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NEXT STEPS IN BIM EXECUTION PLANNING: A REVIEW OF GUIDES IN THE USA

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ABSTRACT

Building information modeling implementation has brought forward the development of planning guides, or BIM Execution Plans (BEP), which support teams in identifying implementation steps and the stakeholders responsible for generating and managing information. However, numerous BEP templates that exist present a challenge when choosing the guide that can fit every need. With this study, the authors aimed at evaluating a small sample size of BEPs and suggest essential guidelines that must be followed when developing a BEP. With this early study, the authors hope to open a new avenue of research in identifying the next steps in BIM planning.

INTRODUCTION

Building Information Modeling (BIM) is a technology-based management process that enables architecture, engineering, construction (AEC) professionals to collaborate effectively during the design, construction, operation and maintenance of a facility (Sacks *et al.*, 2018). BIM has been steadily increasing its demand among the AEC industry. The most notable uptake of BIM has been projected to take place between 2017 and 2019. According to Dodge Data and Analytics (2017), by 2019 a high implementation of BIM is projected to reach 61% and expected to increase within the next five years. With the increased BIM adoption, standards and guidelines are being developed to identify the uses, goals, and processes and to ensure that all parties are aware of project requirements and responsibilities (Kreider, Dubler and Messner, 2012). One procedure to ensure that all parties are in agreement of project requirements and responsibilities is by developing a BIM Execution Plan (BEP). A notable BEP template in the industry is the Penn State *BIM Project Execution Planning Guide - Version 2.1* (Computer Integrated Construction Research Program, 2011). Penn State has laid out the fundamental BEP steps and procedures that projects and organizations should use or build upon to implement BIM to create value. While Penn State's BIM Project Execution Planning Guide is widely adopted, there are several BEP templates that a project team can choose from. This variety of BEPs presents a challenge to the project team to choose the guide that best fits their needs. With this study, the authors aimed to evaluate a small sample size of BEPs to identify the standard guidelines and requirements found in each guide. To perform this analysis, the authors used the Penn State BEP as a baseline. By performing this analysis, the authors suggested then the essential guidelines that must be followed when developing a BEP.

ANALYSIS OF EXISTING BIM EXECUTION PLANNING GUIDES

Survey of BIM Plans and Guides

To analyze various BIM Execution Plans and Guides against a baseline BEP, a search was done first through Google Scholar, Library Databases, Science Direct, and Google. The majority of the BEPs were found using Google, with a few successful finds through Google Scholar. Initially, the search produced far more international BEP variations, rather than those in the U.S. A brief review of the international BEPs yielded numerous results dense with information. However, it was decided early during the research to focus on BEPs used in the U.S. to be consistent when comparing with a baseline BEP. A comparison to the EN ISO 19650 was also performed as an early step of future research when looking at the international BIM implementation context. The final search engine, Google, produced the most finds, although different variations of BEPs wording was used to find sufficient quantities to analyze. The most successful search phrases used were "BIM Execution Plan", "BIM Execution Plan Guides", "BIM Execution Plan Template", and "BIM Templates".

For each search, Google query expansion was also used in search of any relevant guide. Ultimately, the "BIM Execution Plan Template" phrase yielded the most finds, especially when sorting through all the international and domestic guides for review. For future research, international BEPs will be analyzed, beyond the EN ISO 1950 standard, to see how they compare with a baseline and guides from the U.S.

Table 1: BIM Execution Plans for Review

Organization/ Institute/ Agency	Document Name	Publication Date	Document Version
Pennsylvania State University (PSU) - ***Chosen Baseline***	BIM Project Execution Planning Guide	N/A	V2.1
University of Southern California (USC)	BIM Information Modeling (BIM) Guidelines - For Design Bid Build Contracts	04/18/2012	v1.6
University of South Florida (USF)	BIM Project Execution Plan for Architects, Engineers and Contractors	02/12/2018	N/A
Massachusetts Institute of Technology (MIT)	MIT Design Standards – BIM Execution Plan	11/01/2016	v6.0
College of the Desert (CD)	BIM Guide – Protocols and Project Execution Plan	2011	N/A
Department of Veterans Affairs (VA)	The VA BIM Guide	04/2010	v1.0
Ohio Department of Administrative Services (ODAS)	State of Ohio Building Information Modeling Protocol	N/A	N/A
National Institute of Building Sciences (NIBS)	National BIM Guide for Owners	01/2017	N/A
Smithsonian Institution (SI)	Smithsonian Facilities BIM Guidelines	10/2017	N/A

A total of nine BEPs were found (Table 1), including Penn State's, which range from different types of organizations, such as universities, community colleges, government agencies to education and research institutes. The majority of the BEPs are from universities and colleges, which were more easily found compared to other organizations. All BEP publication dates span within the last ten years, with some indicating version updates of their guide.

