ERDC SR-12-2

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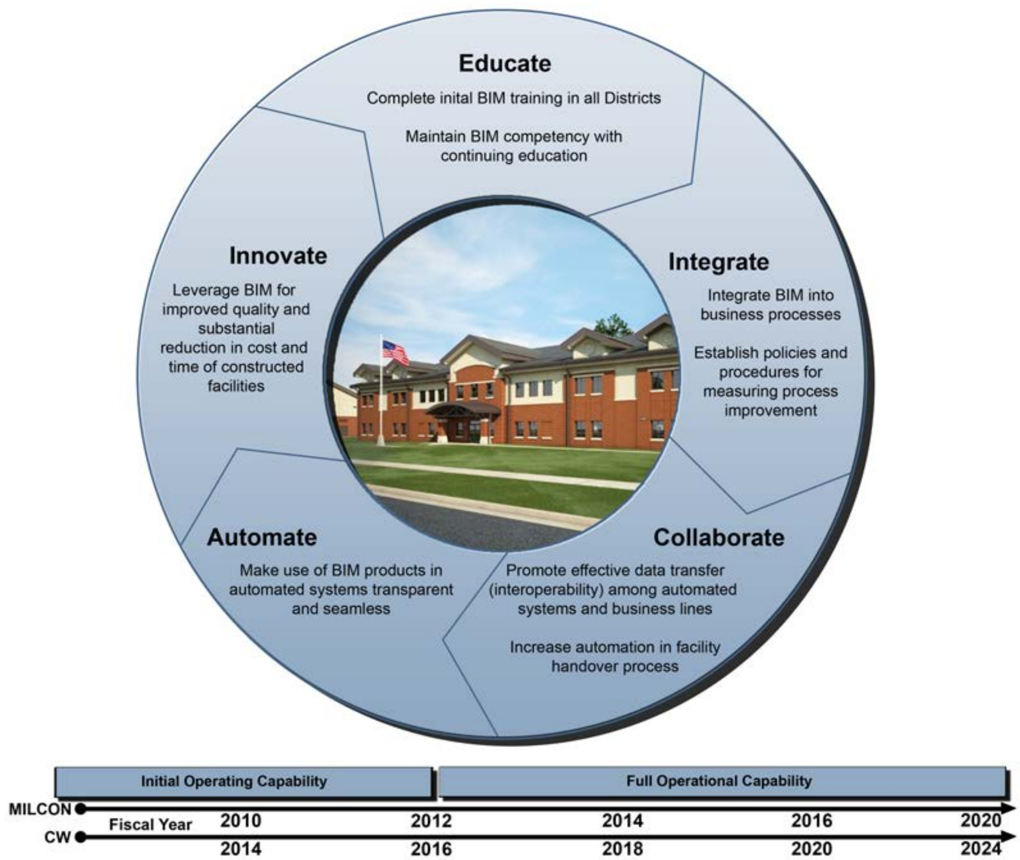
The US Army Corps of Engineers Roadmap for Life-Cycle Building Information Modeling (BIM)

US Army Corps of Engineers

Directorate of Civil Works
Engineering and Construction Branch
Washington, DC 20314-1000

November 2012



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Final report

Approved for public release; distribution is unlimited.

Prepared for US Army Corps of Engineers
Washington, DC 20314-1000

Abstract

Building Information Modeling (BIM) technology has rapidly gained acceptance throughout the planning, architecture, engineering, construction, operations, and maintenance industries. The challenge for the US Army Corps of Engineers (USACE) is to extend BIM use beyond its basic labor- and time-saving benefits to become a fully realized information network that permanently transforms conventional business processes to unprecedented levels of efficiency and organization.

This document describes the current USACE strategic plan, reflecting progress made toward the goals of the original 2006 USACE BIM roadmap as published in Engineer Research and Development Center (ERDC) Technical Report TR-06-10 (October 2006). This update of the strategic roadmap focuses on fuller integration of BIM technologies into USACE planning, design, construction, and operations and maintenance (O&M) processes. It describes how USACE will meet or exceed the vision of its customers, including the Office of the Secretary of Defense (OSD), the Army, and the Air Force. The scope of this plan is BIM implementation within the business processes of the Military Construction (MILCON) and Civil Works programs, including processes for working with USACE industry partners and software vendors.

