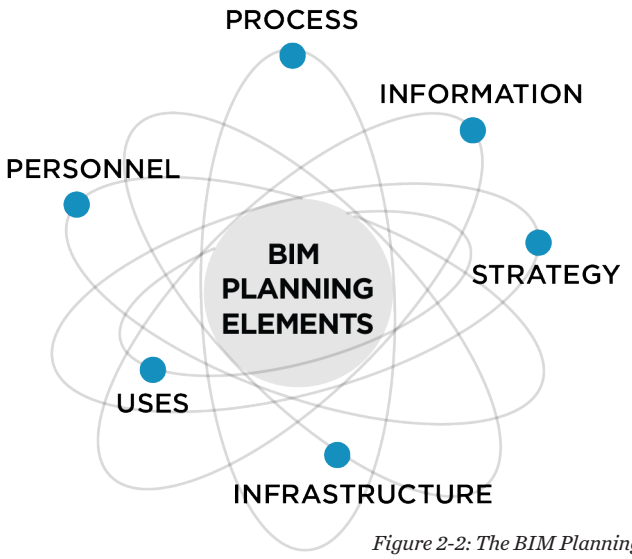

Figure 2-2: The BIM Planning Elements

Strategy

Defines the BIM goals and objectives; assess change readiness; and management and resource support.

Uses

Identifies the methods in which BIM will be implemented, or BIM Uses, for generating, processing, communicating, executing, and managing information about the owner's facilities.

Process

Describes the means to accomplish the BIM Uses by documenting the current processes, designing new BIM processes and developing transition processes.

Information

Defines the information needs of the organization, including the model element breakdown, level of development, and facility data.

Infrastructure

Determines the technology infrastructure to support BIM including computer software, hardware, networks, and physical workspaces.

Personnel

Establishes the roles, responsibilities, education, and training of the active participants in the BIM process establish.

Assessment: Conduct Organizational BIM Assessment

The first step in Strategic Planning is to conduct an assessment of the organization. The assessment includes evaluating the organization both internally, to determine the current status, and externally, to determine its performance within its business market. The goal of this process is to identify possible areas of adoption and implementation of new processes and technologies.

Document the Current Implementation of BIM

The Planning Committee should measure the maturity of the BIM Planning Elements. A BIM Organizational Assessment Profile has been developed to assist the Planning Committee with assessing the current maturity level of each of the elements.

There are a number of approaches that the organization can use to collect information for assessing their status. The most common and efficient method of gathering the required information is by conducting interviews with the operating unit's personnel who are directly involved with the performance of the organization. Other methods that supplement this process include organizational wide surveys, document analysis, process observations, and workflow analysis. Example questions that could be used to assess the current condition of an organization and its units could be related to duties of the organizational unit, information they manage, process of managing information, some of the challenges associated with the process, etc.

The Organizational BIM Assessment Profile is a matrix, which has been developed for the purpose of assessing the organization's maturity of the Planning Elements. The first step is to determine the current maturity level of each of the planning elements. This can be accomplished by scoring their maturity based on the description given in the matrix. The profile provides a basic description for each the maturity levels identified within the planning elements. The Level of Maturity begins with zero (0), which represents non-existence or non-use of that element within the organization, and continues to level five (5) in which the planning element is optimized. By using the assessment profile, the organization can quickly document the implementation status for each category. Figure 2-3 shows a section of the Organizational BIM Assessment Profile, with an example of the current maturity level highlighted.

A template spreadsheet of the profile is available for free download at the bim.psu.edu website

Planning Element	Description	Level of Maturity						Current Level	Target Level	Total Possible
Strategy	the Mission, Vision, Goals, and Objectives, along with management support, BIM Champions, and BIM Planning Committee.	0 Non-Existent	1 Initial	2 Managed	3 Defined	4 Quantitatively Managed	5 Optimizing	11	0	25
Organizational Mission and Goals	A **mission** is the fundamental purpose for existence of an organization. **Goals** are specific aims which the organization wishes to accomplish.	No Organizational Mission or Goals	Basic Organizational Mission Established	Established Basic Organizational Goals	Organization Mission which addressed purpose, services, values (at a minimum)	Goals are specific, measurable, attainable, relevant, and timely	Mission and Goals are regularly revisited, maintained and updated (as necessary)	3	0	5
BIM Vision and Objectives	A **vision** is a picture of what an organization is striving to become **Objectives** are specific tasks or steps that when accomplished move the organization toward their goals	No BIM Vision or Objectives Defined	Basic BIM Vision is Establish	Established Basic BIM Objectives	BIM Vision address mission, strategy, and culture	BIM Objectives are specific, measurable, attainable, relevant, and timely	Vision and Objectives are regularly revisited, maintained and updated (as necessary)	2	0	5
Management Support	To what level does management support the BIM Planning Process	No Management Support	Limited Support for feasibility study	Full Support for BIM Implementation with Some Resource Commitment	Full support for BIM Implementation with Appropriate Resource Commitment	Limited support for continuing efforts with a limited budget	Full Support of continuing efforts	3	0	5
BIM Champion	A BIM Champion is a person who is technically skilled and motivated to guide an organization to improve their processes by pushing adoption, managing resistance to change and ensuring implementation of BIM	No BIM Champion	BIM Champion identified but limited time committed to BIM initiative	BIM Champion with Adequate Time Commitment	Multiple BIM Champions with Each Working Group	Executive Level BIM Support Champion with limit time commitment	Executive-level BIM Champion working closely with Working Group Champion	1	0	5
BIM Planning Committee	The BIM Planning Committee is responsible for developing the BIM strategy of the organization	No BIM Planning Committee established	Small Ad-hoc Committee with only those interested in BIM	BIM Committee is formalized but not inclusive of all operating units	Multi-disciplinary BIM Planning Committee established with members from all operative units	Planning Committee includes members for all level of the organization including executives	BIM Planning Decisions are integrated with organizational Strategic Planning	2	0	5
BIM Uses	The specific methods of implementing BIM	0 Non-Existent	1 Initial	2 Managed	3 Defined	4 Quantitatively Managed	5 Optimizing	4	0	10
Project Uses	The specific methods of implementing BIM on projects	No BIM Uses for Projects identified	No BIM Uses for Projects identified	Minimal Owner Requirements for BIM	Extensive use of BIM with limited sharing between parties	Extensive use of BIM with sharing between parties within project phase	Open sharing of BIM Data across all parties and project phases	3	0	5
Operational Uses	The specific methods of implementing BIM within the organization	No BIM Uses for Operations identified	Record (As-Built) BIM model received by operations	Record BIM data imported or referenced for operational uses	BIM data manually maintained for operational uses	BIM data is directly integrated with operational systems	BIM data maintained with operational systems in Real-time	1	0	5

Figure 2-3: Organizational BIM Assessment Profile

Identify Opportunities for Improvement

By analyzing business performance, the Planning Committees will be able to identify key performance indicators that will help determine which aspects of the organization require improvement. Apart from identifying status, performance measures are assessed to control behavior towards the intended goal; inform external stakeholders of information requirements; and empower decision making. Organizations can benchmark their performance against other organizations to determine opportunities for improving their processes.

Most strategic planning literature specifies that internal and external analysis include an assessment of the administrative, political, economic, stakeholder, and technological features. For a facility owner, however, these aspects also include the business processes, organizational structure, organizational culture, procurement strategies, financial considerations, and market positions.

Readiness Assessment

The Planning Committee should consider the readiness for change of the organization. Without ensuring that the committee has assessed the needs and accommodated for these pre-requisites, it will be difficult to start the strategic planning process. A list of elements that the committee or the organization should consider before initiating the strategic planning procedure includes:

- Defining the BIM Champion, a Planning Committee, and / or a consultant to initiate the procedure;
- Gaining involvement and buy-in from the top-level management and stakeholders;
- Establishing the availability of adequate time, resources, and funds for the planning effort; and
- Gaining a fundamental understanding that strategic planning for BIM is a continual effort and is not a one-time event.

Alignment: Establish Desired Level of Implementation

Once the organization has conducted an assessment of its status, the BIM Planning Committee should establish a desired level of maturity for each of the planning elements. Careful deliberation should be exercised with the selection of a target level that is measurable and achievable. The inherent capabilities of an organization such as experience and knowledge are some of the competencies that have to be considered when targeting maturity levels. Additionally, the Planning Committee will need to determine future BIM Objectives and BIM Uses for the organization.

Establish BIM Goals & Objectives

Establishing BIM Goals and Objectives helps provide a direction in which the Planning Committee should proceed. The BIM goals should be measurable, and include items such as reducing operational and lifecycle costs; improving operational workflows; understanding and defining information needs; or developing internal quality assurance systems. Goals can also target the workforce and their capabilities by providing education and training to the team members, or developing the necessary infrastructure to support BIM integration. It is incumbent upon the committee to identify goals that provide value to the organization, and that support the overall organization goals, mission and vision. These goals can be organized and prioritized (see an example in Table 2-1).

PRIORITY	STRATEGIC GOAL
REQUIRED	Improve work order management through the timely entry of facility data into the facility management system (FMS)
REQUIRED	Provide improved facility data to facility managers after building turnover
RECOMMENDED	Reduce energy use by integrating more detailed energy analysis

Table 2 -1: Example Organizational Goals

Determine BIM Uses

A BIM Use is defined as a method or strategy of applying Building Information Modeling during a facility's lifecycle to achieve one or more specific objectives. The BIM Uses at this stage of the planning process are identified based on the goals and objectives. For example, if an organization wants to manage as-built record models and maintenance information on the building equipment, then record modeling and asset management could be beneficial BIM Uses. Some goals and objectives may directly imply the specific implementation of a BIM Use, while others may require several Uses to support a goal.

GOAL	BIM USES
IMPROVE CONSTRUCTION QUALITY	Design Review, Design 3D Coordination, Digital Fabrication
REDUCE RFIs AND CHANGE ORDERS	Design Review, 3D Coordination
REDUCE ENERGY USE	Energy Analysis, Performance Monitoring
PROVIDE FACILITY MANAGERS IMPROVED FACILITY DATA AFTER BUILDING TURNOVER	Record Modeling, Existing Conditions Modeling

Table 2 -2: Example Organizational Goals

There are many ways in which BIM can be used to improve a facility owner's processes. The following, while not a comprehensive list, are some BIM Uses applicable to facility owners. In most cases, owners are already performing these items through other methods, however without the context of BIM. The integration of BIM and facility data within these tasks allow for improved and often more cost effective processes. Some of the more critical BIM Uses in operations include:

Record Modeling: Record Modeling is the process used to depict an accurate representation of the physical conditions, environment, and assets of a facility. The record model should, at a minimum, contain information relating to the main architectural, structural, and MEP elements. It is the culmination of all the BIM Modeling throughout the project, including linking Operation, Maintenance, and Asset data to the As-Built model (created from the Design, Construction, 4D Coordination Models, and Subcontractor Fabrication Models) to deliver a record model to the owner or facility manager. Additional information including equipment and space planning systems may be necessary if the owner intends to utilize the information in the future.

Building Maintenance Scheduling: Building Maintenance Scheduling is a process in which the functionality of the building structure (walls, floors, roof, etc) and equipment serving the building (mechanical, electrical, plumbing, etc) are maintained over the operational life of a facility. A successful maintenance program will improve building performance, reduce repairs, and reduce overall maintenance costs.

Building System Analysis: Building System Analysis is a process that measures how a building's performance compares to the specified design. This includes how the mechanical system operates and how much energy a building uses. Other aspects of this analysis include, but are not limited to, ventilated facade studies, lighting analysis, internal and external CFD airflow, and solar analysis.

Asset Management: Asset Management is process in which an organized management system is bi-directionally linked to a record model to efficiently aid in the maintenance and operation of a facility and its assets. These assets, consisting of the physical building, systems, surrounding environment, and equipment, must be maintained, upgraded, and operated at an efficiency which will satisfy both the owner and users in the most cost effective manner. It assists in financial decision-making, short-term and long-term planning, and generating scheduled work orders. Asset Management utilizes the data contained in a record model to populate an asset management system which is then used to determine cost implications of changing or upgrading building assets, segregate costs of assets for financial tax purposes, and maintain a current comprehensive database that can produce the value of a company's assets. The bi-directional link also allows users to visualize the asset in the model before servicing it potentially reducing service time

Space Management & Tracking: Space Management & Tracking is a process in which BIM is utilized to effectively distribute, manage, and track appropriate spaces and related resources within a facility. A facility building information model allows the facility management team to analyze the existing use of the space and effectively apply transition planning management towards any applicable changes. Such applications are particularly useful during a project's renovation where building segments are to remain occupied. Space Management and Tracking ensures the appropriate allocation of spatial resources throughout the life of the facility. This use benefits from the utilization of the record model. This application often requires integration with spatial tracking software.

A detailed list of BIM Uses for all lifecycle stages along with descriptions, value, resources and competencies required is provided at http://bim.psu.edu.

Establish Desired Levels of Implementation Maturity

Having mapped the status of the Planning Elements within the organization, the desired levels should be identified in the maturity profile. These desired levels should be the areas which would need to be achieved for reaching the BIM Objectives. An organization may not need to advance to level five to obtained the desire level of BIM implementation.

Planning Element	Description	Level of Maturity						Current Level	Target Level	Total Possible
Strategy	the Mission, Vision, Goals, and Objectives, along with management support, BIM Champions, and BIM Planning Committee.	0 Non-Existent	1 Initial	2 Managed	3 Defined	4 Quantitatively Managed	5 Optimizing	11	20	25
Organizational Mission and Goals	A **mission** is the fundamental purpose for existence of an organization. **Goals** are specific aims which the organization wishes to accomplish.	No Organizational Mission or Goals	Basic Organizational Mission Established	Established Basic Organizational Goals	Organization Mission which addressed purpose, services, values (at a minimum)	Goals are specific, measurable, attainable, relevant, and timely	Mission and Goals are regularly revisited, maintained and updated (as necessary)	3	5	5
BIM Vision and Objectives	A **vision** is a picture of what an organization is striving to become **Objectives** are specific tasks or steps that when accomplished move the organization toward their goals	No BIM Vision or Objectives Defined	Basic BIM Vision is Establish	Established Basic BIM Objectives	BIM Vision address mission, strategy, and culture	BIM Objectives are specific, measurable, attainable, relevant, and timely	Vision and Objectives are regularly revisited, maintained and updated (as necessary)	2	4	5
Management Support	To what level does management support the BIM Planning Process	No Management Support	Limited Support for feasibility study	Full Support for BIM Implementation with Some Resource Commitment	Full support for BIM Implementation with Appropriate Resource Commitment	Limited support for continuing efforts with a limited budget	Full Support of continuing efforts	3	4	5
BIM Champion	A BIM Champion is a person who is technically skilled and motivated to guide an organization to improve their processes by pushing adoption, managing resistance to change and ensuring implementation of BIM	No BIM Champion	BIM Champion identified but limited time committed to BIM initiative	BIM Champion with Adequate Time Commitment	Multiple BIM Champions with Each Working Group	Executive Level BIM Support Champion with limit time commitment	Executive-level BIM Champion working closely with Working Group Champion	1	3	5
BIM Planning Committee	The BIM Planning Committee is responsible for developing the BIM strategy of the organization	No BIM Planning Committee established	Small Ad-hoc Committee with only those interested in BIM	BIM Committee is formalized but not inclusive of all operating units	Multi-disciplinary BIM Planning Committee established with members from all operative units	Planning Committee includes members for all level of the organization including executives	BIM Planning Decisions are integrated with organizational Strategic Planning	2	4	5
BIM Uses	The specific methods of implementing BIM	0 Non-Existent	1 Initial	2 Managed	3 Defined	4 Quantitatively Managed	5 Optimizing	4	8	10
Project Uses	The specific methods of implementing BIM on projects	No BIM Uses for Projects identified	No BIM Uses for Projects identified	Minimal Owner Requirements for BIM	Extensive use of BIM with limited sharing between parties	Extensive use of BIM with sharing between parties within project phase	Open sharing of BIM Data across all parties and project phases	3	5	5
Operational Uses	The specific methods of implementing BIM within the organization	No BIM Uses for Operations identified	Record (As-Built) BIM model received by operations	Record BIM data imported or referenced for operational uses	BIM data manually maintained for operational uses	BIM data is directly integrated with operational systems	BIM data maintained with operational systems in Real-time	1	3	5

Figure 2-4: Organizational BIM Assessment Profile with Desired State

The alignment to a desired Level of Maturity may require a considerable amount of time. The Planning Committee should not only identify the desired levels, but also investigate the level of effort and potential schedule for making the change to inform the planning of their stages for integration. It is important to consider the difference between their desire and the ability for the organization to change. An organization should understand that while it might desire to reach a particular level of maturity; it also needs to plan the outcome based on its ability to do so over a realistic period.