EVALUATION OF BIM PLANS AND GUIDES

The first step in the research was to choose and evaluate the baseline BEP. The authors chose Penn State University (PSU) BIM Project Execution Planning, Version 2.1. to be the baseline (Computer Integrated Construction Research Program, 2011). This first step allowed the authors to get a general understanding of the content and how the information was structured into sections. Then a comprehensive review of the baseline BEP was completed, including a summary of all the significant components within each section, which can be used as guidelines to review the other BEPs. A table was created, including the eight major sections found within the baseline BEP to record findings of the various BEPs. A ninth section was added, which was not part of the baseline BEP, and it was labeled "Other Section" to record findings not necessarily fitting within the prescribed eight sections.

The following is a general overview of the eight sections within PSU to allow the readers to have a general understanding of the baseline content with respect to the selected BEP to be analyzed:

- **Section 1. Overview of the BIM Execution Planning Procedure for Building Information Modeling** – The first section is essentially a high-level overview of each component that goes into creating the BEP. This section includes high-level goal questions for a user to consider "why should the project develop a BEP?" or "who should develop the BEP?" It prepares the user for the next sections, which go into detail of the BEP development.
- **Section 2. Identify Project Goals and BIM Uses** – This section describes the first steps in developing the BEP, which is identifying project goals and BIM uses. PSU utilizes a few charts and tables for the user to understand the process and to utilize during their own BEP development. Some of the charts and tables used describe BIM Uses throughout the building lifecycle, Project Goals table with priority ranking, an example of BIM Use description, and a BIM Use selection worksheet example.
- **Section 3. Designing the BIM Project Execution Planning Process** – This section discusses the procedure for designing the BIM process for a project. Once the BIM Use is identified, then a team develops process maps to understand the information exchanges between different parties and different stages of the project. The overview map aids in defining process sequences so that parties understand what is expected and their responsibilities.

- **Section 4. Developing Information Exchanges** – Once the processes are mapped, the task is to identify points of information exchanges for the parties to understand what information is necessary to deliver each BIM Use. This section walks the user through five steps breaking down the information further while utilizing a worksheet. The worksheet breaks the model down to various elements by the BIM Use indicating information and the responsible party.
- **Section 5. Define Supporting Infrastructure for BIM Implementation** – This section helps the teams identify the infrastructure required to support their BIM process. There are fourteen categories that are discussed to support BEP and can vary between projects. These categories are meant for project teams to discuss and develop their individual BEP requirements.
- **Section 6. Implementing the BIM Project Execution Planning** – Discusses a method for project teams to develop the BEP through a series of meetings and subsequent tasks. The section outlines four meetings and tasks to be completed to maintain momentum in the developmental process.
- **Section 7. BIM Project Execution Planning for Organizations** – This section guides an organization how to use BIM by internally evaluating what their BIM intentions are to develop internal standards. Then a re-discussion of Sections 2 through 5 at an organizational level with standards developed can then be implemented when developing the BEP for future projects.
- **Section 8. Conclusions and Recommendations** – Discusses ten lessons learned from case study projects and organizations that have implemented BEP.

Similar to the first step, the second step was to initially review each of the eight BEPs for a basic understanding of the content and general layout of the information. The second and third review of the BEPs was a thorough review of each section and the main components. What each section detailed, how it compared to the baseline, where it aligned with the baseline BEP section, and lastly, checking if all findings were recorded in the appropriate baseline section. PSU BEP provides a high-level approach to the development of BEPs by providing a detailed description of the who, what, when, and how BIM must information flow. Therefore, the PSU BEP is a document that provides guidelines in incorporating BIM or those who are either unfamiliar with the process or need the fundamental knowledge to develop a plan. When comparing the University of Southern California (USC) BIM Guidelines v1.6 (2012) with the PSU BEP, there are similarities in providing guidelines for BIM processes, modeling requirements, and addressing a few of the categories in PSU section 5, Define Supporting Infrastructure for BIM Implementation.