Contents

Preface

This document was prepared for Headquarters, US Army Corps of Engineers (HQUSACE), to supersede Engineer Research and Development (ERDC) Technical Report TR-06-10 (Brucker et al. October 2006). The proponent for the USACE Building Information Modeling Roadmap is the Directorate of Civil Works, Engineering and Construction Branch. The Technical Monitor was Jason C. Fairchild, CECW-CE.

This work was coordinated through the Engineering Processes Branch (CF-N) of the Facilities Division (CF), US Army Engineer Research and Development Center – Construction Engineering Research Laboratory (ERDC-CERL); and the CAD/BIM Technology Center (IS-C) of the Software Engineering and Informatics Division (IS), Information Technology Laboratory (ERDC-ITL). At the time of publication, Donald K. Hicks was Chief, CEERD-CF-N; L. Michael Golish was Chief, CEERD-CF; Dr. Kirankumar Topudurti was the Deputy Director; and Dr. Ilker Adiguzel was the Director of ERDC-CERL. Edward L. Huell was Chief, CEERD-IS-C; Ken Pathak was Chief, CEERD-IS; Dr. Kevin M. Barry was the Acting Deputy Director; and Dr. Reed L. Mosher was the Director of ERDC-ITL.

The following individuals, groups, and industry firms are acknowledged for their contributions to the preparation and technical review of this report:

- ERDC: Beth A. Brucker, CEERD-CF-N; Stephen C. Spangler, CEERD-IS-C; Toby Wilson, CEERD-IS-C; E. William East, CEERD-CF-N
- Army Engineer Districts: Steve P. Hutsell, Van Woods, CENWS-EN-ES-GS; Lisa Hansen, CENWS-EN-DB
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COL Kevin J. Wilson was the Commander of ERDC, and Dr. Jeffery P. Holland was the Director.

Glossary

Army Corps of Engineers – Information Technology (ACE-IT): the USACE information technology activity, a hybrid entity consisting of USACE government personnel to perform core mission-assurance duties and Lockheed Martin Corp. to provide industry best practices.

Architect-Engineer-Construction Exchange Markup Language (aecXML): a specialized XML markup language that uses the Industry Foundation Class (IFC) definitions to create vendor-neutral data exchanges for use in BIM software tools.

Building Information Modeling (BIM) model: "a digital representation of physical and functional characteristics of a facility [that] serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life cycle from inception onward" (NIBS 2007).

buildingSMART Alliance: an international group of architects, engineers, constructors, product manufacturers, facility managers, and software vendors established to coordinate open interoperability and full life-cycle implementation of BIM models at lowest cost with highest sustainability, energy conservation, and environmental stewardship.

CAD: computer-aided design. The term refers to computer technology, including software applications, processes, and output files, developed to improve efficiency and precision in the creation of technical drawings. CAD drawings may be two-dimensional (2D) or three-dimensional (3D), and are used to visualize building plans, elevations, interior spaces, subsystems, fixtures, and other elements used in a BIM model.

Charrette: an intensive collaborative process engaging all project stakeholders at the beginning of a project to develop a comprehensive plan or design. The USACE Engineering and Construction Bulletin on DD Form 1391, *Preparation Planning Charrette Process*, can be found on the Whole Building Design Guide's Construction Criteria Base http://www.wbdg.org/ccb/ARMYCOE/COEECB/ARCHIVES/ecb_2003_8.pdf

Construction Operations Building information exchange (COBie): a standardized, open data specification for use in a digital documentation process to facilitate the transfer of design and construction records from the project team to the facility management team.

Deliverable: a product of engineering and design efforts, typically the concept submittal and a corrected final design. A deliverable may be completed in multiple phases.

Design: in the context of the BIM Roadmap, this is a general term for the tasks performed by the Engineering Division, specifically the preparation of plans, specifications, and design analysis. Design-phase requirements will vary by project, as determined by the project's Acquisition Strategy Meeting. All plans and specifications are required to be clearly identified in terms of the design phase it represents.