Finally, you must consider the interdependencies associated with each BIM Use. When considering a BIM Use, it is helpful to develop a long-term plan to map out the progression of BIM Uses. For example, if you desire Digital Fabrication as a BIM Use, it may require Design Authoring and 3D Coordination as prerequisites.

Advancement: Develop an Advancement Strategy

The implementation process will vary from one organization to another depending on the goals and objectives, the size of the organization, time and financial investment, ang experience with BIM and the available resources. Advancement planning helps the Planning Committee determine a defined approach to avoid the risk of escalating costs and misdirected time and resources. Advancement planning also establishes a baseline to track progress at predetermined milestones or points in time.

Strategic BIM Roadmap

Roadmapping is the process of displaying the integration of strategic changes in a business process. A roadmap quickly communicates the key components of the organizations strategic plan in a simple graphical representation or snapshot view.

To roadmap the BIM strategy for an organization, it is valuable to understand the type of information to be displayed and the steps involved in developing a roadmap. The categories defined for developing a strategic roadmap include:

- Planning elements;
- Time frame;
- Current status of the organization with BIM (Where are you now?);
- Desired end state of the organization with BIM (Where do you want to be?);
- Intermediate stages or milestones required to be achieved (How to get there?); and
- BIM Uses that will be used internally within the organization.

/// CASE STUDY EXAMPLE: Penn State office of Physical Plan Roadmap

Figure 2-5 Shows an example of Penn State's Office of Physical Plant's BIM Strategic Roadmap. The vertical axis delineates the levels of implementation within the organization, while the horizontal axis provides the goals with anticipate completion timeframes.

	1 Year	2 Year	5 Year	10 Year
Work Control Center	Deploy Maximo 7	Begin integration of BIM with Maximo systems	Standard information integration for assets and space	Full integration of all major information systems within the university
D&C	Integrate BIM and Revit into design process Advance BIM in construction	Full integration of BIM within design and construction	BIM becomes standard process for all projects	Undetermined
Energy & Engineer	Begin integration of energy into BIM	-	Begin integration of energy and BAS data into Maximo system	Undetermined
FRP	-	FIS system replaced with BIM and Maximo	Full adoption of new FIS system	Undetermined
Common wealth Serv	Integrate BIM and Revit into design process Advance BIM in construction	Full integration of BIM within design and construction	BIM becomes standard process for all projects	Undetermined
Campus Plan & Design	Education	Provide basic visualization tools	-	Develop virtual campus
Bldg & Gnds	-	Use information from BIM for maintenance	Full adoption of BIM information	-
Admin & Financial	OPP stores and Maximo Integration	-	BIM info linked with stores to improve predictive purchasing	-

Figure 2-5: Penn State OPP Strategic BIM Roadmap

Roadmaps are used as a tool to plan, visualize, and implement a strategy. Since each organization is different in terms of the objectives and services that they perform, customization will be required to leverage maximum benefit from road mapping. Some sections of a roadmap that should be considered by an organization are:

1. TIME: Time can be represented in a number of methods (i.e. months, quarters of a financial year, years, or milestones). Organizations should consider representing time in short intervals (the Penn State OPP Roadmap in years) when considering their next adoption phase. The latter part of the time axis which shows the maturity in more advanced stages of development, longer periods may be needed to achieve the long-term vision and objectives of the organization.

2. INTEGRATION / STRATEGIC DRIVERS: Significant effort should be placed on the development of integration/strategic drivers. To push

the integration of a process or technology, it is important to identify the layers and sub layers that are defined by the strategic drivers. The drivers also include the BIM Uses that the organization intends to integrate over the period determined by the BIM Planning Committee. The space on the earlier section along the time scale will display the current situation of these planning elements, the middle layer with the milestones or intermediate goals, and the later portion with the end state followed by the long-term vision.

3. SUPPORTING INFORMATION: The Planning Committee needs to identify the information to be displayed on the roadmap in addition to time and the drivers. These items include the people responsible to implement the phases, checkpoints throughout the time frame, and links between drivers that support the advancement of one another.

The development of a detailed roadmap involves multiple work sessions or workshops with various members of the Planning Committee and the operational units of the organization. An analysis of the status, the desired level of maturity, and the gaps to be bridged should be identified. The sequence in which the BIM Planning Elements are to be approached should be assessed based on the BIM goals and objectives

Business Case for BIM Use(s)

An effective Business Case generates support, participation and leadership commitment required to transform an idea into reality. For most organizations, a Business Case is necessary to gain support and to justify investments for implementing the targeted BIM Use(s) to the management and key decision makers in the company. The Business Case does not focus on the details of the implementation of BIM, nor detailed contract language, but rather is focused specifically on the business drivers to consider when investing in a BIM Use(s).

The development of a Business Case is a collaborative effort. The BIM Planning Team, including representatives from the operating units affected, creates the Business Case. A Business Case for BIM Use(s) includes the following items (at a minimum):

- Executive Summary of Business Case
- Table of Contents
- Introduction and Background
- Business Drivers and Problem Statement
- Desired Business Goal(s) and Objectives
- Proposed BIM Use(s)
- Cost / Benefit Analysis
    - o Estimated Benefits and Metrics
    - o Cost Estimates
    - o Risk Assessment
    - o Assumptions
- Implementation Timeline
- Final Recommendations

An appropriate amount of time should be devoted to developing the Business Case. Some research has suggested that a general rule of thumb is that the development of the business case should take approximately five to ten percent of the anticipated implementation / transition time. The length of the Business Case should be kept to a minimum for a clear and concise understanding of factors weighing into the decision whether or not to implement a BIM Use(s).

/// Implementation Planning

After establishing a strategic plan for the integration of BIM within your processes, you should develop a detailed plan to achieve the goals outlined. During this stage, the goals and objectives of the strategic plan are translated into day-to-day projects and tasks to integrate BIM into the organization's processes.

Establish a BIM Implementation Team

The first step in the BIM Implementation Planning process is to establish the BIM Implementation Team. While the Strategic Planning Committee was tasked with developing the high-level plan for the organization, the Implementation Team is to be composed of the individuals personally responsible for the execution of BIM.

Determining BIM Implementation Team Members

Having the proper personnel is one of the most critical factors to successful implementation and integration of BIM. The BIM champion(s) and a few key members of the Strategic Planning Committee should become members of the Implementation Team, but this team should primarily consist of the people responsible for implementing each BIM Use defined in the Strategic Plan.

The Implementation Team members should be determined according to the BIM Uses and Roadmap developed in the Strategic Plan. The individual whose responsibilities most closely influence the success of a BIM Use are the most likely candidates. They should be open to change, possess the authority to modify processes within their division, and have the ability to dedicate time to BIM implementation.

/// CASE STUDY EXAMPLE: Penn State Office of Physical Plant

The Penn State Office of Physical Plant is developing preventative maintenance uses for BIM. To support this development, they have members from the preventative maintenance management as part of their Implementation Team. This provides valuable inside knowledge of how preventative maintenance is approached from within the organization, and how BIM can supplement their efforts.

Over time, BIM integration may change or expand to additional divisions within an organization, and it will become necessary to modify the members of the team to maintain members who can provide valuable guidance to the tasks being implemented.

Roles and Responsibilities

With a BIM Implementation Team established, the roles and responsibilities of each member of the team should be established and documented. This includes requirements and deliverables for each of the individuals on the team. It may be necessary to divide the responsibilities amongst multiple individuals depending upon the organization's size and structure.

BIM Champion(s)

An organization should have at least one BIM Champion with a strong desire to implement BIM within the organization. It is their responsibility to take the planning process to its conclusion and share its value with others to ensure that the proper amount of resources (time, personnel, and effort) is given to planning.

Responsibilities

- Develop Organizational BIM Standards and Processes including contract language; and
- Oversee BIM implementation within the organization.

Capabilities

- BIM expertise;
- Self-motivated individuals; and
- Easily adaptable to ever changing processes.

Management BIM Advocate/Sponsor

It is critical to have management buy-in to the concept of using BIM to improve operations to ensure a successful planning process. Establishing a BIM Sponsor at the management level of the organization is often helpful to BIM implementation. Management must understand the resources necessary for successful BIM implementation including time, personnel, and effort and the ability to ensure that these resources are made available.

Responsibilities

- Promote organizational BIM Adoption and Change.

Capabilities

- Ability to provide financial support for BIM adoption;
- Basic understanding of BIM; and
- Understanding of organization's BIM goals and objectives.

Operating Unit BIM Leads

Within the BIM Implementation Team, each primary operating unit of the organization should have a BIM Lead. The operating unit BIM Lead will provide valuable information to the BIM planning about the operating unit's processes and information needs; will evaluate BIM planning results; will implement BIM with the operating unit. The operating unit BIM lead does not need to be the manager of that operation but should have influence within the operating unit and the support of the operating unit's manager.

Responsibilities

- Document operating unit's processes and information needs;
- Validate BIM Plans appropriateness for the operating unit;
- Lead implementation and integration of BIM within the operating unit.

Capabilities

- Significant influence within the operating unit;

- Detailed understanding of BIM's impact the operating unit; and
- Training on BIM systems related to that operating unit.

Acquiring a Consultant to Assist in BIM Implementation

If it is decided that the organization does not have the necessary internal resources, it may be necessary to procure outside expertise. Many owners have recognized that acquiring a consultant to guide their internal staff may expedite the adoption process. If you hire a consultant, they hsould possess the skills necessary to implement BIM, and have the potential to assist the BIM Implementation Team.

Design BIM Integrated Processes

It is essential to understand and document the current state of the organizational processes. Once the current processes are documented, those that will become BIM integrated processes are mapped. These new BIM integrated operations should also be thoroughly documented and be included along with the activities of the entire organization.

Methods of Documentation

There are several methods that can be used to map processes. Some of the more commonly used methods include integrated definition (IDEF) with IDEF0 Functional Modeling, Unified Modeling Language (UML), and Business Process Modeling Notation (BPMN). Each process modeling technique has its own benefits and purpose, and one is not necessarily better than another. Each organization should select a standard to offer consistency throughout the organization. Many organizations already have a standard in place and should continue with that standard. The BIM Project Execution Planning Guide's maps are based on Business Process Modeling Notation. An explanation of symbols within that notation can be found in the BIM Project Execution Planning Guide. Additionally, example process maps for a select number of the BIM Uses can be found on the project website (http://bim.psu.edu).

Organizational Structure and Process

Unlike a facility construction project, which typically has a finite beginning and end, operating a facility is a continuous process. Facility operations typically consist of multiple different operating units that have defined tasks and responsibilities. It is these tasks and responsibilities that should be clearly documented.

There are several methods to accomplish documenting the organizational structure. In most cases, organizations have their structure already documented. This documentation may or may not include tasks and responsibilities. Another method to document organizational structure with tasks

and responsibilities is to meet with each operating unit's manager and together determine the responsibilities of the unit. Additionally, the BIM Implemention Team should be identified within this structure. It may lie outside the primary structure as its own operating unit or it may be aligned with multiple units. Once the structure has been identified, the BIM Uses selected by the organization should

Current Processes

The processes that will integrate BIM during the course of the Implementation Plan are mapped to provide a basic understanding of the current process and to help with developing a transition process. The processes should be documented through meeting with the head of each operating unit or meeting with the implementers of the process. Another way to document the process is through observation of the tasks. The process should also include the information exchanges between operating groups. After an observation or meeting, the process should be documented using a process mapping notation decided on by the group. After the process is documented, the process stakeholders should review and edit the document until it accurately represents the workflow of the organization.

Target Processes

Once the current processes are documented, the Implementation Team, with the assistance of the operating unit members, can design suggested revisions to current process map to include the integration of BIM. This will include replacing, adding, or editing processes within the map in order to more appropriately utilize BIM. The process map will also need to include any new or revised information

Form Clear Tasks for Transition

Once both the existing and target processes for each BIM Use are developed and documented, a detailed advancement/ transition plan for each of the BIM Uses identified for advancement can be created to allow for smooth transition between the current process and the new process. It is critical to identify the tasks required to transition the process to a BIM integrated process. The tasks should include measureable outcomes and milestones with a timeline for the completion of each transition. Some items to be considered are purchasing software, training, setting-up new systems, creating process guidelines, and progress monitoring. More tasks may need to be determined based on the status of the organization and the specific task, which is being transitioned. There are several ways to display this transition process including, for example, a process mapping notation or a critical path method (CPM) schedule.

Overall Transition Plan for the Organization

After the detailed transition plan for each BIM Use has been documented, an overall transition map for the duration of the implementation plan is created. This should include the adoption of each BIM Use at every level of maturity, along with other critical milestones. The transition plan should include a timeline for completion of the milestones and can be displayed using several methods including process mapping notation or a CPM schedule. The timeline should reflect the transitions in the process over the planning period.

Document Model and Facility Data Information Needs

For each working group and process defined in the prior step, the geometric model and facility data requirements are to be defined and documented. The information requirements should then be summarized and compiled into overall organizational information requirements. There are two primary items to be considered when determining information needs: the geometric model and facility data. The geometric model is an electronic, three-dimensional representation of facility elements with associated intelligent attribute data (facility data). Facility data is non-graphical information that can be stored for objects within the geometric model that defines various characteristics of the element. Facility data can include properties or attributes such as manufacturing data, materials, and project identification numbers. It is important to consider both types of information when defining information requirements.

How to Determine Information Needs

Similar to how the processes were documented; the most comprehensive method to determine information needs is by interviewing key stakeholder in each working group. This can be performed during the process documentation or at separate follow-up meetings. Alternatively, it is possible to have the BIM Implementation Team make an initial pass at the information needs using the information needs template available at the project website (http://bim.psu.edu).

If the organization has undefined information needs, the BIM Implementation Team may determine that it is more beneficial to adopt the information needs documented by other organizations. Organizations such as the DoD Military Health System, the US Army Corps of Engineers, Penn State Office of Physical Plant, and the Department of Veteran Affairs, along with others, have comprehensive information needs documented in their contract language, which is freely available.

To determine the information needs for the working group or organization, four primary questions should be addressed:

1. What building elements or other information (e.g., rooms and zones) is tracked and what additional formation would be beneficial to track?

2. What information is beneficial to be displayed geometrically (in a model) and what information is best displayed in a spreadsheet or database?

3. What is the level of development necessary for each element of the Model to receive the benefit?

4. What are the properties or facility data about the building elements that need to be documented, including those that are currently tracked and those that would be beneficial to be tracked?

Choose a Model Element Breakdown Structure for the Organization.

To transfer information seamlessly from one application to another, information must be categorized according to a model element standard. To answer the four questions above for each operating unit, the BIM Implementation Team

should use an element breakdown structure similar to the Information Needs Template. There are several different model element breakdown structures that can be used depending upon the granularity the organization wishes to document. The Information Needs Template, provided at http://bim.psu.edu, is based on the OmniClass Table 21 – Elements breakdown structure; however OmniClass Table 22 – Work Results, and OmniClass Table 23 – Products are viable options as they are open standards which can be freely shared. CSI UniFormat and MasterFormat are also widely used depending on an organizations existing documentation format. It is important to note that some breakdown structures lack information that may be important to owners, e.g., spaces, zones, or temporary facilities, and therefore, the team may wish to add these elements.

Determine Model Needs

Once a model element breakdown structure has been selected for the organization, the model needs of each facility element for each working group should be determined. Stepping through each element of the facility data and determining if a visualization of that element would be beneficial to the working group can accomplish this.