USC BEP, however, differs from PSU BEP by providing direct and concise guidelines to be used for design bid build contracts. There are two main core sections in the guide that differ from the PSU BEP. One is Section 6, Design Phases, which identifies four phases in a project: schematic design, design development, construction documents, and bidding phase. Each phase outlines the model content, level of detail, program validation, and collision detection to bid deliverables. The second difference is Section 7, Construction Team: BIM Process and Modeling Requirements. This section outlines the BIM process and university standards for the construction team. It also illustrates how to facilitate the model between parties once the contractor/subcontractor has been awarded the project. The guide provides a general process map to demonstrate the flow of information. This process map is color-coded by stakeholders, and it shows the interaction of information between USC, the design team, and the construction team. USC BEP thus appeared to be more of a standard rather than a guideline, which could be inserted or referenced into Architecture/Engineer agreement services or the contract documents between the owner and the contractor.

University of South Florida (USF), BIM Project Execution Plan Template (2018) begins by providing a brief introduction, uses, general requirements, and critical roles. This section is similar to the PSU BEP Section One-Overview of the BIM Execution Planning Procedure for BIM but abbreviated. Most of the guide comprises templates to be filled-in and reference charts to use throughout the BEP process. Two templates resemble the content provided by the PSU BEP. The first is “4.1 Major BIM Goals/Objectives,” which is identical in format to PSU “Project Goals,” and the other is “4.2 BIM Uses,” which is identical content to PSU “Figure 2.1: BIM Uses throughout a Building Lifecycle”. The rest of the USF template, similar to USC, is broken into a design and construction phase and goes as far as to provide a project closeout section, all of which outline objectives, roles, and responsibilities for each phase. The design and construction phasing sections dovetail into the Level of Development (LOD), and BIM collaboration, procedure, and management sections as a teamwork their way through the project. Overall, this template is a manageable document to review and implement, as it is under thirty-five pages in length.

The Massachusetts Institute of Technology (MIT) BEP (2016) replicates the format and most of the content of the USF BEP. The entire plan is composed of templates and charts with minimal explanation throughout the plan. The similarity to PSU BEP is in the same two templates that USF uses, BIM Uses, and Project Goals. The MIT BEP includes a process map for BIM model exchange to provide an overview diagram of the model information at each phase. This diagram starts at the design phase, leading to construction and ending with the project's operation. Though this process map resembles the PSU BEP process maps, the format is simplified to guide the users. Section 6, Model Transition

Process Diagram, also suggests modifying the process map based on project specifics and requirements. MIT BEP is probably one of the shortest and streamlined plans reviewed from the universities and college BEPs. The MIT BEP eliminates general complexity and provides a user's plan to engage from the beginning of the process to execute BIM throughout the project.

The BIM Guide for the College Desert (CD) (2011) provides a slightly more detailed explanation in its sections, compared to the last two reviewed guides, followed by templates located in the appendix. The guide itself consists of categories that are similar to the PSU BEP, Chapter 5 – Figure 5.1: BIM Project Execution Plan Categories, to which the college provides its own definition for these categories. There are a couple of differences to note in the CD guide. One is, the CD BEP references the AIA E202 BIM Modeling Protocol to define their Level of Development (LOD) 100 through 500, which is to be used during the design phase. The other difference is that the CD BEP provides a Contract Strategies section where three common strategies are defined and loosely identifies how BIM is implemented within each of these contract types.