Discipline Model: a separate model that depicts a structure's discipline-specific design into 3D floor plans. It constitutes an object-oriented database of information shared among project participants that undergoes continuous development and is used through the design, construction, and operation phases. If a structure is extremely complex, the need may arise to break the structure's Discipline Models up into Zone Models.

Discipline Master Model: the representation of a structure by collective reference to all discipline-specific Design Models. The work of specific disciplines may be separated into Discipline Models, which allow architects and engineers to work concurrently on separate parts of a structure without waiting on another's work. For instance, one architect may begin working on the exterior shell of a building, while another architect works on the interior model of the first floor. See also *Project Master Model* and *Project Model*.

Family: an organized group of parts or elements in a set of data within a virtual model. The USACE Corporate Template set of data organizes the parts into families based on construction systems such as Exterior Walls, Doors, Spaces, etc.

Industry Foundation Class (IFC): a group of data-element-exchange requirements for representing the parts of buildings, shape components, spatial relationships and other object properties. IFCs are used by multiple computer applications to assemble a computer-readable model of the facility that contains all the information of the parts and their relationships to be shared among project participants. The International Alliance for Interoperability (IAI) has created the IFC data exchange format specifications and guidelines. http://buildingsmart.com/standards/ifc

Interoperability: the complete exchange of modeling information and data throughout the life cycle of a facility by direct communication between software applications without data degradation or destruction.

Lead Technician: the technician responsible for coordinating the efforts of all modelers and technicians within the BIM project. The Lead Technician is selected for each project from the technicians assigned to a project and is generally from the same section as the Project Engineer/Architect (PE/A). This person may also be called the *Lead Modeler*.

Model File: the BIM file that contains a referenced section, cut, or view, including model file-specific information. It is recommended that extractions/views not serve directly as Model Files because all file-specific information will be lost if extractions/views have to be regenerated.

National Building Information Model Standard (NBIMS): The goal of NBIMS is "to establish the standards needed to foster innovation in processes and infrastructure so that end-users throughout all facets of the industry can efficiently access the information needed to create and operate optimized facilities" (http://www.buildingsmartalliance.org/index.php/nbims/).

Object: a predesigned electronic element in BIM software that represents an individual design component such as a window, wall, floor, roof, or staircase. It may be a 2D or 3D object, and it must either have data connected to it (i.e., an *intelligent object*) even if it is simply named for counting purposes; or it can be programmed to respond to input automatically (i.e., a *smart object*).

Project Engineer/Architect (PE/A): an individual assigned as the technical manager responsible for day-to-day coordination of the design. The PE/A is the Design Team representative on the Project Team.

Project Master Model: a compilation of all Project Models, sometimes including the Civil Digital Terrain Model (DTM) files, referenced together. It shows the entire project (i.e., all building Project Models), rather than just a portion of the project (i.e., one building's Project Model). See also *Discipline Master Model* and *Project Model*.

Project Model: a compilation of all the Discipline Master Models linked and depicted together in a single, integrated 3D model. The Project Model composes the entire structure that will be constructed for the project.

Sheet File: a 2D CAD file that shows a selected view or portion of a 3D Model File within a referenced border sheet. Sheet Files are used to generate the plotted construction sheets.

Zone Master Model: a breakdown of a structure's Discipline Model elements into specific zones or quadrants. Use of this model is recommended only for highly complex structures.

1 Introduction

1.1 Background

The US Army Corps of Engineers (USACE) mission is to provide quality, responsive engineering services to the nation. The mission encompasses a large, complex portfolio of construction-management responsibilities, including:

- Planning, designing, building, and operating water resources and other Civil Works (CW) projects addressing requirements for navigation, flood control, environmental protection, disaster response, hydropower, recreation, etc.
- Designing and managing the construction of military facilities for the Army and Air Force (i.e., Military Construction, or MILCON).
- Design and construction management support for other Department of Defense (DoD) and Federal agencies (i.e., Interagency and International Services).