Determining Level of Development

If a model element has been determined to be valuable to the working group, the working group then determines what Level of Development (LOD) is necessary to achieve the benefit for that specific model element. The Level of Development describes the level of completeness to which a Model Element is developed. There are several ways that Level of Development can be documented. An indicator for the Level of Development, as found in the original BIM Project Execution Planning Guide and shown in Figure 3-1, can be used to represent geometric reliability.

	INFORMATION
A	Accurate Size & Location, Include Materials and Object Parameters
B	General Size & Location, Include Parameter Data
C	Schematic Size & Location

Table 3-1

A more detailed option to select is the Level of Development (LOD) defined in the model progression specification and adopted in AIA E202. This Level of Development is currently the most widely accepted breakdown in the industry. The descriptions are in the process of being updated, however Table 3 1 shows an example of the Level of Development descriptions. An additional format has also been proposed by the US Army Corp of Engineers which is the Minimum Model Matrix (M3) which is available at https://cadbim.usace.army.mil/. If possible, it is recommended that, at a minimum, an organization would select an industry standard.

LEVEL OF DEVELOPMENT	DESCRIPTION
LOD 100 SCHEMATIC DESIGN MODEL	Overall building massing indicative of area, height, volume, location, and orientation may be modeled in three dimensions or represented by other data.
LOD 200 DESIGN DEVELOPMENT MODEL	Model Elements are modeled as generalized systems or assemblies with approximate quantities, size, shape, location, and orientation. Non-geometric information may also be attached to Model Elements
LOD 300 CONSTRUCTION DOCUMENTATION MODEL	Model Elements are modeled as specific assemblies accurate in terms of quantity, size, shape, location, and orientation. Non-geometric information may also be attached to the Model Elements.
LOD 400 CONSTRUCTION MODEL	Model Elements are modeled as specific assemblies that are accurate in terms of size, shape, location, quantity, and orientation with complete fabrication, assembly, and detailing information. Non-geometric information may also be attached to Model Elements.
LOD 500 RECORD MODEL	Model Elements are modeled as constructed assemblies actual and accurate in terms of size, shape, location, quantity, and orientation. Non-geometric information may also be attached to modeled elements.

Table 3-2

Determining Facility Data Needs

One item that the Level of Development does not specify is the facility data needed about each facility element. The facility data, attributes, and properties should be specified about each element and even elements not modeled may require facility data to be documented. There are several examples of the properties that need to be collected for each element. A few of these include the MHS Facility Life-Cycle Management (FLCM) Building Information Modeling (BIM) Minimum Requirements and the object element matrix in the VA BIM Guide . These examples, which vary in level of detail, can be used as a basis for an organization facility data needs. Additionally, it is possible to specify facility data properties necessary using the items list in Omni-Class Table 49 - Properties.

Another option when selecting attributes and necessary facility data is to select necessary columns of the Construction Operations Building Information Exchange (COBie) worksheets. COBie is designed to enable information exchanges between data sources by providing a standard structure for facility data. It does not however specify what properties an organization needs to track and populate. This is up to the organization. Figure 3 2 shows an example the properties in the component tabs of COBie 2.26.

Name	CreatedBy	CreatedOn	TypeName	Space	Description	ExtSystem	ExtObject	ExtIdentifier	SerialNumber	InstallationDate	WarrantyStartDate	TagNumber	BarCode	AssetIdentifier
	Email		Name	Name			objComponent							

Figure 3-1: Example of the Components Tab Properties in COBie 2.26

Compile Organizational Information Needs

After both model needs and facility data needs have been determined for each operating unit, they should be compiled into a single list of information needs for the organization. This can be accomplished by selecting the highest Level of Development for each model element and by compiling the facility data elements. When choosing a standard term for the property, the term selected could originate from the OmniClass Tables documented or the COBie Spreadsheet when available, as these are becoming standards. Once all the information needs are compiled, they are used as a central structure for all the model and facility data information needs throughout the organization. It may be beneficial to identify both required and optional information elements since there is a cost to compiling the information for each project, and the owner must consider the cost to value for the information elements.

Determine Infrastructure Needs

While this guide primarily focuses on the process changes caused by BIM, it may be necessary to procure additional infrastructure to support those process changes. The infrastructure needs should consider the BIM Uses, processes, and information needs of the organization. The infrastructure that an organization should consider includes software, hardware, and physical spaces.

Selecting Software

Selecting the proper software is one of the critical factors to successful BIM implementation within the organization. There are many factors that should be considered when selecting software. Of these, it is important to always ask, "Does the software meet the needs?" Before purchasing and evaluating software, an organization should know the purpose they are trying to accomplish with the implementation of that software. In this case, what BIM Use does this software support and how well does it support it.

Factors to Consider when Selecting Software Systems

Chan (1995) has defined the following factors for consideration when selecting software:

VARIABLE	FACTOR
SOFTWARE (TECHNICAL)	-Availability of an integrated hardware/ software package -Compatibility with existing hardware/software -Ease of use/user-friendliness -Availability of source code
SOFTWARE (NON-TECHNICAL)	-Price (initial cost and maintenance/upgrades) -Popularity
VENDOR (TECHNICAL)	-Technical support -User training -Technical skills -Experience of using products developed by the
VENDOR (NON-TECHNICAL)	-Reputation -Business skills -References -Past business experience with the vendor
OPINIONS (TECHNICAL SOURCES)	-Potential vendors/sales representatives -In-house "experts" -External consultants -Public Reviews
OPINIONS (NON-TECHNICAL SOURCES)	-Subordinates -End-users -Outside personal acquaintances

Table 3-3: Factors to Consider when Selecting Software Systems

Types of Software Systems

Software needs to be selected to support the BIM Uses. The list of software packages that support BIM implementation is constantly shifting and growing. It is important that the organization knows what they need the software to support and keeps in mind that one software package may support multiple BIM Uses. However, it may not be feasible or desirable to obtain all the organization's BIM objectives through one software package.

Four major categories of software systems to be considered for owner use include:

Facility Management Systems (FMS)

Facility Management Systems are software packages that support the maintenance and management of a facility. It helps to manage work orders, assets, inventory, and possibily safety. Some names that can be classified under Facility Management Systems include Computerized Maintenance Management Systems (CMMS), Computer-Aided Facility Management (CAFM), and Computerized Maintenance Management Information System (CMMIS). If an organization has a FMS, it should be evaluated for its ability to support the BIM Data and Uses as defined in the previous steps. If an organization does not have a FMS, it is important that the proper one is selected.

Some additional factors to consider when selecting a FMS include :

- **Standalone**: Is the system standalone or are there extra software packages or modules that should be purchased? Some systems should be mounted on top of other systems or require the purchase of multiple modules.
- **Scope**: What are the services that the FMS provide? How does each service integrate? How does the FMS support the BIM Uses selected?
- **Integration with Legacy Data**: Does the FMS support the import and/or export of data to other systems? It is especially important to consider the integration and acceptance of BIM Data. Does the FMS have the ability to import and/or export BIM data directly from the BIM Model? Does the FMS support open standards for data transfer such as COBie, IFC BIM model and the information within the BIM Model directly within the FMS? How seamless is the integration? Also consider how the FMS handles other graphical data such as photographs and plans.
- **Vendor**: Does the vendor install and customize the software? Does the vendor handle upgrading legacy data? What is the software support and training programs provided?

Design Authoring

Another common purchase for an owner is Design Authoring systems. Design Authoring systems support the BIM Uses such as Drawing Production, Design Review, and 3D Coordination. The first question that must be asked, is whether the owner needs the system. If your organization does self-perform tasks, then it is most likely these systems will need to be purchased. However, if your organization simply reviews a model provided by others, then most software systems provide a "free viewer" to view the model.

Facility Monitoring and Control

Facility tracking software systems help to track the performance of a facility in regards to environmental, HVAC, and energy monitoring, to name a few. It may be possible that these tools are integrated into a FMS. However, if not part of the current and future FMS, the organization should consider how they are going to monitor their facility. When

purchasing facility tracking software systems, an organization should consider the ability to monitor additional new facility systems and the integration of the tracking systems.

Planning/Design/Construction Software Systems

The organization should also consider additional software systems for planning, design, and construction of facilities. These software systems should be considered when developing an organization's BIM Project Execution Plan Template. It is critical to consider what software is necessary to pull information from the FMS and the operation of a facility to improve future design. In addition, organizations should consider how the design and construction information will be able to support the operational systems if they have already been established.

Choosing Hardware

Not having the proper hardware to support the software systems can lead to challenges and frustration when implementing and integrating BIM. It is essential that the organization understands the hardware specifications of the computers on which models are created. If the owner does not match or exceed those specifications, the model and data created throughout design and construction may become unusable in operations. Also, it is important to ensure that the hardware supports the BIM Uses that were selected for the operation of the facility.

Interacting with Facility Data

The organization should consider how the end-users will interact with the data. This includes both the device and physical space. Three workstation types that need to be considered are mobile, fixed, and collaborative, each of which has its own benefits and drawbacks.

Mobile Workstations

If the end-user is mobile, it may be possible to access information via a smart phone, slate, or tablet devices. A number of software vendors supply mobile versions that can seamlessly access facility data from the cloud. These versions allow for ease of access of the facility data and the ability to update information in the location in which the task is being performed. Additionally, tablets and smart phones usually have a smaller learning curve than a personal computer.

Fixed/Semi-Fixed Workstations

If the end-user does not change locations often, consider a desktop computer. If there are occasions that the end-user has to relocate but can work at a desk consider a laptop computer. In either case, a personal computer usually affords the user more processing power and higher functionality of software. When selecting a computer, the most critical specifications to consider are the processor speed, the amount of RAM, and the graphics card. Additionally, selecting a large format display or multiple monitors may also allow for productivity improvements.

Collaborative Workstations

The implementation team should also consider how the end-users interact with each other when determining infrastructure needs. It may be valuable to develop collaborative spaces to allow for interacting with the data in a larger group. First, the organization should consider the necessity of this space or if they already have a space that could be converted into a more collaborative environment. If the organization decides to proceed with the development of a new collaborate environment, they should consider a number of items. First, the number of people the space should support, remembering that anything much larger than 20 persons should be a presentation space rather than a collaborative workspace. Second, the display should be considered. Based on the size of the space, the number of people it supports and the primary purpose of the space, the display can be selected. Consider items such as large high definition monitors, interactive displays and large format projection, remembering that in any case, size and resolution of the display is important. Also, do not discount the importance of the furniture and general space characteristics such as lighting.

Education and Training

There are many different strategies related to both educating and training personnel about Building Information Modeling. While the definition of education and training are very similar, in this context the purpose of the instruction varies. Training is to teach someone to become fit, qualified, or proficient in a specific task or process, while educating is to formally instruct about a body of knowledge regarding subject – in this case BIM.

Education

Education is critical to helping an organization better understand BIM and the organization's purpose for using BIM. It is important that an organization develops a consistent education program for the staff about the true capabilities of BIM, to educate the staff, but not oversell the capabilities of BIM.

What To Teach

An organization needs to determine what is important to convey through the various education mediums. A few examples of these items include:

- What is Building Information Modeling and how can BIM be use?
- What is the organization's purpose for BIM including mission statements and the Strategic BIM Plan?
- How BIM influences their roles and responsibilities, and their processes?
- What are the organizational lessons learned and the resources available?

Additional Education

Like other forms of education, there are multiple levels of expertise required. The management of the organization may only need a basic introduction to BIM and what it means to the organization. While those who implement will need a much deeper understanding of what BIM is and how it can be used, along with how the organization plans to use it and how it influences their roles.

Education Methods

There are several different methods for educating employees on BIM. The majority of staff can be trained internally through workshops developed and taught by the BIM champion and implementation team. Additionally, software vendors or local chapters of various associations may provide education courses.

The key BIM personnel should receive continuous external training to promote their development. These processes and technologies are continuously evolving, and national conferences are a good way to keep up-to-date with recent advancements.

Training

In most cases, BIM training will relate to a specific process or software system. Before any training takes place, a training strategy should be established. The training strategy should include (1) what subjects to train on, (2) who needs what training, and (3) what are the methods to achieve the necessary training.

What To Train

First, a list of the necessary training subject should be generated. These items include new and existing organizational business processes and procedures, and new and existing software systems.

Who Needs What Training

Remember that not everyone in the organization needs to be trained on every software system or business process. In most cases, it is only necessary to train them on the purpose of an activity rather than on how to perform the activity

themselves. Typically, upper management needs only to be educated about BIM processes. Middle management, on the other hand, may need to have extensive education and only introductory training on different software systems. The implementers will need extensive education and training on the process and software systems, however the scope of their training and education may be much more focused. To maximize the organization's resources, including time, training should focus on the most important BIM Uses and their process integration.

Training Methods

The methods of training, like education, can be both internal and external. Often a software vendor will provide training with the purchase of software or for an additional fee. This may be necessary if no one in the organization has prior experience with the software. The training itself can take place in a classroom setting or on a website with tutorials. The training needs of the organization will vary based on the size of an organization and scope of the BIM adoption. It is up to each organization to determine to what extent and by what method are education and training necessary.

/// Procurement Planning

When shifting to the need for BIM use on projects being procured, the terms for BIM shift from the uses of the model, to the providing of BIM services by the designers, contractors, or consultants involved in a given project. To procure BIM services on a project, an owner needs to communicate their BIM goals to the project team. This documentation sets the direction and the minimum requirements of the project before any design or construction begins. To successfully accomplish this, it is critical to plan ahead and determine the BIM needs for the project. This section of the Guide addresses many of the issues an owner may wish to consider when planning for procuring BIM services.

Prior to the start of a new project, the owner should develop, or update, the procurement language for the upcoming project. This procurement language is necessary to ensure that the owner's needs are met, and the project team understands the scope and detail of the requirements to which they are agreeing. Having the BIM requirements documented prior to the start of the project allows the team to begin the BIM process earlier and more effectively. There are three documents for procurement in which BIM should be included. These documents are:

1. TEAM SELECTION DOCUMENTS
2. CONTRACT REQUIREMENTS
3. PROJECT EXECUTION PLAN DELIVERABLES

Selecting the proper team sets the foundation for a successful BIM project. The requests for qualifications and proposals (RFQ and RFP) must contain adequate BIM language to communicate the owner needs and enable the owner to select a project team possessing the necessary skills.

The Contract Requirements should serve as the foundation to the BIM use within a project. The use of BIM Project Execution Plans serves as an interim tool for the team to align their project BIM Uses with the owner's needs, defined in the contract. The purpose of these documents is to provide a clear description of the BIM expectations to the project team. As Figure 4-1 indicates, the BIM Contract Requirements directly feed the BIM Project Execution Plan and they often contain similar information, and should complement each other, referencing the other document as necessary to eliminate duplication.