Moving forward to the Federal Government, the Department of Veterans Affairs (VA) (2010) BIM Guide has similarities with PSU BEP Chapter 5, Define Supporting Infrastructure for BIM Implementation categories. The VA provides concise and thorough informative sections from outlining responsibilities, technology infrastructure requirements, BIM uses, to quality control. It also provides information not necessarily addressed in PSU BEP, such as: construction bidding requirements; utilization of Construction Operations Building Information Exchange (COBie) and commissioning; BIM 4D to illustrate phasing plan and schedule planning to communicate with trade partners; and virtual testing and balancing. Additionally, the VA BEP provides a section regarding acquisition strategy, which discusses different project delivery methods that should be identified early to set up the project correctly and to monitor progress. The last section of the VA BEP is a list of credits that contributed to creating their guide. It appears that the VA BEP utilized information from the National Institute of Building Sciences (NIBS), later included in this study, and Los Angeles Community College District. The Los Angeles Community College District standards are based on the National Building Information Standards (NBIMS) and reference technology standards developed by the General Services Administration (GSA) and the US Army Corps of Engineers (USACE) (General Services Administration, 2007; United States Army Corps of Engineers, 2010).

The State of Ohio (ODAS) BEP (2011) is a simple guide consisting of three sections: 1) Statement of Purpose, 2) The Protocol and, 3) Implementation. The first section provides a brief overview of what BIM is, how it is used, and who uses it. A general overview of technology mapping to organize electronic information is similar to the PSU BEP Section 3, Designing the BIM Project Execution Planning Process. At the end of the first section, ODAS BEP discusses BIM goals that will assist current and future ODAS BIM protocols. The goals are further specified as immediate, short term, midterm, and long-term goals. The second and third sections borrow from the PSU BEP categories in Section 5, Define Supporting Infrastructure for BIM Implementation. The ODAS BEP has chosen to separate specific categories between the Protocol and Implementation sections. In the Protocol section, the ODAS BEP is defined as serving a foundation or structure for BIM implementation. The Protocol section discusses a model to use and management, data requirements, RFQ for BIM requirements, and compensation expectations. Meanwhile, the Implementation section discusses the level of development and deliverables. The ODAS BEP indicates it has no specific standard, but rather it provides information that could be used on projects associated with the state for those project teams that need guidance when requesting "qualifications, agreements, bidding requirements, contracts and other documents affected by this new medium and process".

Similarly to the ODAS BEP, the National Institute of Building Sciences (NIBS) (2017), National BIM Guide for Owners, is a relatively simple guide that includes four sections: 1) Introduction, 2) Process, 3) Infrastructure and Standards, and 4) Execution. The Introduction section provides a general overview of the owner's perspective on managing projects. The majority of the next two sections address PSU categories in Section 5, Define Supporting Infrastructure for BIM Implementation. For its Process section, NIBS utilizes information from the PSU BEP, Section 1 *Overview of the BIM Execution Planning Procedure for Building Information Modeling*. Similarly, NIBS uses the PSU BEP *BIM Project Execution Planning Procedure* chart to describe their BIM planning process. In their last section, NIBS predominately describes BIM Uses by leveraging the categories from the PSU BEP. NIBS then provides definitions to the BIM Uses and indicates that the uses should be applied to all their projects. NIBS indicates that the last three sections are the minimum BIM standards that should be utilized on a project.

The last BEP review is the Smithsonian Institution (SI) (2017), Facilities BIM Guidelines, a concise and detailed guide again lending the majority of its categories from the PSU BEP Section 5, Define Supporting Infrastructure for BIM Implementation. As the title indicates, it is a guide rather than a BIM Execution Plan. It focuses primarily on the model requirement, level of detail (LOD) for each project phase, templates, standards, and deliverables. A brief section discusses BIM Goals and Uses from the perspective of an existing building for the project team to consider when developing their project execution plan. Overall this guide is meant to be used to implement SI standards. Some key processes and project deliverables are consistent for all their projects, incorporated into BEP for individual projects.