Over the past 6 years, major growth has been required in the MILCON Program to support Army MILCON Transformation (MT) as well as the 2005 Base Realignment and Closure (BRAC) initiative, Army troop restationing, modularity, and Grow-the-Army plans. This growth has amounted to a requirement for more than $40 billion in Army MILCON expenditures over 5 years. In response to this unprecedented program-management challenge, in the words of Major General Merdith W.B. (Bo) Temple:

> USACE realized that to be able to execute this huge construction mission, we had to change our processes, procedures and practices in order to provide facilities better, faster, less expensively, safer and greener. In short, we transformed.

One critical aspect of this transformation was the investigation and adoption of Building Information Modeling (BIM) to reduce facility-delivery times and project costs. A Building Information Model is:

> ... a digital representation of physical and functional characteristics of a facility. (*The National BIM Standard-United States™ (NBIMS-US™) Version 2 (V2), May 2012*).

In March 2005, USACE established a project delivery team (PDT) to investigate the adoption of BIM and make recommendations for an implementation strategy. A USACE memorandum entitled "Realignment/Establishment of Centers of Standardization (COSs)," dated 6 March 2006, assigned responsibility to the COSs for developing and/or maintaining BIMs for standard facility designs.

In October 2006, the Engineer Research and Development Center (ERDC) published the recommendations of the PDT as ERDC Technical Report TR-06-1, *Building Information Modeling (BIM): A Roadmap for Implementation to Support MILCON Transformation and Civil Works Projects within the US Army Corps of Engineers*. That document, usually referred to as the 2006 BIM Roadmap, outlined the goals, objectives, and schedule for implementing BIM.

Significant accomplishments as well as changes in the 2006 USACE BIM implementation initiative have now made it necessary to update and revise the roadmap. This report documents a revised and fully integrated USACE BIM implementation plan.

1.2 Objective

The objective of this document is to fully update the USACE BIM Roadmap, to include reviewing progress toward the original strategic goals and objectives established in 2006, extending the implementation strategy to encompass the Civil Works mission, redefining strategic plans and goals for the MILCON and Civil Works programs, and reaffirming BIM vendor-neutrality principles.

1.3 Overview of BIM implementation status

1.3.1 Vision

USACE continues to pursue its BIM Vision, as established in the 2006 roadmap:

> USACE will be a leader in using Building Information Modeling to improve delivery and management of facilities and infrastructure for the nation.

In the original roadmap, the vision focused largely on MT facilities, but it has now been extended to include Civil Works infrastructure projects. Key principles in pursuing the BIM vision are that USACE

- is committed to implementing BIM on in-house and contracted projects.
- directly participates in developing BIM open data standards.
- actively promotes BIM platform (vendor) neutrality.
- focuses on quality and integrity of models and data.

Under the supervision of HQUSACE, ERDC laboratories have provided significant leadership in the development of open, nonproprietary data standards that have been incorporated into BIM technologies marketed by competing vendors (e.g., Industry Foundation Class [IFC], Construction Operations Building information exchange [COBie]). In further progress toward the principle of vendor neutrality, USACE has begun publishing vendor-prepared supplemental BIM implementation documents to support projects using different BIM technologies and services that meet Corps requirements. These documents, which are published as supplements to the roadmap, represent guidance provided by vendors for use of their products on MILCON and CW projects. These supplements and other BIM implementation tools are distributed at the CAD/BIM Technology Center website, https://cadbim.usace.army.mil/BIM.

1.3.2 Changes in USACE information technology environment

Progress on the BIM strategic plan was significantly affected by the 2007 consolidation of USACE information technology functions resulting from a USACE competitive sourcing initiative executed under the authority of Office of Management and Budget Circular A-76 (2004). The resulting new enterprise-level Army Corps of Engineers Information Technology activity, ACE-IT, was assigned the responsibility to streamline, standardize, modernize, and transform information technology and management operations. The transition to ACE-IT, a hybrid government-industry activity, involved a replacement of all information management and technology components, including personal computers, major networking hardware, peripherals, and cellular network devices. During this transition, extensive effort was dedicated to configuring USACE engineering workstations and components as well as network support required for the implementation of BIM-based technologies.