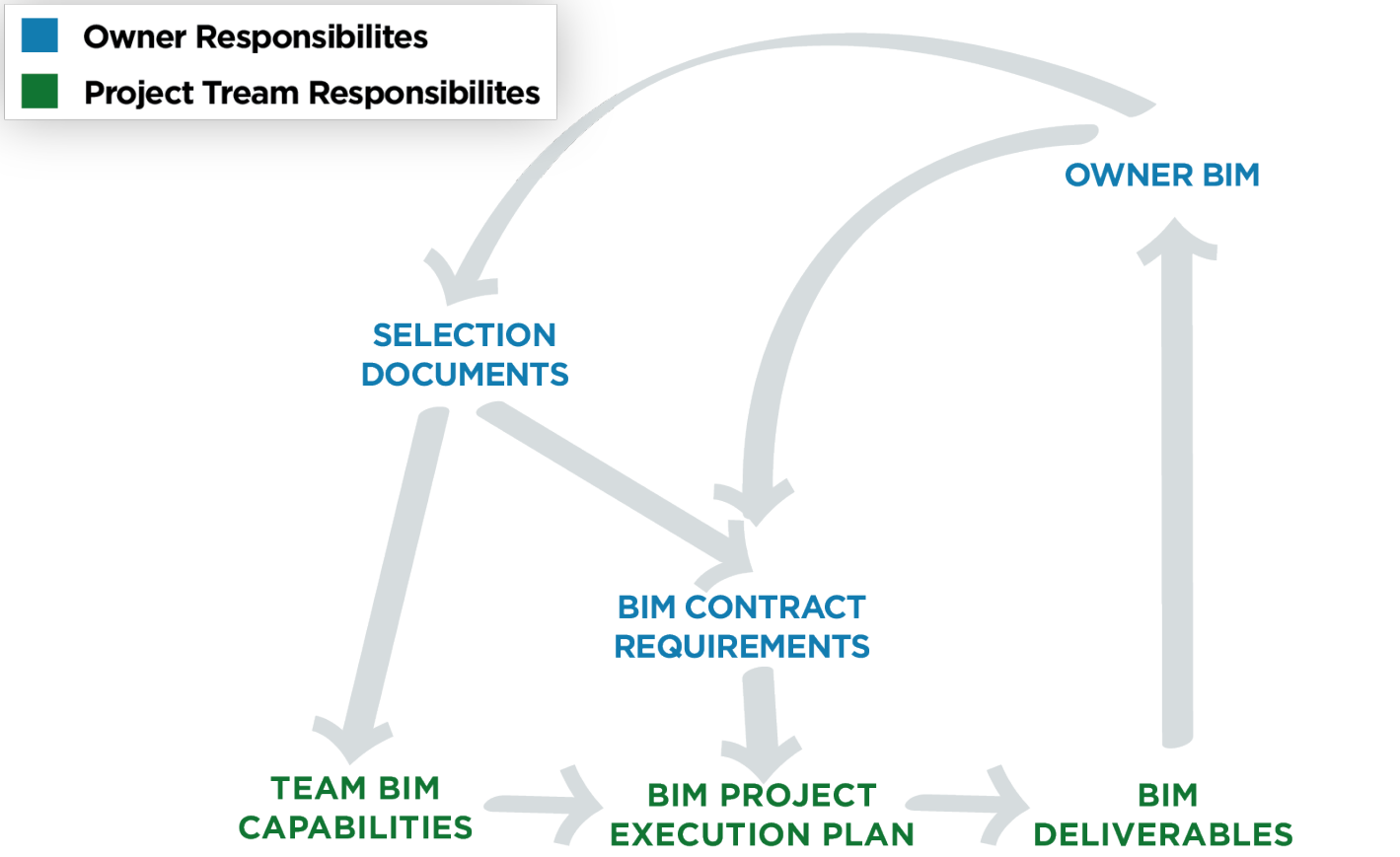

Figure 4 -1: BIM Procurement Areas

Prior to Developing Procurement Documents

Before your organization begins to develop BIM procurement documentation, it is beneficial to consider the general format of the contract and how BIM requirements may affect it. BIM contract requirements can be added into the existing design/ construction contract, or can be included as an addendum. For many owners who do not build on a regular basis, it may be most beneficial to include the BIM requirements into the existing contract in an effort to simplify the documentation. For owners who build on a frequent basis using standard contracts, it may be more beneficial that the Contract Requirements be added as an addendum for the following reasons:

1. BIM is constantly evolving resulting in frequent updates and modifications to the BIM contract requirements. Structuring the BIM contract re quirements as an addendum may simplify the update process.

2. The same addendum can be included in the design, construction, and prime contract. Using the same addendum for all project participants is beneficial because it minimizes the risk of discrepancies and increases the transparency of each partici pant's responsibilities.

When creating the requirements for each project, owners should require only the aspects of BIM which add value to the organization in line with the defined Roadmap, while keeping in mind additional items may add unnecessary risk and cost to a project. However, similar to design alternatives it may be beneficial to demonstrate the interest in certain BIM uses which may be more beneficial to a particular project type or may be unexpected opportunities to advance the BIM planning and roadmap efforts. Once the required and alternative uses are defined, the BIM Project Execution Planning Guide can assist the owner in determining value on a project-by-project basis with the selected team.

Existing BIM Contract Language Examples

Prior to developing your own BIM procurement documentation, it is beneficial to become familiar with existing industry BIM requirements, including how the organization's procurement method(s) affects the contract and how the documents complement each other. There are numerous BIM procurement language examples which an owner can reference when creating their own procurement language. Two examples are:

1. American Institute of Architects (AIA) E203 Building Information Modeling and Digital Data Exhibit
2. ConsensusDOCS 301 BIM Addendum

These documents were created as a means of providing BIM users with contract language to reference for the creation of their own documents. Each document takes a different approach to implementing BIM and many owners find it beneficial to include elements from both into their customized BIM contracts. There are also numerous owner created documents which are available for reference:

- Penn State OPP BIM Addendum V2.0 and BIM Execution Plan Template
- US Army Corps of Engineers Attachment F-BIM Requirements and USACE BIM Project Execution Plan (PxP) Template
- Indiana University BIM Guidelines and Standards
- State of Ohio BIM Protocol
- Los Angeles Community College BIM Standards and BIM Standard Template

These documents and many others have been created by facility owner organizations who wish to further specify their BIM requirements. Many of these guides have incorporated aspects from both AIA E202 and ConsensusDOCS 301 into their language, and have also added customized BIM language specific to their organization's present and future needs.

BIM in Different Procurement Methods

For BIM to reach its full potential, it is necessary for the project participants to work in a collaborative manner, working together and sharing information. Due to legal and situational restrictions, or preferences it is often necessary to procure projects using more specific organizational structures, contracting approaches, and selection methods such as Design-Bid-Build (DBB), Design-Build (DB), or Construction Management (CM). Although some delivery methods may facilitate easier sharing for BIM across organizational boundaries and closer collaboration than others, if the project emphasizes and the needs and necessary planning for BIM processes, the benefits of BIM can be achieved within all project delivery methods.

/// CASE STUDY EXAMPLE: Penn State Office of Physical Plant

Penn State University's Physical Plant is often required to procure projects using traditional delivery methods such as DBB with a CM. To foster collaboration between all the project participants, they hire the CM for preconstruction services and require all parties involved to agree to the same BIM contract addendum and Project Execution Plan. This makes it clear what Penn State expects from the project team, and what the project participants can expect from each other. Even though the primary contract creates no responsibility toward the other project participants (privity), the collaboration expectations written in the addendum and the BIM Project Execution Plan are clearly documented, thus facilitating the collaboration necessary for a successful BIM project.

Hierarchy of Documents

With the evolution of BIM processes and requirements that are typical with projects, it is important to define a hierarchy of documents within the contract requirements (if not already included in existing documents). This hierarchy prioritizes the documents in the event they contain conflicting information. While the order of hierarchy may depend on the organizational structure and may vary from one owner to another, it is important to consider how the hierarchy will affect the BIM process.

Potential contractual documents to prioritize:

- BIM Project Execution Plan
- Primary Contract Requirement
- Submittals
- BIM Contract or BIM Addendum
- Additional Contract Addendums

Potential design/construction documents to prioritize:

- Design Model(s)
- Construction Model(s)
- 3D Details
- Submittal Information
- 2D Documents
- 2D Details
- Embedded Model Information
- Database Embedded Information
- Specifications

Level of BIM Implementation

Implementing BIM on every project, particularly at the early stages of developing BIM requirements for your organization, may not be appropriate. Each project must be analyzed individually prior to the decision to use BIM. You may which to choose to set a minimum limit for which BIM is to be implemented based on size, scope, complexity, and cost of the facility. This provides a minimum threshold for BIM implementation, but still grants the flexibility to choose for each project. The Roadmap should be used to identify the defining traits for identifying the projects in which owner BIM uses are targeted, along with guidelines for consistent standards and requirements.

Typical reasons for implementing BIM on a project inlcude:

- The efficiencies gained through BIM are greater than the cost of implementing BIM Uses;
- The building has complex systems that would be difficult to construct without modeling ; and
- The owner desires to use the BIM model and information from construction for operations and maintenance.

Once the use of BIM requirements has been piloted, it becomes important to be able to define the attributes or traits

which impede BIM use on a project, partially because they may still vary on a project by project basis. Some example reasons an owner may choose not to implement BIM on a project include:

- The project is a small renovation scope or renovation and modeling the facility would add significant cost without providing an equal or greater benefit; and
- The local project teams are not capable of implementing BIM, or the scale of the project would prohibit smaller firms from competing.

The reasons are important because the clarification or breakeven point for implementing BIM is a moving target. The capabilities of a given team are variable, and can be defined as part of the selection process. Similarly, while the cost of accurately modeling an existing facility may seem high, the technologies are rapidly advancing and the benefit may outweigh the costs on any given project if implemented

Selecting a Project Team

Before any contract negotiation or BIM Project Execution Plan development can begin, the project team must be selected. Depending on the delivery method selected, a Request for Qualifications or Request for Proposals may be used.

Request for Qualifications

The Request for Qualifications (RFQ) is the first tool an owner has for determining the BIM experience of potential project team members. The items defined below are not specific to any discipline, but representative of both general design and construction capabilities expected for all of the team members that will become involved in a BIM use. After the qualifications are reviewed, the owner should be able to determine:

- Competence of the firm and its personnel with BIM based, on minimum BIM requirements;
- Ability of the firm's specific project personnel to meet minimum BIM requirements;
- Experience and means of sharing information with other design and construction firms;
- Experience in BIM Project Execution Planning and implementation;
- Standard BIM Uses and software platforms implemented on typical projects; and
- Technical Capabilities when implementing BIM, e.g.; can the organization self-perform the necessary requirements, or do they have to rely on a third party?

When analyzing the submitted qualifications, it is often helpful to use a scoring matrix to be able to consistently compare capabilities, similar to that shown in Table 4-1. Although it is sometimes difficult to determine the specific skills and capabilities of an organization and the potential team members, using a matrix can aid in organizing the submissions into a quantifiable score that can quickly and easily be ranked.

Planning Element	Description	Level of Maturity						Score
Category	**Category Description**	**0**	**1**	**2**	**3**	**4**	**5**	**0**
BIM Project Execution Planning Experience	The prior experience the team has with planning for BIM on projects	Team has no experience with BIM planning on a project	Team has completed discrete BIM Uses but has not composed a BIM plan	Team has assisted in BIM Planning with other teams	Team has led BIM planning on projects	Team has integrated BIM planning into standard operating procedures	Team has developed a standard BIM Execution Plan to use on projects	0
Collaboration Experience	How willing is the team to collaborate with others and what is their experience in doing so	Team has not collaborated with other teams and does not encourage collaboration	Team has collaborated on previous projects, but is not willing to share model/information fluidly	Team has experience and is willing to share information with other team members	Team leads collaboration efforts and encourages information sharing among parties	Team is willing to co-locate for a project	Team encourages co-location on all projects	0
BIM Tools	Is the project team competent in implementing various BIM tools	Team has not implemented BIM and is not willing to do so	Team has not implemented BIM, but is willing to	Team has implemented BIM to a limited extent	Team has implemented BIM on many projects if required by the owner	Team implements BIM tools on all projects	Team encourages all parties to implement BIM tools on all project	0
BIM Champion	Technical Capabilities	Team does not implement BIM or any other electronic technology	Team does not implement BIM but utilizes limited electronic communication tools	Team does not implement BIM but extensively uses electronic communication tools for items such as RFI, Submittals, etc	Team Uses BiM to a limited extent and electronic communication tools	Team implements cutting edge technologies on projects	Team is innovative in developing new technologies and BIM uses	0

Table 4-1: BIM Qualifications Scoring Matrix

It is important to require proof of qualifications. To filter through exaggerated BIM qualifications, an owner can ask questions such as the following:

1. Please describe a recent challenge in implementing BIM that you / your firm has overcome to be able to improve project outcomes?
2. Please explain the BIM training the project team has undergone.
3. Please describe any specific resources (personnel or other) that you expect to leverage for this project, and how you will enable success in the BIM Execution and overall project goals.
4. Please identify BIM uses you may be able to implement on this project that you have found as valuable and complementary to the other BIM uses we have requested.
5. Provide an example of a project(s) in which you previously implemented (BIM use). Provide the following information for each project:
   - A. Project Name
   - B. Building Type
   - C. Brief Project Description
   - D. Project size and value
   - E. Location
   - F. Completion Date
   - G. Description of value added through BIM implementation
6. Provide a completed BIM Project Execution Plan for a project mentioned in item 5. If no BIM plan was used, provide a detailed description of how BIM was used in project. Be sure to include roles and responsibilities, BIM Uses implemented, collaboration between project participants, and deliverables.

   Note: Requiring a BIM plan within the qualifications/proposal submission greatly increases the size of the submission, but provides the owner with important evidence as to the true qualifications of the project team.
7. Please explain the lessons you have learned from a recent project regarding model sharing or collaboration using BIM, preferably related to the BIM requirements we have requested.

Some of these questions would need to be provided with the RFQ to allow documentation to be submitted, while others may be more valuable in an interview to seek an ad hoc response from the team and their ability to respond to questions and changes in a BIM planning process.

Request for Proposal

The Request for Proposal (RFP) can provide the owner with a price and description of the proposed BIM Uses to be performed. The RFP should request the following information:

- A price for the proposed BIM services to be performed;
- A description the proposed BIM Uses, collaboration procedures, and deliverables;
- A description of the BIM project team; and
- A description of the BIM project team and their qualifications.

A sample of a proposal scoring matrix is shown in Table 4-2. Much like the matrix provided for ranking the qualifications of applicants, the BIM Proposal Scoring Matrix provides the owner with the ability to rank the proposals based on the BIM services of greatest importance, and identify deficiencies in proposals prior to any contract award.

Description	Level of Maturity						Score
Category Description	**0**	**1**	**2**	**3**	**4**	**5**	**0**
What is the total price for the listed services	Price is significantly different from the estimated price	Price is significantly higher than estimated price	-	Price is close to estimated price	-	Price is lower than estimated price but still within acceptable range	0
What additional BIM services are proposed	Many Required BIM Uses are not included in the proposed	A few required BIM Uses are not included in the proposal	-	All required BIM Uses are included in the proposal	-	Required and additional BIM Uses (with added value described) are included	0
How much experience and success has the proposed project team had	None	Team has had minimum success with BIM projects	Team has limited experience and success with BIM projects	Team has adequate experience with BIM projects	Team has significant experience with BIM projects	Team has expert experience with BIM projects	0
What collaboration procedure is included in the proposal	No collaboration procedure described	Team proposes a basic collaboration procedure	Team has developed a BIM Execution plan detailing collaboration	-	A detailed BIM Execution plan including a collaboration procedure is proposed	A detailed BIM Execution Plan including a collaboration procedure is proposed for every team member including onsite collaboration	0
What are the deliverables proposed	Minimum deliverables are not met	Some of the minimum deliverables are met	Most of the minimum deliverables are met	All of the minimum deliverables are met	All of the minimum deliverables are met and additional ones are proposed	All of the minimum deliverables are met and additional ones are proposed with a value added description	0

Table 4-2: Proposal Scoring Matrix

To score the proposals accurately, the owner should provide a detailed description of the services they expect to be provided. This description is often provided through the Contract Requirements and the Project BIM Execution Plan Template. In addition to explaining the requirements, it is also helpful to inquire about the project teams BIM experience and skill in BIM. Potential BIM RFP questions may include the following.

1. Describe the BIM Use your organization proposes to provide on this project. This should include proposed BIM Uses, collaboration procedures, and deliverables.
2. Who is the BIM Manager for the proposed project?
    - A. How many BIM projects has he/she managed?
    - B. What were the budgets for the projects?
    - C. What BIM Uses has the BIM manager implemented?
    - D. What were the final BIM deliverables?
3. Provide the total cost for the contracted BIM services.

4. What BIM Uses are assumed on all projects you perform?
5. What BIM Uses requested pose in this RFP the greatest challenge, and why?
6. What roles / responsibilities do you see us (the owner) playing in the BIM planning and turnover processs?

The questions are intended to help you narrow the field of firms that are capable of delivering the value of BIM for your project and supporting your organizational BIM goals. If a single selection step is used, you will want to combine questions from the RFQ and RFP discussions.