Comparison to EN ISO 19650

The analysis of the selected BEPs cannot be separated from a comparison with the EN ISO 19650 standard, which currently has an internationally recognized value. The focus in this case is on the information delivery cycle that must follow pre-defined exchange information requirements (EIR). EIR set out managerial, commercial, and technical aspects of producing project information, including information standards and production methods to be implemented by the delivery team, being aligned with trigger events representing the completion of some or all project stages. The delivery team then must develop their BIM execution plan as a response to the exchange information requirements as "it explains how the information management aspects of the appointment will be carried out" (ISO, 2018). According to the EN ISO 19650 standard, the BIM execution plan's structure should include: (1) the proposed members who will undertake the information management function on behalf of the delivery team; (2) the proposed information delivery strategy containing the (a) delivery team's approach to meeting the appointing party's EIRs; (b) a set of objectives and goals for the collaborative production of information; (c) an overview of the delivery team's organizational structure and commercial relationships; (d) an overview of the delivery team's composition, in the form of one of more task teams. Moreover, the BIM execution plan should include the (3) proposed federation strategy to be adopted by the delivery team; (4) the delivery team's high-level responsibility matrix, containing the allocated responsibility for each element of the information model and the key deliverables associated to each element; (5) any proposed additions and amendments to the project's information production methods and procedures that the delivery team requires to manage information as well as to (6) the project's information standard; (7) a proposed schedule of software, hardware and IT infrastructure the delivery team intends to adopt.

From a preliminary comparison of the EN ISO 19650 standard with sections outlined in the baseline PSU BEP, it emerges how the focus should be first on management sections rather than technical ones, pushing the idea of BIM as a set of procedures and not only to adopt technologies. Moreover, the role of a clear definition of BIM uses and goals, defined since the beginning of the BIM execution plan in both the cases, results to be pivotal to manage the information delivery cycle effectively stressing the need for well-defined workflows and clearly established levels of information need.

PROPOSED BIM GUIDE STRUCTURE

After analyzing the nine BEPs and the BIM execution plan's organization as proposed in the EN ISO 19650-2:2018 standard, a fundamental understanding was achieved of the similarities and differences against the PSU baseline and other BEPs' structure. It allowed for a further evaluation of which sections conveyed a thorough description and is well developed for implementation on projects. This stems from the idea of creating an outline using the various parts of all nine BEPs as a proposed update to the BEP. It is composed of existing BEP sections considered as fitting, best suited for actual projects, and perhaps in the future could be further expanded. The relevant sections were selected based on three factors: design project management, industry best practices for contracts and project lessons learned. These factors were selected based on past project experience on common areas lacking through the most projects that could have been proactively addressed before commencing a project to avoid conflict or confusion. Each of these factors is discussed in detail below, and the team describes how they will be reflected in the future BIM guide.

- **Design Project Management.** American Institute of Architects (AIA) is a professional organization for architects in the United States. AIA provides many resources for architectural professionals to utilize, such as education, advocacy, events, best practices, and contract standard forms, to name a few of their services. AIA publishes "The Architect's Handbook of Professional Practice," in which many design and construction projects modeled their project requirements, mainly publicly funded projects (Hayes, 2014). The handbook provides a chapter on managing the design phase of projects and what deliverables are required, by adhering to the following design phases: planning, schematic, design development, construction document, and bidding. Each of these phases, respectively, has its deliverables and level of information needed to proceed to the next design phase. In reviewing the BEPs, several organizations included deliverables for each design phase as part of the BEP. This is a crucial component in managing design development and maintaining the overall project schedule by providing the required development at each phase for review and revisions. It breaks down the whole process into tangible sections to manage, track, ultimately approve progress and payment of the consultant/contractor work performed. The inclusion of design phases within the BEP assists with the overall design management of a project. Without an outline of deliverables or directions provided, managing expectations will be increasingly difficult. For this reason, the updated BEP includes the breakdown of the design phase leading up to bidding (depending on the delivery method) into the construction phase and finally completing the project with the closeout phase.
- **Industry Best Practices for Contracts.** Contract management is another topic to consider in the proposed BEP. Executed contracts are legally binding and should be addressed within the BEP to indicate the type of contract(s) and the requirements to adhere to and enforce them. Contracts include various terms or clauses, including responsibilities and services,

termination, fee and payment method, and exhibits. Typically, contracts on publicly funded projects are more stringent than privately funded and may utilize contract exhibits to include or reference their project standards. Referencing or adding the owner's standards within a contract provides an opportunity for BEP inclusion, which communicates the project requirements and deliverables. Taking this proactive approach and developing their own BEP rather than being silent in a contract or leaving it to other parties' hands, provides specifically the requirements to be implemented and managed throughout the project. The proposed BEP includes a section to address project delivery strategies and contracts. Providing the BEP delivery strategies and contract section is essential in managing the project and for all key team members to understand the project strategy from the beginning stages.