1.3.3 BIM technology

USACE is facilitating the use of all approved BIM technology products and training. Engineer Districts may use existing purchasing agreements (Enterprise License Agreements, or ELAs) to minimize the cost of implementing BIM. USACE has ELAs with both Bentley Systems, Inc. (Exton, PA), and Autodesk, Inc. (Mountain View, CA). Both ELAs include support for training; BIM-capable modeling and analysis software; and solutions for visualization, quality assurance, drafting, cloud computing, and content management.

The USACE ProjectWise Collaboration Model (PCM) is an implementation of the Bentley ProjectWise™ content management system. It standardizes the management and sharing of engineering content (including drawings, calculations, and other documents) within USACE. No other collaboration tools for engineering content are currently approved for MILCON or Civil Works projects.

1.3.4 BIM submittal format

The BIM submittal format that is best for each project shall be determined by the project's Project Delivery Team (PDT), which includes the Customer, the Geographic District Project Lead, and the BIM Manager. If the project is for a standard facility, then the COS District Project Lead and BIM Manager is also included in determining the submittal format.

1.4 USACE directive on implementation requirements for BIM Uses

All applicable Civil Works and Army MILCON projects (new construction and renovation/expansion) in the continental United States (CONUS) shall use BIM technology for design and construction. To establish applicability, the flowcharts shown in Figure 1 and Figure 2 shall be used by the PDT to determine and document when BIM technology is appropriate or inappropriate for a specific project. This decision process shall be completed as a standard part of developing the Project Management Plan (PMP). The PDT shall include the Customer, the Geographic District Project Lead, and the BIM Manager.

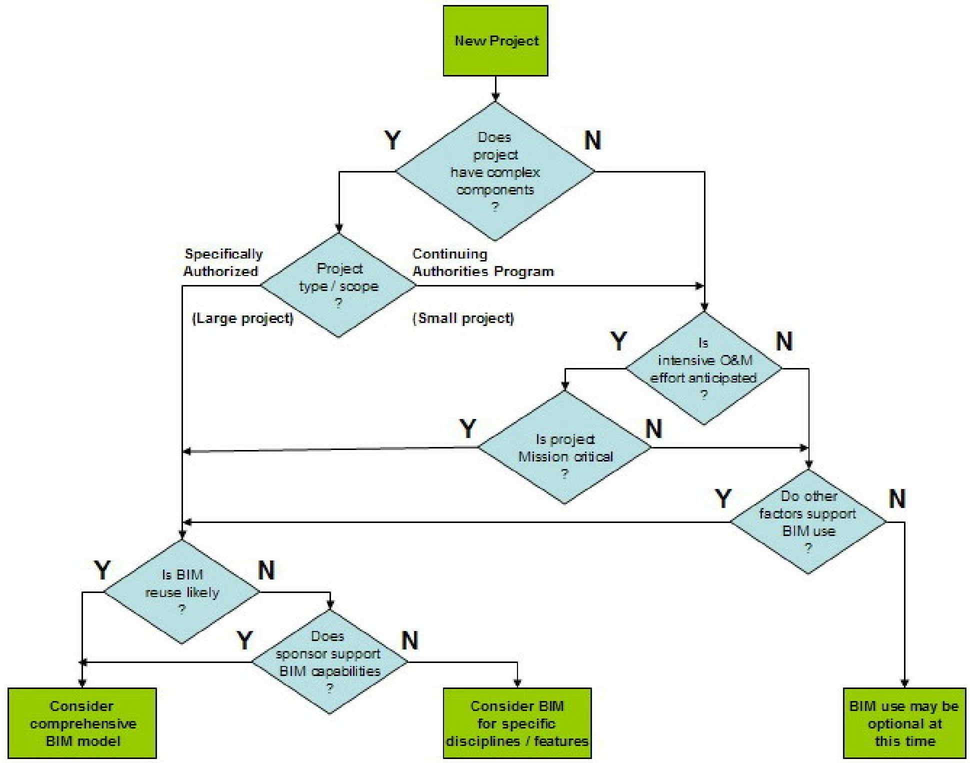

Figure 1. BIM decision flowchart for new projects.