BIM Contract

The BIM contract (addendum) for projects is intended to document the standard BIM requirements of the owner organization. This document focuses on standard project goals and BIM objectives of the organization, while the BIM Project Execution Plan, developed with the project team after selection, will contain much of the project-specific BIM requirements, processes, and information workflows. It is recommended to include a *typical* BIM Project Execution Plan, if one is available, to communicate the expectations for the planning process and deliverables. The contract should complement the typical BIM Project Execution Plan, as they are intended to work together to create complete documentation for a project. In many situations topics, such as required BIM uses, will be introduced in the contract requirements, but will reference the BIM Project Execution Plan for project specific details. The elements of the BIM Contract Language should, at a minimum, include:

- Definition of Terms,
- Typical or template BIM Project Execution Plan,
- BIM Champion,
- Collaboration requirements, e.g. the sharing of a design model to the contractor,
- Deliverables,
- Ownership of the Model and Information,
- BIM Requirements for 2D Documents, and
- Security of information.

The discussion of BIM contract terms assumes the use of an addendum for addressing BIM requirements. The same items can be addressed directly within a contract, but the development of a contract addendum highlights those requirements to solicited firms, as well as facilitating organizational updates maintain consistent requirements. Someone from the BIM Implementation team should serve as the lead contact for coordinating and maintaining the current version and changes which are identified as the implementation of BIM proceeds and the requirements

Definition of Terms

Many BIM terms have several different definitions available. Unless the owner provides a detailed description of their specific meaning of the term, potential disputes may arise. Providing standard organizational BIM definitions removes ambiguity in expectations. Potential terms an owner may want to define include:

- As-Built Model,
- BIM Champion/Manager,
- BIM Project Execution Plan,
- BIM Use,
- Design Model,
- Fabrication Model,
- Facility Data,
- Federated Model,
- Level of Development,
- Project Team, and
- Record Model.

General descriptions of each term can be found in the Glossary, but each term should be customized to reflect the owner's needs and expectations.

BIM Project Execution Plan

Developing a BIM Project Execution Plan for every project has been found to be beneficial to owners. Unlike contract language, which typically contains only general requirements for a project, a BIM Project Execution Plan is able to provide more detailed information for a project team. To accomplish

this, it is helpful for to develop a typical BIM Project Execution Plan template prior to the beginning of the first BIM project. This template will serve as the foundation for the BIM Project Execution Plan as it will already contain the necessary owner specified information and requirements while supporting the documentation in the contract language. If the use of a BIM Project Execution Plan is desired, the contract language should require the development and revision of the BIM Project Execution Plan by all project participants at the earliest stage of each member's involvement in the project. The expected team member involvement should be clarified along with a typical frequency of update and revision to allow for the team to plan appropriately. The instructions for creating a standard BIM Project Execution Plan template are included in Section 4.4: BIM Project Execution Planning Template for Typical Projects.

/// CASE STUDY EXAMPLE: US Army Corps of Engineers

For projects implementing BIM for the United States Army Corps of Engineers, the project team is required to use the USACE Standard BIM Project Execution Planning Template. If the plan developed is unacceptable, it must be re-developed and approved prior to any payment.

BIM Champion/Manager

The BIM Champion/Manager for each organization on the project team plays a critical role in communication and information sharing, and will influence the success of the project in either a positive or a negative way. It is beneficial to require each project team to designate an individual to operate as the BIM Champion for the project. They will serve as the primary BIM contact and will be the responsible party for each of the project team's BIM coordination needs, as well as supporting development and revision of the BIM Project Execution Plan. Some potential responsibilities may include:

1. Contribution to the development and compliance of the BIM Project Execution Plan.
2. Management of the quality of BIM model(s) and facility information.
3. Timely sharing of model and data, as defined in the BIM Project Execution Plan.
4. Participation in applicable coordination meetings, as defined in the BIM Project Execution Plan.

Collaboration

Many view BIM as a change in process than specific technology. Much of process change is created through collaboration. By working together and sharing information among project team members, the project team is able to reduce duplication of work, improve the quality of information, and ensure a successful project. To achieve these benefits, the entire project team, including the owner, should work in a collaborative manner. For this to occur, everyone must share project information in a consistent, reliable and up-to-date fashion.

To encourage the necessary collaboration in traditionally delivered projects, it is important to list collaboration requirements explicitly in the contract documentation. This may include:

1. **COLLABORATION BETWEEN PARTIES:** All project participants should be willing to collaborate with each other to meet achieve the project goals. Agreeing to the collaboration pro cesses and communication procedures detailed in the BIM Project Execution Plan is necessary for all team members. The preliminary BIM Project Execution Plan documenting responsibilities, processes, collaboration, and deliverables should be completed during the contract agreement stage

of the project and be included in the final contract for all project participants.

2. **INFORMATION SHARING:** The project team should be willing to share information throughout the duration of the project. This means all parties should have access to the BIM models, reports, facility data, and any other neces sary information in appropriate intervals as de fined in the BIM Project Execution Plan. This often requires setting up a file exchange website or other collaboration software designed specifically for file sharing.
3. **ERRORS:** Any project participant discovering an error must notify the creating party in a pre-de fined method to fix the error.

/// CASE STUDY EXAMPLE: ConsensusDOCS

The ConsensusDOCS contract addresses this problem by requiring "If any project participant becomes aware of a discrepancy between a model and either another model or another contract document, such project participant shall promptly notify the other party or parties to that project participant's governing contract and the information man-ager.'

Co-Location

When possible, one method of facilitating collaboration among the project team is using co-location. This is a method of placing the entire, or certain portions of the, project team together in one location to develop the design and manage the project execution. Although successful collaboration is possible through remote communication, there are many benefits from direct access and real time feedback in the modeling process. This is challenging on certain projects, particularly smaller projects due to personnel resources allocations, but locating the team together offers interaction and information sharing benefits which may lead to a more successful project.

Minimum Deliverables

Throughout the project, significant savings can be achieved by collecting the data to be used during the operations and future renovations of the facility. Traditionally, owners require As-Built drawings, submittals, commissioning reports, and O&M manuals as deliverables. If specified effectively, BIM provides the capability for the owner to receive both the model and detailed facility data in an organized, electronic fashion.

Minimum As-Built/Record Model Deliverable

The As-Built and Record model deliverables should represent the design intent and as-constructed conditions of the completed facility, however simply requiring a model as a deliverable is not adequate. The owner must specify the level of development desired and the format in which it is desired.

Record Model

The owner has many options for specifying the record model deliverable. One option is to require a record model, from the design model(s), containing design intent information with As-Built conditions. Often considered the most beneficial for facility management, it contains design level detail and lacks fabrication information. This model can be delivered as a federated model (model consisting of many discipline specific models combined into one model) as a static, read-only, file type. The model can also be provided in a modifiable format such that it can be updated with renovation informaton. Often, there is additional cost associated with specifying the record model in a modifiable format, as this file is not necessarily updated during construction. For example, designers may not add submittal specific information for equipment into the design intent

model, or small dimensional changes resulting from specialty contractor coordination layout adjustments. Despite potential added costs for updating the design intent model, it may be the most cost effective solution if your organization plans to use the model for renovation work and facility management.

As-Built Model

Another option is to request an As-Built model containing construction and fabrication information. This model, typically developed from the specialty contractors' fabrication and coordination models, contains much more detailed geometry, and is typically created using many discipline specific software packages combined into one federated model. This option can also be delivered as a federated read-only version or as many discrete native files. Owners may find challenges in using this model for operations because, while it contains much more detail than a record model, it is more difficult, and possibly more costly, to modify or document changes throughout a facilities lifecycle due to the use of multiple software packages.

Software Platforms and File Formats

There are many software tools and platforms which project teams may choose to implement for a given project. There are two main concerns for an owner organization to consider and address when requesting the file format in a BIM Project Execution Plan or BIM Deliverables:

1. Interoperability and data transfer for owner uses; and
2. Re-use of the model data, both within the project.

Whether the owner desires to receive a record model or an as-built model, or both, it is beneficial to ensure that the model data and geometry can be re-used for whichever BIM Uses identified within the Organizational Goals. The two strategies commonly considered are a platform specific solution to align with the known compatibility and interoperability needs, or to request files which comply with open industry standards. Within the building industry, the BIM information standard is an IFC (Industry Foundation Class) compatible format. IFC is an open standard data schema, adopted as part of the National BIM Standard which most commercial BIM software packages have the ability to support to varying levels of detail. The benefit of IFC is that it allows interoperability among many software platforms. The open schema also provide a map to the data that ensures the ability to read the data in the future, which is not necessarily the case with proprietary data formats. A challenge to current use of IFC is the level of adoption by some vendors. One option to allow both the short term benefits of a specific software platform and of IFC would be to request both native files from the used software platform(s) and an IFC model.

/// CASE STUDY EXAMPLE: Penn State Office of Physical Plant

Penn State OPP requires a combination of the options mentioned above. They require:

- An As-Built construction model which they use for the as-built documentation of the facility, and
- A Record Model in a Revit format which allows them to update the model and use it for renovation work throughout the lifecycle of the facility.

Minimum Facility Data Deliverable

Many owners have a significant interest in obtaining the facility information after construction. Most of the data needed for facility management (e.g., equipment submittals, O&M manuals, and specifications) is already required in standard contracts to be delivered to the owner, but often it is delivered in a paper format or in electronic documents. With new BIM technologies, owners who can define the specific information they need for operations and maintenance, or other purposes, can now specify exactly the information they require for every piece of equipment in their facility

management system, and receive it in a modifiable electronic format. This provides the ability to decrease the time and cost of populating the facility management system.

Data Attached to a Model

One option an owner has is to request the facility data to be embedded in the As-Built or Record model. The federated model can have facility data attached to elements within the model for use in facility management. This option has benefits because the facility managers can visually see the equipment for which they are receiving information, but it requires model navigation skills for the owners' staff and can quickly become outdated for high turnover buildings. The information embedded in the model may be difficult to extract into a facility management system, reducing the effectiveness of the information.

COBie

An open industry standard format for delivering facility data is the Construction Operations Building Information Exchange (COBie). This is a data structure that enables the creators of the data during design, construction, and commissioning to populate a spreadsheet with the desired information such as equipment name, type, location, etc. From that spreadsheet, many facility management systems can import and populate the facility data. This information delivery method is part of the National BIM Standard and is a required deliverable growing in popularity for many owners. Figure 4-2 shows a sample of a spreadsheet populated with facility information.

/// CASE STUDY EXAMPLE: Veterans Affairs and USACE

The Department of Veterans Affairs and the Army Corp of Engineers (USACE) have adopted COBie as the required data structure to transfer building information electronically to facilities management.

Name	CreatedBy	CreatedOn	TypeName	Space	Description	ExtSystem	ExtObject	ExtIdentifier	SerialNumber	InstallationDate	WarrantyStartDate	TagNumber	BarCode	AssetIdentifier
Bath/Shower-1	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:27	Bath/Shower	B204	M_Bath Tub:1525 mmx760 mm - Private:1525 mmx760 mm - Private:582931	Autodesk Revit MEP 2011	IfcFlowTerminal	2h405XJT83A5BK7w5kl4b	VACA689	2010-04-18T09:00:00	2010-04-18T09:00:00	n/a	n/a	n/a
Bath/Shower-2	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:28	Bath/Shower	A204	M_Bath Tub:1525 mmx760 mm - Private:1525 mmx760 mm - Private:582924	Autodesk Revit MEP 2011	IfcFlowTerminal	1YLPoI7bl0fvdanmaXQreg	VACA690	2010-04-18T09:00:00	2010-04-18T09:00:00	n/a	n/a	n/a
Boiler-1	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:29	Boiler	B205	M_Hot Water Boiler - 59-440 kW:147 kW:147 kW:557516	Autodesk Revit MEP 2011	IfcEnergyConversionDevice	1jQu9wkdr0iwNuem13FlSi	357N83HJ	2010-05-10T09:00:00	2010-05-10T09:00:00	n/a	n/a	n/a
Boiler-2	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:30	Boiler	A205	M_Hot Water Boiler - 59-440 kW:147 kW:147 kW:530072	Autodesk Revit MEP 2011	IfcEnergyConversionDevice	1ZpBelQPb2z91uXg6Q1dzp	357N83HJ	2010-05-10T09:00:00	2010-05-10T09:00:00	n/a	n/a	n/a
Cabinet Type A-1	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:31	Cabinet Type A	B103	M_Base Cabinet-Double Door & 2 Drawer:1000mm:1000mm:159159	Autodesk Revit Architecture 2011	IfcFurnishingElement	0wkEuT1wr1kOyafLY4vyMO	FGHFT685	2010-05-31T09:00:00	2010-05-31T09:00:01	n/a	n/a	n/a
Cabinet Type A-10	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:41	Cabinet Type A	A103	M_Base Cabinet-Double Door & 2 Drawer:1000mm:1000mm:162487	Autodesk Revit Architecture 2011	IfcFurnishingElement	2OBrcmyk58NupXoVOHUvqo	FGHFT694	2010-05-31T09:00:00	2010-05-31T09:00:01	n/a	n/a	n/a
Cabinet Type A-11	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:42	Cabinet Type A	A103	M_Base Cabinet-Double Door & 2 Drawer:1000mm:1000mm:162488	Autodesk Revit Architecture 2011	IfcFurnishingElement	2OBrcmyk58NupXoVOHUvqz	FGHFT695	2010-05-31T09:00:00	2010-05-31T09:00:01	n/a	n/a	n/a
Cabinet Type A-12	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:43	Cabinet Type A	A103	M_Base Cabinet-Double Door & 2 Drawer:1000mm:1000mm:162489	Autodesk Revit Architecture 2011	IfcFurnishingElement	2OBrcmyk58NupXoVOHUvqy	FGHFT696	2010-05-31T09:00:00	2010-05-31T09:00:01	n/a	n/a	n/a
Cabinet Type A-13	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:44	Cabinet Type A	A103	M_Base Cabinet-Double Door & 2 Drawer:1000mm:1000mm:162493	Autodesk Revit Architecture 2011	IfcFurnishingElement	2OBrcmyk58NupXoVOHUvqu	FGHFT697	2010-05-31T09:00:00	2010-05-31T09:00:01	n/a	n/a	n/a
Cabinet Type A-14	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:45	Cabinet Type A	A103	M_Base Cabinet-Double Door & 2 Drawer:1000mm:1000mm:162495	Autodesk Revit Architecture 2011	IfcFurnishingElement	2OBrcmyk58NupXoVOHUvqw	FGHFT698	2010-05-31T09:00:00	2010-05-31T09:00:01	n/a	n/a	n/a
Cabinet Type A-15	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:46	Cabinet Type A	A103	M_Base Cabinet-Double Door & 2 Drawer:1000mm:1000mm:162496	Autodesk Revit Architecture 2011	IfcFurnishingElement	2OBrcmyk58NupXoVOHUvr5	FGHFT699	2010-05-31T09:00:00	2010-05-31T09:00:01	n/a	n/a	n/a
Cabinet Type A-16	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:47	Cabinet Type A	A103	M_Base Cabinet-Double Door & 2 Drawer:1000mm:1000mm:162497	Autodesk Revit Architecture 2011	IfcFurnishingElement	2OBrcmyk58NupXoVOHUvr4	FGHFT700	2010-05-31T09:00:00	2010-05-31T09:00:01	n/a	n/a	n/a
Cabinet Type A-2	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:32	Cabinet Type A	B103	M_Base Cabinet-Double Door & 2 Drawer:1000mm:1000mm:159262	Autodesk Revit Architecture 2011	IfcFurnishingElement	0wkEuT1wr1kOyafLY4vyOn	FGHFT686	2010-05-31T09:00:00	2010-05-31T09:00:01	n/a	n/a	n/a
Cabinet Type A-3	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:33	Cabinet Type A	B103	M_Base Cabinet-Double Door & 2 Drawer:1000mm:1000mm:160671	Autodesk Revit Architecture 2011	IfcFurnishingElement	2OBrcmyk58NupXoVOHUvGQ	FGHFT687	2010-05-31T09:00:00	2010-05-31T09:00:01	n/a	n/a	n/a
Cabinet Type A-4	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:34	Cabinet Type A	B103	M_Base Cabinet-Double Door & 2 Drawer:1000mm:1000mm:160717	Autodesk Revit Architecture 2011	IfcFurnishingElement	2OBrcmyk58NupXoVOHUvH8	FGHFT688	2010-05-31T09:00:00	2010-05-31T09:00:01	n/a	n/a	n/a
Cabinet Type A-5	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:35	Cabinet Type A	B103	M_Base Cabinet-Double Door & 2 Drawer:1000mm:1000mm:162230	Autodesk Revit Architecture 2011	IfcFurnishingElement	2OBrcmyk58NupXoVOHUvup	FGHFT689	2010-05-31T09:00:00	2010-05-31T09:00:01	n/a	n/a	n/a
Cabinet Type A-6	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:36	Cabinet Type A	B103	M_Base Cabinet-Double Door & 2 Drawer:1000mm:1000mm:162311	Autodesk Revit Architecture 2011	IfcFurnishingElement	2OBrcmyk58NupXoVOHUvs2	FGHFT690	2010-05-31T09:00:00	2010-05-31T09:00:01	n/a	n/a	n/a
Cabinet Type A-7	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:37	Cabinet Type A	B103	M_Base Cabinet-Double Door & 2 Drawer:1000mm:1000mm:162357	Autodesk Revit Architecture 2011	IfcFurnishingElement	2OBrcmyk58NupXoVOHUvsm	FGHFT691	2010-05-31T09:00:00	2010-05-31T09:00:01	n/a	n/a	n/a
Cabinet Type A-8	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:38	Cabinet Type A	B103	M_Base Cabinet-Double Door & 2 Drawer:1000mm:1000mm:162383	Autodesk Revit Architecture 2011	IfcFurnishingElement	2OBrcmyk58NupXoVOHUvtA	FGHFT692	2010-05-31T09:00:00	2010-05-31T09:00:01	n/a	n/a	n/a
Cabinet Type A-9	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:40	Cabinet Type A	A103	M_Base Cabinet-Double Door & 2 Drawer:1000mm:1000mm:162486	Autodesk Revit Architecture 2011	IfcFurnishingElement	2OBrcmyk58NupXoVOHUvqp	FGHFT693	2010-05-31T09:00:00	2010-05-31T09:00:01	n/a	n/a	n/a
Cabinet Type B-1	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:82	Cabinet Type B	B203	M_Tall Cabinet-Single Door(2):800 mm:800 mm:158080	Autodesk Revit Architecture 2011	IfcFurnishingElement	0wkEuT1wr1kOyafLY4vy6f	9UF4X789	2010-05-25T09:00:00	2010-05-25T09:00:01	n/a	n/a	n/a
Cabinet Type B-2	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:83	Cabinet Type B	B203	M_Tall Cabinet-Single Door(2):800 mm:800 mm:158081	Autodesk Revit Architecture 2011	IfcFurnishingElement	0wkEuT1wr1kOyafLY4vy6k	9UF4X790	2010-05-25T09:00:00	2010-05-25T09:00:01	n/a	n/a	n/a
Cabinet Type B-3	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:84	Cabinet Type B	B202	M_Tall Cabinet-Single Door(2):800 mm:800 mm:157200	Autodesk Revit Architecture 2011	IfcFurnishingElement	0wkEuT1wr1kOyafLY4vyuS	9UF4X791	2010-05-25T09:00:00	2010-05-25T09:00:01	n/a	n/a	n/a
Cabinet Type B-4	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:85	Cabinet Type B	B202	M_Tall Cabinet-Single Door(2):800 mm:800 mm:157607	Autodesk Revit Architecture 2011	IfcFurnishingElement	0wkEuT1wr1kOyafLY4vy_8	9UF4X792	2010-05-25T09:00:00	2010-05-25T09:00:01	n/a	n/a	n/a
Cabinet Type B-5	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:86	Cabinet Type B	A203	M_Tall Cabinet-Single Door(2):800 mm:800 mm:157950	Autodesk Revit Architecture 2011	IfcFurnishingElement	0wkEuT1wr1kOyafLY4vy3H	9UF4X793	2010-05-25T09:00:00	2010-05-25T09:00:01	n/a	n/a	n/a
Cabinet Type B-6	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:87	Cabinet Type B	A203	M_Tall Cabinet-Single Door(2):800 mm:800 mm:157951	Autodesk Revit Architecture 2011	IfcFurnishingElement	0wkEuT1wr1kOyafLY4vy3G	9UF4X794	2010-05-25T09:00:00	2010-05-25T09:00:01	n/a	n/a	n/a
Cabinet Type B-7	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:88	Cabinet Type B	A202	M_Tall Cabinet-Single Door(2):800 mm:800 mm:157983	Autodesk Revit Architecture 2011	IfcFurnishingElement	0wkEuT1wr1kOyafLY4vy4m	9UF4X795	2010-05-25T09:00:00	2010-05-25T09:00:01	n/a	n/a	n/a
Cabinet Type B-8	mariangelica.carrasquillo@usace.army.mil	2011-09-27T16:15:89	Cabinet Type B	A202	M_Tall Cabinet-Single Door(2):800 mm:800 mm:157984	Autodesk Revit Architecture 2011	IfcFurnishingElement	0wkEuT1wr1kOyafLY4vy4F	9UF4X796	2010-05-25T09:00:00	2010-05-25T09:00:01	n/a	n/a	n/a