- **Project Lessons Learned.** The final topic considered is the project's lessons learned. This topic may, at times, seem like an unrated topic when managing projects but is a potent knowledge-building tool that can help refine and improve areas that were missing or lacking further development that caused significant issues. It was evident that the point of lessons learned is to avoid repeating these mistakes on a future project. According to Seed (2015) capturing these lessons learned before it is lost is vital. Having an audit of a past recent project to revisit issues and record them before moving forward with another project may help avoid conflict. The Royal Institution of Chartered Surveyors (RICS) indicates "common causes of project failures are: failed project planning, management, clear objectives, lack of understanding scope, lack of ownership or procedural issues," to name a few (Schulte, 2000; Herald, 2007). These issues lead to undefendable contract documents, mismanaged expectations, or lack of clarity in contracts leading to additional project time and costs. By providing a well-developed and clear BEP, it can aid in avoiding most project issues. The proposed BEP outline sections were selected based on well-developed sections with clear intent. However, lessons learned should be incorporated within the BEP to record any issues encountered in future projects. Similarly, PSU *Section 8 – Conclusion and Recommendations* concludes their BEP by reporting ten recommendations based on projects implementing their procedures that would potentially improve their BEP for future uses.

Based on the three factors mentioned above, the team has proposed a new outline for comprehensive BEPs. The outline is broken into nine sections: 1) Introduction, 2) BIM Goals, and BIM Use, 3) BIM Roles and Responsibilities, 4) Technology Infrastructure and Standards, 5) Modeling Requirements, 6) Delivery Strategy/Contracts, 7) Project Information, 8) Design Phases, and 9) Construction Phases. An excerpt of the proposed outline with reference organization's BEP is found in Table 2.

Table 2. Excerpt from Proposed BIM Guide Structure

1. Introduction (USC, Smith., NIBS, USF)
- 1.1 Statement of Purpose (USC) / Mission Statement (VA)
- 1.2 Building Information Model (USC)
- 1.3 Key Ingredients for Success (USC)

2. BIM Goals and BIM Uses (Smith., sec 2.6)
- 2.1 BIM USE Definition
  - 2.1.1 Goal Description Chart (USF, 4.1; MIT, 4.1)
  - 2.1.2 BIM Uses Chart (USF, 4.2; MIT 4.2)
- 2.2 Essential BIM Uses (NIBS, 4.2.2; Smith, 2.6)
  - 2.2.1 Existing Conditions Modeling
    - 2.2.1.1 Laser Scanning for Existing Conditions
  - 2.2.2 Design Authoring
  - 2.2.3 Design Review
  - 2.2.4 Coordination / Clash Detection (VA, 7.9)
  - 2.2.5 Record Modeling
- 2.3 Enhanced BIM Uses (NIBS, 4.2.3)
  - 2.3.1 Cost Estimating
    - 2.3.1.1 Material Take-offs (VA, 7.11)
  - 2.3.2 Phase and 4D Planning
    - 2.3.2.1 Site Utilization – For Construction
  - 2.3.3 Site Analysis – Development
  - 2.3.4 Digital Fabrication
  - 2.3.5 3D Location and Layout
  - 2.3.6 Engineering Analysis
  - 2.3.7 Sustainability Analysis
  - 2.3.8 Codes and Standards Compliance
  - 2.3.9 Construction Systems Design
  - 2.3.10 Virtual Testing and Balancing (VA, 7.10)
- 2.4 Owner-Related BIM Uses (NIBS, 4.2.3)
  - 2.4.1 Asset Management
  - 2.4.2 Disaster Planning and Management
  - 2.4.3 Space Management