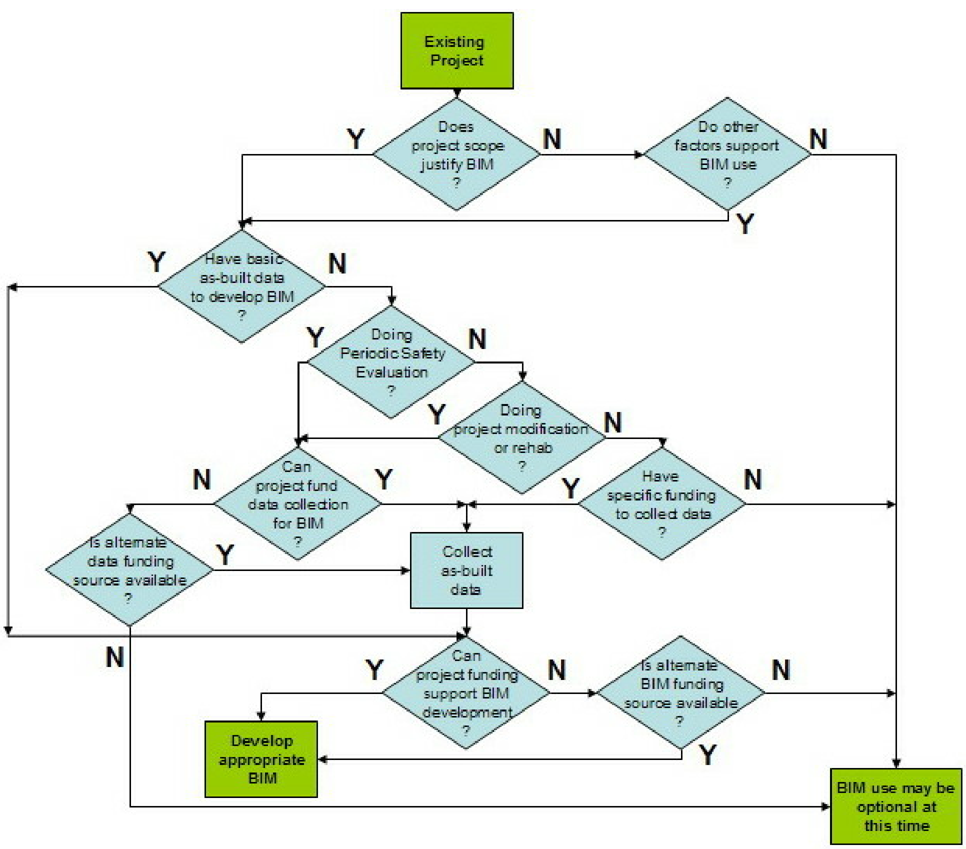

Figure 2. BIM decision flowchart for renovation/expansion projects.

1.5 Updated contract language and project preparation tools

1.5.1 New provisions for incorporating BIM requirements into contracts

MILCON Transformation proponents needed new methods to ensure consistency and criteria compliance during design authoring and reviews, contract awards, and delivery of facilities. That requirement was considered critical to implementing next-generation Army standards and criteria across the current military construction program, which is the largest since World War II. To support the new acquisition strategies, a Model Request for Proposal (Model RFP) document template was created.

In 2006 USACE began facilitating discussions and workshops with a group of firms that were early adopters of BIM to address mutually beneficial solutions to BIM implementation issues. This voluntary group, called the USACE/Industry BIM Advisory Committee, represents users of multiple BIM platforms who collaborate on best practices, contract language, standards, and other topics to coordinate Federal and private-sector BIM initiatives. Committee participation has expanded since 2006 to include design, construction, academic, and legal professionals.

In support of including MT BIM requirements in the Model RFP, the advisory committee developed "Attachment F – Building Information Modeling Requirements" for Section 01 33 16 – Design After Award. These contract provisions now help to implement current BIM best practices on a wide range of public works projects and are actively being refined as projects are implemented and new best practices emerge within the industry. Currently, contracting language requires the use of tools provided by specified vendors. However, the USACE goal is to implement business process transformations that eliminate the need for vendor-specific technical specifications.