Figure 4-2: Sample of COBie Form Documenting Equipment Information

Ownership of Model/Data Reuse

Owners who already have defined requirements and naming standards for their maintenance and operations also have another option, which incorporates exactly the information they need. Owners can develop their own scope of facility information which must be delivered. This alternative gives the owner more control over the information they receive, but requires significant effort to set up and manage.

/// CASE STUDY EXAMPLE: Penn State Office of Physical Plant

Penn State Office of Physical Plant chose to specify their own facility information deliverable standard because they feel it gives them more flexibility than COBie. To develop this standard, they worked with their facility management group to decide what information needs to be tracked by following a similar process as described in the implementation planning section of this Guide.

Ownership of Model/Data Reuse

To enable the information and model created during construction to be used for renovations and throughout operations, the owner must obtain permission from the designer and/or the contractor who created the model. Typically, the creator of the information retains the ownership of the data and limits its re-use and reliability. This protects intellectual property and limits liability among contracted parties. To use this data for more than the initial construction, the owner can specify either, 1) that they own the information, or 2) that they have rights to use it throughout the facility lifecycle. The right to reuse the data can be achieved two ways.

1. The owner can claim ownership of all information created during the design and construction of the facility including models, studies, and calculations for the use of renovation/facility management throughout the life of the facility.
2. The owner can claim the right to re-use the information created during the design and construction of the facility for renovation/facility maintenance while allowing the creator to retain owner ship of the data.

In many situations, both options add risk to the creator of the information and therefore, may add expense to the owner. In the event the data is incorrect, the creator may be liable for the information provided. The owner can limit the use of the data to reduce the creator's risk by:

1. Indemnifying the creators of all errors. This is traditionally how models are delivered to the owner in today's environment when not originally requested. Although this removes the risk for the creator, the quality of the information often suffers as there is no incentive to modify or update the information throughout construction. Because the quality of the information suffers, it is not recommended that an owner completely indemnify the creators of the information if re-use is one of the purposes in the model request.
2. Limiting the liability of the information creator for the accuracy of the data only when used for the purpose in which it was created. In this case, the uses should be explicitly stated.
3. Limiting the use of the data for the renovation and operation of the facility in which it was created.
4. Allowing the creator of the information to maintain the right to the intellectual property inherent within the model/data including families, blocks, and styles. This means the information will not be used or shared for any property or facility other than the project facility for which it was created.

The intellectual property and liability concerns relative to model uses can be a contentious issue, but defining the future model and information needs, in line with the BIM Goals, allows the design and construction team members to be able to understand the information needs and align their contract negotiations to both meet your needs and protect their interests in an appropriate manner.

BIM Requirements for 2D Documents

With the emphasis for BIM primarily focusing on 3D models and electronic data, it is easy to forget that the contract documents and many details are still in a traditional 2D paper form. In the future typically 2D documents may be limited, but currently they are still the primary contract documents. This means the owner may not be able to remove any of the Computer Aided Drafting (CAD) or drawing standards currently employed in the contracts, but must supplement them with additional requirements for BIM. Ensuring the coordination between the 2D documents and the 3D model is of upmost importance. One way to ensure the consistency between the two is to require that all drawings be produced from the model, when possible. This ensures that any change during the duration of the project is documented in both the model and the drawings.

/// CASE STUDY EXAMPLE: US Army Corps of Engineers

To ensure the collaboration between 2D documents and the model, the US Army Corps of Engineers requires that all drawings (e.g., plans, elevations, sections, or schedules) be derived and maintained from the model and facility data.

Security

Before the rise of electronic file sharing, all documents were in paper form, thus accessing facility information required direct access to physical drawings. Today, with information being transferred electronically, it is much easier to copy, modify, share, and access information. For many secure facilities, this access poses a risk to the safety and security of its occupants after the completion of construction. To protect against this, the building data must be protected at all stages of its lifecycle from conception to demolition. Data security measures should be taken into consideration and protocols must be established to satisfy the organization's security requirements for all participants accessing the information. These security measures may include:

1. User specific logins to collaboration systems,
2. Restrictions to the storage of facility information by third parties during and after project comple tion, and
3. Restrictions to sharing of facility information to personnel outside of the project team.

BIM Project Execution Plan Template for Typical Projects

A BIM Project Execution Plan template should reflect the requirements you documented in the BIM Contract Requirements and the issues, goals, and processes identified within the Strategic and Organizational Planning Guides. As identified in the Contract Addendum discussion, the BIM Addendum focuses on standard facility goals and BIM objectives of the organization, while a BIM Project Execution Plan will contain the project-specific BIM requirements, processes, and information workflows. Developing a template BIM Project Execution Plan not only helps inform potential bidders of the typical expectations of the owner, but it significantly reduces the time and effort required by the owner's BIM Champion for each project.

The template is not intended as the final BIM Plan the team will conform to, but an outline of the plan, similar to the way a milestone schedule is the outline for a critical path construction schedule. Once the project specific BIM plan is established by the project team, it should be included in the contract documents so that procedures, responsibilities, processes, level of development, and deliverables are clear.

This section is not intended to walk the reader through the details of developing a BIM Project Execution Plan; *The BIM Project Execution Planning Guide* provides a much more detailed explanation for the creation of a project specific plan, as well as provides the base template. The goal of this section is to use the *BIM Project Execution Plan Template* and customize it so that it can be applied on the majority of projects created by your organization.

BIM Standard Goals and Objectives

The first step in developing a standard BIM Project Execution Plan Template is to determine the standard goals and objectives of the organization for which the template is being developed. These goals and objectives should have been identified in the Strategic BIM Planning step. Most organizations have areas that they choose to focus which align with their strategic plan. Whether the emphasis is on energy efficiency, cost, speed, or quality, BIM can be used to supplement those goals. The key in this situation is to leverage the Roadmap to define the appropriate standard BIM Goals and uses to incorporate into the template. Then as the use of BIM within your organization evolves and progresses along the planned organizational implementation, the Standard Goals and Uses can evolve with the stages identified in the Roadmap.

PRIORITY	GOAL DESCRIPTION	POTENTIAL BIM USES
REQUIRED	Improve Construction Quality	Design Review, Design 3D Coordination, Digital Fabrication
REQUIRED	Reduce RFIs and Change Orders	Design Review, Design Coordination, Construction 3D Coordination
REQUIRED	Reduce Energy Waste	Design Energy Analysis, Programming Energy Analysis
REQUIRED	Provide Facility Managers Improved Facility Data after Building Turnover	Record Model, Existing Conditions Modeling

Table 4-3: Example BIM Goals/Objectives and Potential BIM Uses

After the typical project goals and BIM objectives are established, they can be added to a table in the BIM Project Execution Plan template, as shown in Table 4-3: Example BIM Goals/Objectives and Potential BIM Uses. It is important to note, that not every goal may not apply to every project, and once the specifics for a new project are determined, there may be specific project goals that need to be added or adjusted, as decided in the project BIM kickoff meeting.

Standard BIM Uses

The project goals and BIM objectives list provides a good starting point for determining the standard project BIM Uses for your organization. An owner should only focus on requiring the BIM Uses which provide them with a benefit, and not force the project team to change their internal processes if there is no added value to the owner or the facility. In many situations, designers and contractors may provide additional BIM Uses because it is the most cost effective solution for their internal processes. It is often useful to discuss the potential benefit/costs of each BIM Use with industry partners in design, construction, and operations to determine the implications of each requirement. BIM can improve projects through many Uses, but it exploring additional analysis and simulation of the model which does not support the focus of a project is not the best use of resources, and if implemented may impede the design and construction process or increase project cost.

The balance between trying to gain the full benefit of the BIM Uses available for a project, and trying to resist over-expenditure on non-value adding BIM Uses is a fine line. The BIM Project Execution Plan template should include the core BIM Uses and goals which are expected to add value on nearly every project you pursue. The key in customizing the Plan for each project is to have the appropriate Implementation Team or BIM Champion involvement to help keep that focus, but to be open to opportunities to advance the BIM Uses on the Roadmap when opportunities present themselves.

One simple but valuable step to facilitate this discussion with the project team is to hold a BIM Kickoff meeting with the project team members after selection as the contract is being finalized. The kickoff meeting serves as an opportunity for

you to explain the background and intent of the BIM Goals and requested uses. A re-visiting of the template BIM Project Execution Plan can then be used to develop the full project plan. The required BIM Uses can be negotiated with the project teams to determine if some uses can easily be added with little to no cost, along with others which may be quite onerous to the project team with little value to defined goals.

For a list of BIM Uses and their general functions, refer to the BIM Uses descriptions at http://bim.psu.edu.

PLAN	DESIGN	CONSTRUCT	OPERATE
PROGRAMMING	Design Authoring	Site Utlization Planning	Data Commissioning
SITE ANALYSIS	Design Reviews	Consruction System Design	Preformance Mentoring
	3D Coordination	3D Coordination	Systems Control
	Structual Anyalsis	Digital Fabrication	Space Tracking
	Lighting Anyalsis	3D Control and Planning	Assest Management
	Engery Anyalsis	Record Modeling	Maintence Management
	Mechanical Anyalsis		Condition Documentation
	Other Eng Anyalsis		Scenario Forecasting
	Sustainabilty (LEED) Evaluation		
	Code Validation		
PHASE PLANNING (4D MODELING)	Phase Planning (3D Modeling)	Phase Planning (3D Modeling)	Phase Planning (3D Modeling)
COST ESTIMATION	Cost Estimation	Cost Estimation	Cost Estimation
EXISTING CONDITIONS MODELING	Exisiting Conditions Modeling	Exisiting Conditions Modeling	Exisiting Conditions Modeling

Table 4-4: BIM Uses List

In addition to clearly listing the required BIM Uses, providing a detailed definition of what each BIM Use means to the organization is extremely important. Each BIM Use has many different definitions and levels of implementation depending on the project and parties involved. Providing a project, phase specific, definition of each required BIM use enables the potential project team the ability to understand their requirements and eliminate any potential misunderstandings.

/// CASE STUDY EXAMPLE: Penn State Office of Physical Plant

OPP defines many BIM Uses slightly differently from other owners. This is because their needs are unique to their organization, and it was found that each BIM Use could be provided much more effectively if the project team understood exactly what OPP wanted from each use.

For example, energy analysis is performed during the design development stage using a highly detail model and complex energy software. OPP requires that a traditional energy analysis be performed during design development, but an additional mass model energy analysis be performed during the planning stage. Although this is low in detail and accuracy, it has been shown to help engineers with making quick decisions such as façade, building orientation, and window placement at a stage in the project where changes have a relatively low cost.

In situations such as the energy modeling example, the BIM Use expectations must be detailed in the BIM Project Execution Plan or the project team may not understand the owner's expectations.