3. BIM Roles and Responsibilities
- 3.1 Roles & Responsibilities Chart (CD, p. 5) and BIM Team Coordination Method (NIBS, 2.2)
  - 3.1.1 Owner's Representative(s) (NIBS, 2.2.1)
    - 3.1.1.1 Owner's Representative (CD, p.5)
    - 3.1.1.2 Owner's Project Manager (CD, p.5)
    - 3.1.1.3 Owner's BIM Manager (NIBS, 2.2.1)
  - 3.1.2 Design Team
    - 3.1.2.1 Architecture, Civil, Landscape and MEP Consultants (CD, p. 6)
    - 3.1.2.2 Design Team Project Manager (CD, p. 6)
    - 3.1.2.3 Design Team BIM Manager (CD, p. 6; VA, 4.1; USF 5.1)
    - 3.1.2.4 Lead BIM Coordinators (VA, 4.3; USF, 5.2)
  - 3.1.3 Build Team
    - 3.1.3.1 Multiple Prime Contracts (CD, p.7)
      - a) Construction Manager
    - 3.1.3.2 All Other Contracts (CD, p.7)
      - a) Contractor Team Project Manager
      - b) Construction BIM Manager (VA, 4.3; CD, p.7)
      - c) Discipline BIM Coordinators (VA, 4.2; NIBS, 2.2.3)

4. Technology Infrastructure and Standards (NIBS, 3)
- 4.1 Software with Chart (VA, 9.1; Smith, 2.5; CD p.14)
- 4.2 Computers/Hardware Chart (MIT, 11.2)
- 4.3 File Structure (CD, p.15; MIT, 12; NIBS, 3.4.3)
- 4.4 File Sharing/Transmittal Requirements (NIBS, 3.4.6 3.4.7)
- 4.5 Data Security Protocol (CD, p.16)

5. Modeling Requirements
- 5.1 Standards
  - 5.1.1 Space and Graphical Standards (NIBS 3.3)
    - 5.1.1.1 Owner-Specified Guidelines and Standards
    - 5.1.1.2 Drawing (CD, p.22)
      - a) Font
      - b) Line Styles & Line Weights
      - c) Interior Partitions
      - d) Doors
      - e) Casework/Finishes
    - 5.1.1.3 Sheet Layout
    - 5.1.1.4 Area/Rooms/Spaces Naming and Coding (VA 10.7)
    - 5.1.1.5 Furniture, Fixtures, and Equipment Coding (CD p.1)
  - 5.1.2 Open Standards (NIBS 3.2.3)
  - 5.1.3 Model Geographical Location (VA 10.3)
- 5.2 File Structure (NIBS 3.4)
  - 5.2.1 Project Folder Structure (VA 11.1)
    - 5.2.1.1 BIM Folders
    - 5.2.1.2 Support Files
    - 5.2.1.3 Support Files
    - 5.2.1.4 Coordination Files
    - 5.2.1.5 Other Folders
  - 5.2.2 File Naming / Meta Data (VA, 10.6)
- 5.3 Digital Documentation and Archiving (NIBS 3.3.5)
- 5.4 Intellectual Property (NIBS, 2.1.3)
- 5.5 Indemnification for Use of Files (Ohio 11.7, VA 11.3)

6. Delivery Strategy/Contracts (CD p.8)
- 6.1 Design Bid Build (Traditional)
- 6.2 IPD Integrated Project Delivery
- 6.3 Design-Build
- 6.4 Multiple Prime Contracts

7. Project Information (USF, 2 & 3; MIT, 2 & 3)
- 7.1 Project Owner
- 7.2 Project Name
- 7.3 Project Location and Address
- 7.4 Contract Type/Delivery Method
- 7.5 Project Description
- 7.6 Project Numbers
- 7.7 Project Schedule/Phase/Milestones Chart
- 7.8 Project Core Collaboration Team Contact Chart