Standard BIM Process

The template BIM Project Execution Plan should also include a typical BIM process maps that demonstrates the typical processes the organization encounters on a typical project. These customized maps, similar to that shown, can then provide a starting point for the team at the BIM kickoff meeting to discuss the design and related modeling workflows. The maps should document relationships and identify specific interactions, such as review and approval meetings between the owner and the project team

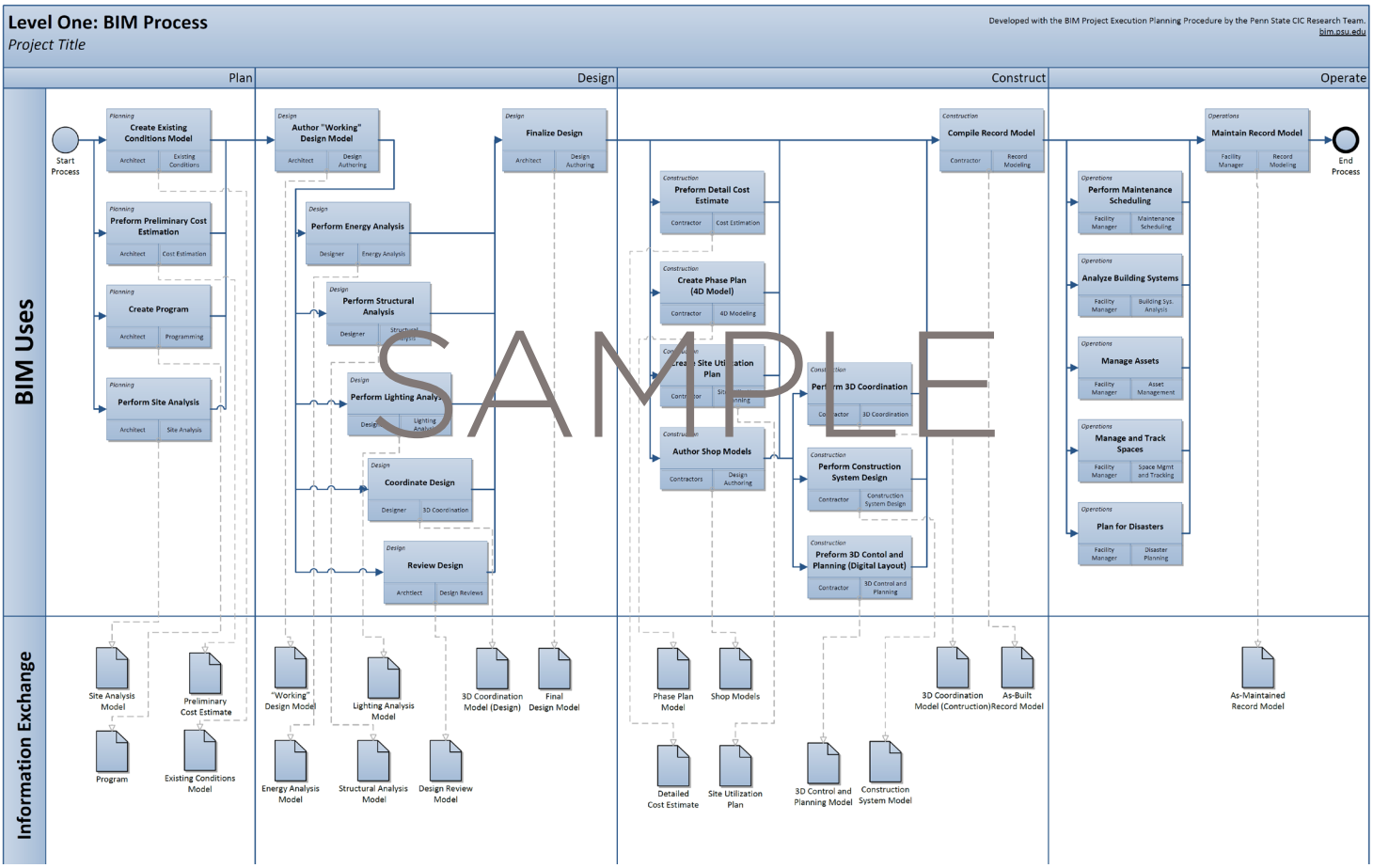

Figure 4 -3: Typical BIM Process Map

BIM Information Exchanges

An owner using BIM information for facility management and renovation work, information needs are very different from that of the contractor and designer. Because of this, it is important to document both the model level of development and facility data property needs at the beginning of the project. The information exchange requirements consist of two components: the model element level of development and the facility data, explained in more detail below.

Model Level of Development

The model information requirements, developed through the Implementation planning stage should be documented. From this, the Level of Development for the Record Model can be established and documented in the Information Exchange worksheet pictured in Figure 4-4: Example Information Exchange Worksheet.

It is important that the Implementation Team work through each building element individually and determine what Level of Development is necessary. In most situations, the Level of Development required for operations is significantly less than that needed for construction, requiring either detail to be removed from the costruction model or some update to the design model. This often creates additional effort for the project team, but results in a simplified model that facility managers can utilize more efficiently.

		Design Model		Design		Construction		Record Model			
		Model Element	Data Only	Construction Documents		Construction Adminstration		Existing Conditions Record Model H. North		Record Drawings	
		Yes/No	Yes/No	LOD	MEA	LOD	MEA	LOD	MEA	LOD	MEA
D3030	**Cooling Generating Systems**										
	Chillers	Yes	No	300	BBA	400		520		535	
	Cooling Towers and Evaporative Coolers	Yes	No	300	BBA	400		520		535	
	Condensing Units	Yes	No	300	BBA	400		520		535	
	Pipes & Fittings	Yes	No	300	BBA	400		520		535	
	Primary Pumps	Yes	No	300	BBA	400		520		535	
	Auxillary Equipment	Yes	No	300	BBA	400		520		535	
	Insulation	Yes	No	300	BBA	400		520		535	
	Means & Methods (Erection/Sequencing/ Shop Standards)							-	-	-	-
D3040	**Distribution Systems**										
	Supply & Return Air Systems	Yes	No	300	BBA	400	HVAC	520		535	
	AHU w/coils, ducts, and devices	Yes	No	300	BBA	400	HVAC	520		535	
	Vent & Exhaust Systems	Yes	No	300	BBA	400	HVAC	520		535	
	Steam, Hydronic, Hot Water, Glycol & Chilled Water Distribution	Yes	No	300	BBA	400	HVAC	520		535	
	Heat Recovery Equipment	Yes	No	300	BBA	400	HVAC	520		535	
	Auxillary Equipment	Yes	No	300	BBA	400	HVAC	520		535	
	Insulation	Yes	No	300	BBA	400	HVAC	520		520	
	Means & Methods (Erection/Sequencing/ Shop Standards)							-	-	-	-
D3050	**Terminal & Package Units**										
	Terminal Self-Contained Units	Yes	No	300	BBA	400	HVAC	520		535	
	Package Units	Yes	No	300	BBA	400	HVAC	520		535	
	Other	Yes	No	300	BBA	400	HVAC	520		535	

Figure 4-4: Example Information Exchange Worksheet

There are several methods of defining the Level of Development required within a model. A general approach to the problem is to describe the model development one of three ways, as shown in Figure 4-4. This method may be a good option for beginners who do not wish to subscribe to any standards such as the AIA Level of Development, but it lacks the detail of other standards and may create unnecessary ambiguity.

INFORMATION	
A	Accurate Size & Location, Include Materials and Object Parameters
B	General Size & Location, Include Parameter Data
C	Schematic Size & Location

Table 4-5

/// CASE STUDY EXAMPLE: Penn State Office of Physical Plant

The Penn State OPP has adopted the AIA E202 Level of Development standard for their projects, but expanded the LOD 500 category to more adequately meet their needs. This detailed level of development scale is an option an owner can incorporate into their information exchange worksheet in an effort to provide the project team additional detail about their information needs.

LOD 510: Model elements represent the project as constructed in As-Built conditions. LOD 510 models will contain LOD 100 facility and geometry data and will be configured to contain the operations & maintenance manuals, warranty information, submittal information, and/or any other documents as applicable.

LOD 520: Model elements represent the project as constructed in As-Built conditions. LOD 520 models will contain LOD 200 facility and geometry data and will be configured to contain the operations & maintenance manuals, warranty information, submittal information, and/or any other documents.

LOD 530: Model elements represent the project as constructed in As-Built conditions. LOD 530 models will contain LOD 300 facility and geometry data and will be configured to contain the operations & maintenance manuals, warranty information, submittal information, and/or any other documents as applicable.

LOD 540: Model elements represent the project as constructed in As-Built conditions. LOD 540 models will contain LOD 400 facility and geometry data and will be configured to contain the operations & maintenance manuals, warranty information, submittal information, and/or any other documents as applicable.

LOD 550: Owner reserved, LOD 550 model elements will not be generated during planning, design, or construction.

Facility Data Requirements

Although the model geometry is useful for facility management and renovations, perhaps more important to operating the facility is the facility data. Traditionally items such as submittals, operations & maintenance manuals, or warranty information are delivered after project completion in the form of paper binders or electronic files. Transitioning this data to a useful format is further complicated because the owner often does not receive these documents immediately after substantial completion. With these documents in "paper" format, facility managers must search through the pages of information they need and then manually populate their facility management system. The necessary properties and attributes (facility data) of each building element should be documented in the BIM Project Execution Plan as defined in the BIM Contract Requirements to facilitate timely electronic data transfers.

/// CASE STUDY EXAMPLE: Penn State Office of Physical Plant

Penn State OPP lists every asset and the properties for which it wants discrete information delivered at the end of the project. Although Penn State utilizes a customized list, as shown in Table 4 5: Sample of PSU OPP Asset Attribute List organized according to PSU UNIFORMAT II Standard, COBie is also capable of housing this information; however, an owner still needs to specify the necessary elements and attributes of those elements.

Asset Information organized according to PSU UNIFORMAT II Standard

Asset	Parameter	Attribute	Responsibilities per Phase		
			Design	Construction	Commissioning
D3020 Heat Generating Systems					
Closed Loop	Equipment ID		Record	Validate	Validate
	Subclassification (Select)	Hot Water	Record	Validate	Validate
	Maximo Barcode #	#	-	Record	Validate
	Location	Room # (bldg#-room ex. 0000000-000X)	Record	Validate	Validate
	Installation Date	Date (MM,DD,YYYY)	-	Record	Validate
	Warranty Date	Date (MM,DD,YYYY)	-	Record	Validate
	Percent/Type Glycol	%	Record	Record	Validate
	System Volume	GAL	Record	Record	Validate
	Type Glycol	Ethylene Glycol, N/A	Record	Validate	Validate
	Water Loop Number	#	Record	Validate	Validate
Boiler	Equipment ID		Record	Validate	Validate
	Subclassification (Select)	Cast Iron, Water Tube, Hot Water, Steam, Fire Tube,	Record	Validate	Validate
	Maximo Barcode #	#	-	Record	Validate
	Location	Room # (bldg#-room ex. 0000000-000X)	Record	Validate	Validate
	Boiler Size	BTU/HR	Record	Record	Validate
	Source Breaker Number(s)	#	-	Record	Validate
	Installation Date	Date (MM,DD,YYYY)	-	Record	Validate
	Warranty Date	Date (MM,DD,YYYY)	-	Record	Validate
	Fuel Type		Record	Validate	Validate
	Manufacturer		-	Record	Validate
	Maximum Working Pressure	PSIG	Record	Record	Validate
	Model #		-	Record	Validate
	National Board Number		-	Record	Record
	Safety Relief Pressure	PSIG	Record	Record	Validate
	Serial #	PSIG	-	Record	Validate
	Source Power Panel Name	Panel Name		Record	Validate
	Type	Hot Water, Steam	Record	Validate	Validate

Table 4-6: Sample of PSU OPP Asset Attribute List organized according to PSU UNIFORMAT II Standard

Collaboration/Meeting Procedures

All the necessary meetings between the project team and the owner should be set in advance as shown in Table 4-7: Example Standard BIM Project Meeting Schedule. This helps the project team understand their time commitments to the owner from day one. These meetings can consist of the BIM kickoff meeting, multiple review meetings, or any other meeting necessary to complete the BIM Uses/Requirements and turnover. Other than BIM Project Execution Planning and update meetings, the meetings identified should align with the planned model development and review processes developed in the Process Map of the Project Execution Plan.

MEETING TYPE	PROJECT STAGE	FREQUENCY	PARTICIPANTS	LOCATION
BIM REQUIREMENTS KICK-OFF	Programming	Once	Owner, Architect	TBD
BIM EXECUTION PLAN DEMONSTRATION	Programming	Once	Owner, BIM Participants	TBD
ENERGY MODEL REVIEW	Programming	As needed	Owner, Architect	TBD
DESIGN REVIEW	Programming, Design	Monthly	Owner, Architect	TBD
CONSTRUCTION OVER-THE-SHOULDER PROGRESS REVIEWS				
ANY OTHER BIM MEETINGS THAT OCCURS WITH MULTIPLE PARTIES				

Table 4-7: Example Standard BIM Project Meeting Schedule

Project Deliverables

Clearly defining the BIM deliverables details is the final step develop of a standard BIM Project Execution Plan template. Project BIM deliverables can be used as a checklist of items, which must be received for the payment to be processed during each stage of the project. Deliverables such as programming validation reports, energy models, or closeout data, can all be specified in the desired format at the desired time as Table 4-8: Example Project BIM Deliverables illustrates

BIM SUBMITTAL ITEM	STAGE	APPROXIMATE DUE DATE	FORMAT	NOTES
PROGRAMMING REPORT	Programming	TBD	PDF	
ENERGY MODEL	Design Development	TBD	GBXML	
DESIGN MODEL	Design Development	TBD	TBD	
RECORD MODEL	Close Out	TBD	TBD	
AS-BUILT MODEL	Close Out	TBD	TBD	

Table 4-8: Example Project BIM Deliverables

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/// Concluding Remarks and Lessons Learned

Throughout the development of this Guide, multiple case studies were conducted to validate the information contained within the planning procedures, and to provide additional insight into the implementation of BIM within existing organizations. The following lessons have been documented from the case studies.

Strategic Planning Lessons Learned:

- **There is no one-size-fits-all approach to BIM adoption.** Every organization is unique. They have different strengths, weaknesses, and priorities. Therefore, it is important to remember that any strategic planning, such as BIM adoption, requires significant effort. The procedures outlined in this Guide can be customized to meet your organizational needs, goals, and mission.

- **Strategic Planning is a long term process.** Capital projects take years to develop and execute. The plan and roadmap will probably not procede exactly as planned, partially because it is difficult to predict which project will move forward next year much less four years from now. The BIM Implementation Team needs to be on the lookout for project opportunities which present themselves to advance the plan.

Implementation Planning Lessons Learned:

- **Set achievable tasks.** As with any change, buy-in from the entire organization is essential to success. By creating realistic and achievable short-term goals, management is able to observe the benefits of the changes and is more likely to buy into the overall initiative and support future, more challenging adoption goals.

- **Communication is the key to success.** One of the most challenging tasks with implementing BIM processes is adequately communicating how BIM will integrate with the rest of the organization. Maintaining an open line of communication with all parties, and discussing their concerns and questions in a way that they understand can significantly improve the implementation success rate.

- **BIM Uses are interdependent.** Many BIM Uses are dependent on other Uses that happen in previous stages of BIM development. To provide an example, developing the record model of a new facility is not possible without an initial design model, 3D coordination of the model, and various updates throughout the model's development. Because of these interdependencies, the BIM Uses and specific information of interest should be mapped out in detail to assist in

determining the Uses to be pursued.

Procurement Planning Lessons Learned:

• **Prior BIM experience improves the likelihood of a successful BIM project.** When selecting a project team, it is important to remember that BIM has a learning curve and those with prior experience are more likely to efficiently implement the required BIM Uses. While this may seem like a simple observation, the focus is not on the project use success, but the successful transfer for Owner BIM Uses and the value of leveraging the teams' knowledge for advancing your interests.

• **No two projects are exactly the same.** While it is recommended to develop standard BIM contract requirements, it was found that all projects cannot be treated the same. The benefits of a BIM Use to building and operating an office building are very different from those for a hospital. Standard BIM requirements are a good start, but each project must be individually evaluated. The BIM Project Execution Plan specializes in guiding a team through this process.

• **Prior BIM Strategic and Implementation planning greatly enhances the quality of BIM contract documents.** While many organizations implement BIM on a new construction project prior to planning and implementing it internally, it is very difficult to create contract requirements that provide BIM benefits to facility operations without first understanding the internal BIM goals and needs.

General Lessons Learned:

• **This Guide can be adapted for organizations other than owners.** While this guide primarily focuses on owner needs, many of the principals and procedures can be applied to benefit organizations such as construction management companies and design firms.