8. Design Phases (USC, 6)
- 8.1 Programming/Pre-Design Phase
  - 8.1.1 Deliverable Chart (USC, 6.1)
  - 8.1.2 Level of Development Chart (USF, 8.2)
  - 8.1.3 Understanding Level of Development (USF, 8.4; CD, p.9)
  - 8.1.4 Quality Control Checks (USF, 10.2)
- 8.2 Schematic Design Phase
  - 8.2.1 Deliverable Chart (USC, 6.1)
  - 8.2.2 Level of Development Chart (USF, 8.2)
  - 8.2.3 Understanding Level of Development (USF, 8.4; CD, p.9)
  - 8.2.4 Program and Space Validation (USC, 6.2.4;
  - 8.2.5 Initial Collision Report and Constructability (USC, 6.2.6)
  - 8.2.6 8.1.4 Quality Control Checks (USF, 10.2)
- 8.3 Design Development Phase
  - 8.3.1 Deliverable Chart (USC, 6.1)
  - 8.3.2 Level of Development Chart (USF, 8.2)
  - 8.3.3 Understanding Level of Development (USF, 8.4; CD, p.9)
  - 8.3.4 Program and Space Validation (USC, 6.2.4;
  - 8.3.5 Initial Collision Report and Constructability (USC, 6.2.6)
  - 8.3.6 Quality Control Checks (USF, 10.2)
- 8.4 Construction Development Phase
  - 8.4.1 Deliverable Chart (USC, 6.1)
  - 8.4.2 Level of Development Chart (USF, 8.2)
  - 8.4.3 Understanding Level of Development (USF, 8.4; CD, p.9)
  - 8.4.4 Program and Space Validation (USC, 6.2.4;
  - 8.4.5 Initial Collision Report and Constructability (USC, 6.2.6)
  - 8.4.6 Quality Control Checks (USF, 10.2)

9. Construction Phases (USC, 6)
- 9.1 Bidding Phase (USC, 6.5)
  - 9.1.1 Archiving of Design BIM
  - 9.1.2 Deliverable Chart (USC, 6.1)
  - 9.1.2 BIM Execution Plan (USC, 6.5.3)
  - 9.1.3 Co-Location (USC 6.5.4)
  - 9.1.4 Design Model Updates (USC 6.5.5)
  - 9.1.5 Model Mashups (USC 6.5.6)
- 9.2 Construction Phase
  - 9.2.1 Deliverable Chart
  - 9.2.2 BIM Execution Plan Feedback and Revision (USC 7.1)
  - 9.2.3 Construction Model Updates (USC 7.5)
  - 9.2.4 Trade Coordination (USC 7.6)
  - 9.2.5 Installation (USC 7.6.3)
  - 9.2.6 Requirement for 3D models, Formats and Model Structures (USC 7.6.4)
    - 9.2.6.1 File Format
    - 9.2.6.2 Level of Detail
    - 9.2.6.3 Local Coordinates
    - 9.2.6.4 Clearances and Access
    - 9.2.6.5 Trade Colors
    - 9.2.6.6 File Naming
- 9.3 Closeout Phase
  - 9.3.1 Deliverable Chart (USC, 6.1)
  - 9.3.2 As-Built Model (NIBS 4.3)
  - 9.3.3 Record Model (NIBS 4.3)
  - 9.3.3 Operations and Maintenance Data (NIBS 4.3)

CONCLUSIONS

BIM implementation is increasing every year among construction stakeholders, including clients, designers, and contractors. For BIM to make a beneficial impact on projects, implementation of BEP is essential for both clients and delivery teams. BEPs provide a detailed and comprehensive plan in which BIM can be effectively used at different project stages and among project teams to answer information management delivery cycles effectively. The expectation for individual teams and overall project goals is provided before commencing the project to yield significant benefits through a project.

This study explored nine BEPs and the EN ISO 19650 and how the various comprehensive plans compare with PSU BEP, which appears to be the building block of which many other BEPs are developed from. The first

step was to break down the sections found within PSU and understand its content. The next step was to compare it with other industry BEPs and measure whether individual BEP had similar PSU findings or record additional information that would benefit the process. Moreover, a comparison with the current EN ISO 19650 standard is proposed. The research did provide additional sections that could be beneficial to the development of a BEP. As a result, a proposed BEP outline was developed utilizing the additional information or comprehensive sections found within the nine BEP as potentially the next BEP version. The outline is the first step in what future research could expand or edit this outline to develop an execution plan that encompasses the design and construction industry's multi-faceted processes.

Broader questions this study raises is the inherent tension between the efforts to provide a standardized workflow and the recognized practical need for BEP customization to address specific contractual, procurement or project type needs (see for example McArthur and Sun 2015; Wu and Issa 2015). Next steps would be to examine some of the contextual factors and the extent to which BEP can truly be standardized. Additionally, future research could leverage International BEPs since it is more readily found and could potentially cover topics or strategies that may not have been included in the proposed BEP outline. Future research could potentially use this research as a springboard into developing comprehensive and consensus BEPs enabling firms or agencies to have an execution plan that provides standardization across the industry.

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