• **BIM Development is a continuous process.** As the organization progresses in developing their BIM goals, the plan will need to be re-evaluated, and updated. As you may have already learned in deploying the BIM Project Execution Planning process, the plan is intended as a living document that evolves with the project; in this case the BIM Strategic and Implementation Plans are living documents that should evolve with your organization.

• **Pilot initiatives in small steps.** The Implementation Team needs to seek small opportunities to pilot elements of the strategic plan or Roadmap, and not the single perfect project to implement every BIM use. This engages many of the conversations and steps for implementation, but at a much smaller and more manageable scale. These opportunities may not be projects where the targeted BIM Uses were required, but leveraging projects where BIM is already in use by the project team.

- **BIM Planning requires management commitment and resources.** While BIM has the ability to save the organization money in the long run, the initial planning and implementation will require resources and management support. Without this support, it is unlikely that the initiative will be successful.

In conclusion, The BIM Planning Guide for Facility Owners provides methods for facility owners to plan for the implementation of BIM within their organization. With the proper management support, this Guide can assist an owner in developing an overall BIM Strategy that supports the organization's core goals, generating detailed implementation plans, and developing the necessary contract considerations to successfully execute BIM within the organization.

You should develop strategic, implementation, and procurement plans that achieve sufficient buy-in from all parties involved to improve the likelihood of success in integrating the appropriate BIM opportunities into your organization. Adopting BIM, especially as an owner, requires commitment and significant effort, but with a dedicated team and a well-developed plan, you should be able to successfully implement BIM and gain significant value for your organization.

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/// Appendices

A. CITATIONS
B. ABBREVIATIONS
C. GLOSSARY
D. INDEX

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American Institute of Architects. E202–2008 Building Information Modeling Protocol. Washington, DC, USA: The American Institute of Architects, 2008. http://www.aia.org/contractdocs/training/bim/AIAS078742.

Aranda-Mena, Guillermo, John Crawford, Agustin Chevez, and Thomas Froese. "Building Information Modelling Demystified: Does It Make Business Sense to Adopt BIM?" International Journal of Managing Projects in Business 2, no. 3 (2009): 419–434.

Azhar, S., M. Hein, and B. Sketo. "Building Information Modeling (BIM): Benefits, Risks and Challenges." Mc Whorter School of Building Science, Auburn University, Alabama (2010).
Booty, F. Facilities Management Handbook. Fourth ed. Jordan Hill, Oxford OX2 8DP, UK: Elsevier/Butter worth-Heinemann, 2009.

Bryson, J.M. Strategic Planning for Public and Nonprofit Organizations: A Guide to Strengthening and Sustaining Organiza tional Achievement. Vol. 1. Jossey-Bass, 2011.

buildingSMART alliance. National Building Information Modeling Standard Version 1 - Part 1: Overview, Principles, and Meth odologies. National Institute of Building Sciences, 2007.

Campbell, Andrew, and Sally Yeung. "Creating a Sense of Mission." Long Range Planning 24, no. 4 (August 1991): 10–20.

Chau, P.Y.K. "Factors Used in the Selection of Packaged Software in Small Businesses: Views of Owners and Managers." Infor mation & Management 29, no. 2 (1995): 71–78.

Computer Integrated Construction Research Program. BIM Project Execution Planning Guide - Version 2.1. University Park, PA, USA: The Pennsylvania State University, 2011. http://bim.psu.edu.

ConsensusDOCS. "ConsensusdDOCS301 BIM Addendum." ConsensusDOCS, 2008.

Construction Specifications Institute. MasterFormat 2012, 2012. http://www.csinet.org/MasterFormat.aspx.

———. "UniFormatTM 2010," 2010. http://www.csinet.org/Main-Menu-Category/CSI-Store/6/35152343-f0b4-df11-8ffb-0019b9e160b2.txt.

Dept. of Veterans Affairs. The VA BIM Guide. Version 1.0. Washington, DC, USA: Department of Veterans Affairs, 2010. http:// www.cfm.va.gov/til/bim/BIMGuide/lifecycle.htm.

Doran, G. T. "There's a S.M.A.R.T. Way to Write Management's Goals and Objectives." Management Review 70, no. 11 (1981): 35–36.

Drohan, William M. "Writing a Mission Statement." Association Management 51, no. 1 (January 1999): 117.

Eastman, Chuck, Paul Teicholz, Rafael Sacks, and Kathleen Liston. BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors. John Wiley & Sons, 2011.

Eckes, George. The Six Sigma Revolution: How General Electric and Others Turned Process Into Profits. John Wiley and Sons, 2002.

Etzioni, A. Modern Organisations. Prentice-Hall Englewood Cliffs, NJ, 1964.

Forrester, E., B. Buteau, and S. Shrum. CMMI® for Services: Guidelines for Superior Service. Addison-Wesley Professional, 2011.

Gilligan, B., and J. Kunz. "VDC Use in 2007: Significant Value, Dramatic Growth, and Apparent Business Opportunity." Center for Integrated Facility Engineering, Report #TR171 (December 2007).

Graham, J. W., and W. C. Havlick. Mission Statements: A Guide to the Corporate and Nonprofit Sectors. Vol. 900. Routledge, 1994.

Gregory, Amanda. "A Systems Approach to Strategic Management." Proceedings of the 51st Annual Meeting of the ISSS 51, no. 2 (July 31, 2007). http://journals.isss.org/index.php/proceedings51st/article/view/840.

Gross, Edward. "The Definition of Organizational Goals." The British Journal of Sociology 20, no. 3 (1969): 277–294.

Heise, David. "Business Drivers." Data Warehousing Dictionary, September 2, 2002. http://dheise.andrews.edu/leadership/comps/5b/3dw_kpi/dictionary.htm.

Indiana University. "Indiana University Building Information Modeling (BIM) Guidelines and Standards for Architects, Engineers, and Contractors." Indiana University, 2009. http://www.indiana.edu/~uao/IU%20BIM%20Guidelines%20and%20Standards.pdf.

Johnson, Paul. "The Top Five Reasons Why Strategic Plans Fail." Business Know How, 2002. http://www.businessknowhow.com/manage/splanfail.htm.

Kaplan, R.S., and D.P. Norton. The Balanced Scorecard: Translating Strategy into Action. Harvard Business Press, 1996.

Kueng, P. "Process Performance Measurement System: a Tool to Support Process-based Organizations." Total Quality Management 11, no. 1 (2000): 67–85.

Lear, Robert. "Why Most Strategic Plans Fail." Chief Executive no. 110 (February 1996): 10.

Lee, S., and Y. Park. "Customization of Technology Roadmaps According to Roadmapping Purposes: Overall Process and Detailed Modules." Technological Forecasting and Social Change 72, no. 5 (2005): 567–583.

Lipton, M. "Demystifying the Development of an Organizational Vision." Sloan Management Review 37 (1996): 83–92.

Los Angeles Community College District. "Building Information Modeling (BIM) Standards," November 2011. http://standards.build-laccd.org/cgi-bin/projects/dcs/extensions/viewer/code/viewer_client.pl?command=MANUAL_INDEX.

Manning, Russell. "MHS Facility Life Cycle Management (FLCM) Building Information Modeling (BIM) Minimum Requirements." Department of Defense Military Health System, May 21, 2011. http://www.tricare.mil/ocfo/_docs/BIM-UFC-RequirementDetails.pdf.

Marr, B. Managing and Delivering Performance: How Government, Public Sector and Not-for-profit Organisations Can Measure and Manage What Really Matters. Elsevier Science & Technology, 2008.

MHS PPMD. "OCFO : PPMD : About PPMD." OCFO : PPMD : About PPMD, 2012. http://www.tricare.mil/ocfo/ppmd/about.cfm.

Ohio State Architects Office. "State of Ohio Building Information Modeling (BIM) Protocol." Ohio General Services Division, September 29, 2010. http://das.ohio.gov/LinkClick.aspx?fileticket=VD8N3VDCjno%3D&tabid=305.

Oregon Department of Human Services. "Guidelines for Developing a Business Case & Business Case Template," March 2006.

Penn State University. "Strategic Planning at Penn State," 2009. http://strategicplan.psu.edu.

Phaal, R., C. Farrukh, and D. Probert. "Technology Roadmapping: Linking Technology Resources to Business Objectives." Centre for Technology Management, University of Cambridge (2001): 1–18.

Phaal, R., C.J.P. Farrukh, and D.R. Probert. "Developing a Technology Roadmapping System." Technology Management: A Unifying Discipline for Melting the Boundaries 31 (2005).

PSU Applied Facilities Research Group. “PSU OPP BIM Addendum.” PSU OPP, December 2010. http://www.opp.psu.edu/planning-construction/design_and_construction_standards.

———. “Psu Opp Rfq/rfp.” PSU OPP, 2011.

USACE/Industry BIM Advisory Committee. “USACE BIM PROJECT EXECUTION PLAN (USACE PxP).” United State Army Corps of Engineers, 2010. https://cadbim.usace.army.mil/BIM_Files/USACE_BIM_PXP_TEMPLATE_V1.0.pdf.

———. “USACE MILCON Transformation RFP, Section 01 33 16 - Design After Award, Attachment F - BIM Requirements.” US Army Corps of Engineers, April 7, 2011. https://cadbim.usace.army.mil/BIM.

Young, Norbert, Stephen Jones, Harvey M. Bernstein, and John Gudgel. THE BUSINESS VALUE OF BIM: Getting Building Information Modeling to the Bottom Line. Smart Market Report. New York, NY: McGraw Hill Construction, 2009. www.bim.construction.com.

Young, NW, SA Jones, and HM Bernstein. SmartMarket Report on Building Information Modeling (BIM): Transforming Design and Construction to Achieve Greater Industry Productivity. McGraw-Hill Construction, Washington, DC, 2008. http://www.dbia.org/NR/rdonlyres/1631EDF1-8040-410D-BE1A-CF96AB1E9F84/0/McGrawHillConstructionBIMSmartMarketReportDecember2008.pdf.

“bSa Active Projects | The National Institute of Building Sciences,” n.d. http://www.buildingsmartalliance.org/index.php/projects/activeprojects/162.

“Glossary of Terms,” n.d. http://www.csn.edu/pages/2820.asp.

“Grants Office - Grant Resources- Glossary - Pasadena City College,” n.d. http://www.pasadena.edu/externalrelations/grants/glossary.cfm.

“Kaiser Permanente Our Mission,” n.d. http://mydoctor.kaiserpermanente.org/ncal/facilities/region/eastbay/area_master/about_us/missionstatement.jsp.

“OmniClass: A Strategy for Classifying the Built Environment.” OmniClass, n.d. http://www.omniclass.org/.

2D – Two-Dimensional

3D – Three-Dimensional

AEC – Architecture Engineering Construction

AIA – American Institute of Architects

BIM – Building Information Model(ing)

BPMN – Business Process Mapping Notation

bSa – buildingSMART alliance

Computer Aided Drafting

CAFM – Computer Aided Facility Management

CIC – Computer Integrated Construction Research Program

CIFE – Center for Integrated Facilities Engineering

CM – Construction Management

CMMI – Capability Maturity Model Integrated

CMMIS – Computerized Maintenance Management Information System

CMMS – Computerized Maintenance Management Systems

COBie – Construction Operations Building Information Exchange

CPM – Critical Path Method

DB – Design-Build

DBB – Design-Bid-Build

DoD – Department of Defense

E&TM – Equipment and Technology Management

FF&E – Furniture, Fixtures, and Equipment

FLCM – Facility Life-Cycle Management

FM – Facility Management

FMS – Facility Management System

FTP – File Transportation Protocol

HBC – Healthcare BIM Consortium

HVAC – Heating Ventilation and Air Conditioning

IDEF – Integrated Definition

IFC – Industry Foundation Class

IO&T – Initial Outfitting and Transition

LoD – Level of Development

MHS – DoD Military Health System

NBIMS-US – The United States National Building Information Modeling Standards

NFS – National Facilities Services (Kaiser Permanente)

OPP – Office of Physical Plant

PACE – The Partnership for Achieving Construction Excellence

PDF – Portable Document Format

PFD – Program for Design

PSU – The Pennsylvania State University

PxP – Project Execution Plan

RAM – Random Access Memory

RFP – Request for Proposal

RFQ – Request for Qualifications

SWOT – Strength, Weakness, Opportunity, Threat

USACE – United States Army Corps of Engineers

UML – Unified Modeling Language

VA – Department of Veteran Affairs

As-Built Model: A model representing the as-built conditions of a facility. Often times delivered as a federated model with the level of development required for construction.

BIM (Building Information Modeling) (CIC Research Program): A process focused on the development, use, and transfer of a digital information model of a building project to improve the design, construction and operations of a project or portfolio of facilities.

BIM (Building Information Model) (NBIMS): A digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition. A basic premise of BIM is collaboration by different stakeholders at different phases of the life cycle of a facility to insert, extract, update or modify information in the BIM to support and reflect the roles of that stakeholder.

BIM Champion/Manager: A person who is technically skilled and motivated to guide an organization to improve their processes by pushing adoption, managing resistance to change, and ensuring implementation of a new technology or process. BIM Deliverables: Information (in numerous formats) that may be required by contract or agreement to be submitted or passed to another party.

BIM Goals: Objectives used to define the potential value of BIM for a project and for project team members. BIM Goals help to define how and why BIM will be used on a project or in an organization.

BIM Process: A generic name for the practice of performing BIM. This process can be planned or unplanned. The BIM Process may also be referred to as the BIM Execution Process or the BIM Project Execution Process. The BIM Project Execution Planning Process suggests diagramming the BIM process using process maps.

BIM Process Maps: A diagram of how BIM will be applied on a project. The BIM Project Execution Plan proposes two levels of Process Maps: BIM Overview Map and Detailed BIM Use Process Maps.

BIM Project Execution Plan (BIM PxP or BIM Plan): A planning the results from the BIM Project Execution Planning Process. This document lays out how BIM will be implemented on the project as a result of the decision of the group.

BIM Project Execution Planning Procedure: A process for planning the execution of BIM on a project. It consists of four primary steps: 1) identify BIM Goals and BIM Uses, 2) design BIM Project Execution Process, 3) develop Information Exchanges, 4) define supporting infrastructure for BIM Implementation.

BIM Use: A method or strategy of applying Building Information Modeling during a facility's lifecycle to achieve one or more

specific objectives.

Construction Operations Building Information Exchange (COBie): A specification that denotes how information may be captured during design and construction and provided to facility operators.

Co-Location: A collaboration technique where the entire project team moves into one location to develop a project. Contractor: Construction Manager (CM) Agent or At-Risk, General Contractor (GC)

Detailed BIM Use Process Maps: A comprehensive BIM Process Map that defines the various sequences to perform a specific application of BIM or BIM Uses. These maps also identify the responsible parties for each process, reference information content, and the information exchanges which will be created and shared with other processes.

Fabrication Model: A BIM model with an adequate level of detail and accuracy for use in prefabrication.

Federated Model: A BIM model that is the combination of BIM models (i.e. Architecture, plumbing, electrical, and HVAC). Often used for 3D coordination.

Facility Data: Any information for a building that has value to an owner

Information Exchange (IE): The information passed from one party to another in the BIM process. The parties involved should agree upon and understand what information will be exchanged. These are often in the form of deliverables from a process that will be required as a resource for future processes.

Level of Development(LoD): The level of completeness to which a model element is developed.

Objective: Specific tasks or steps that when accomplished move the organization toward their goals.

Operating Units: A working group within an larger organization that has a specific mission

Overview Map: A high level BIM Process Map that illustrates the relationship between BIM Uses which will be employed on the project.

Project Team: Every participant contracted to work on a project. This may include the owner, designer, contractor, and subcontractor.

Professional: The designer. This may include the Architect and Engineer

Record Model: A facility model illustrating as-built conditions in the Level of Development and file format specified by the owner.

Reference Information: Structured information resources (enterprise and external) that assist or are required to accomplish a BIM Use.

Roadmapping: The process of displaying the integration of strategic changes in a business process.

Subcontractor: A contractor contracted by the CM or GC, or a Prime Contractor contracted by the owner

Vision Statement: A picture of what an organization is striving to become.