1.5.2 Contract preparation tools

The Model RFP is generated using a web-based tool called the RFP Wizard All MILCON design-build projects are required to use it.

On 4 January 2008, Model RFP Section 01 33 16, Attachment F was incorporated into the RFP Wizard, thereby establishing requirements for BIM deliverables in most MT RFPs for FY08 projects and beyond. Prior to

FY08, BIM was an optional deliverable. As of September 2012, more than 500 RFPs have been generated through the RFP Wizard.

Information on the Model RFP Section 01 33 16, Attachment F, and on the RFP Wizard, can be found on the Military Construction Requirements and Standardization Integration (MRSI) site, https://mrsi.usace.army.mil.

1.5.3 USACE BIM Project Execution Plan (PxP) template

The committee also developed the USACE BIM Project Execution Plan (PxP) Template in partnership with the Computer Integrated Construction Research Program at Pennsylvania State University (State College, PA). This USACE-specific template identifies mandatory and elective BIM Uses (see section 2.2) and provides a standard format for organizations to establish their general means and methods for meeting the scope and deliverable requirements in Model RFP Section 01 33 16, Attachment F. The template also accelerates USACE review and acceptance of BIM Project Execution Plan submittals. The USACE BIM PxP Template can be downloaded from https://cadbim.usace.army.mil/BIM_Contract_Requirements.

The PxP template was adapted from the BIM Project Execution Plan Guide and Templates guidance document previously developed by Pennsylvania State for the National Institute of Building Sciences (NIBS) buildingSMART alliance™, which was sponsored by the Charles Pankow Foundation, the Construction Industry Institute, the Penn State Office of Physical Plant, and the Partnership for Achieving Construction Excellence. The BIM Project Execution Plan Guide and Templates guidance was subsequently incorporated into the National BIM Standard (NBIMS) V2, and can be downloaded from the website at http://www.buildingsmartalliance.org/index.php/projects/activeprojects/20.

1.5.4 Minimum Modeling Matrix (M3)

Beginning in 2008, Section 4 of Model RFP Section 01 33 16, Attachment F, defined minimum modeling requirements as a narrative list of required objects and systems. However, that list was found to be open to subjective interpretation, which created opportunity for inaccurate and inconsistent deliverables. USACE and industry partners identified this as a key issue, and determined that clarifying the existing minimum modeling requirements would ensure more useful deliverables at all stages of the project, especially for the owner and facility manager.

To address inconsistencies arising from subjective interpretation, the requirements defined in the "USACE BIM Minimum Modeling Matrix (M3)" are referred to in the September 2012 releases of the Model RFP Section 01 33 16, Attachment F, and USACE BIM PxP Template documents. As the name suggests, the M3 provides modeling requirements in a straightforward matrix format, provided as a spreadsheet. The M3 tool can help the project team to

- document and communicate the scope of modeled content within the BIM deliverables.
- organize the content by using common classification systems such as OmniClass, UniFormat, and MasterFormat.

1.5.5 Consolidated contract requirements package

Combined, the USACE BIM Contract Language, BIM PxP, and M3 documents are known as the USACE BIM Contract Requirements. The package can be downloaded from https://cadbim.usace.army.mil/BIM_Contract_Requirements.

1.6 Summary

As implementation of BIM proceeds within USACE there will be a continual need to balance long-term implementation expectations with current design and construction experience. The goal is to encourage innovation within a vendor-neutral (i.e., platform-neutral) BIM environment while ensuring that the requirements are practical, equitable, and reasonable considering the current state of technology and standards. To maximize the benefits of BIM for facility designers, builders, managers, and owners, design and construction contractors must be enabled to select technologies and internal processes that provide the most value and potential for innovation. USACE must continue to investigate and promote performance-based delivery of building information and to seek greater interoperability and capability from available BIM products and processes.

2 Goals and Timelines

This chapter introduces the major goals discussed in this roadmap. Figure 3 visually summarizes the main points of each goal and shows how the goals relate to one another in a complete BIM implementation life cycle. The figure also represents the MILCON and Civil Works timelines with respect to first establishing initial, then full operational BIM capabilities for each program.

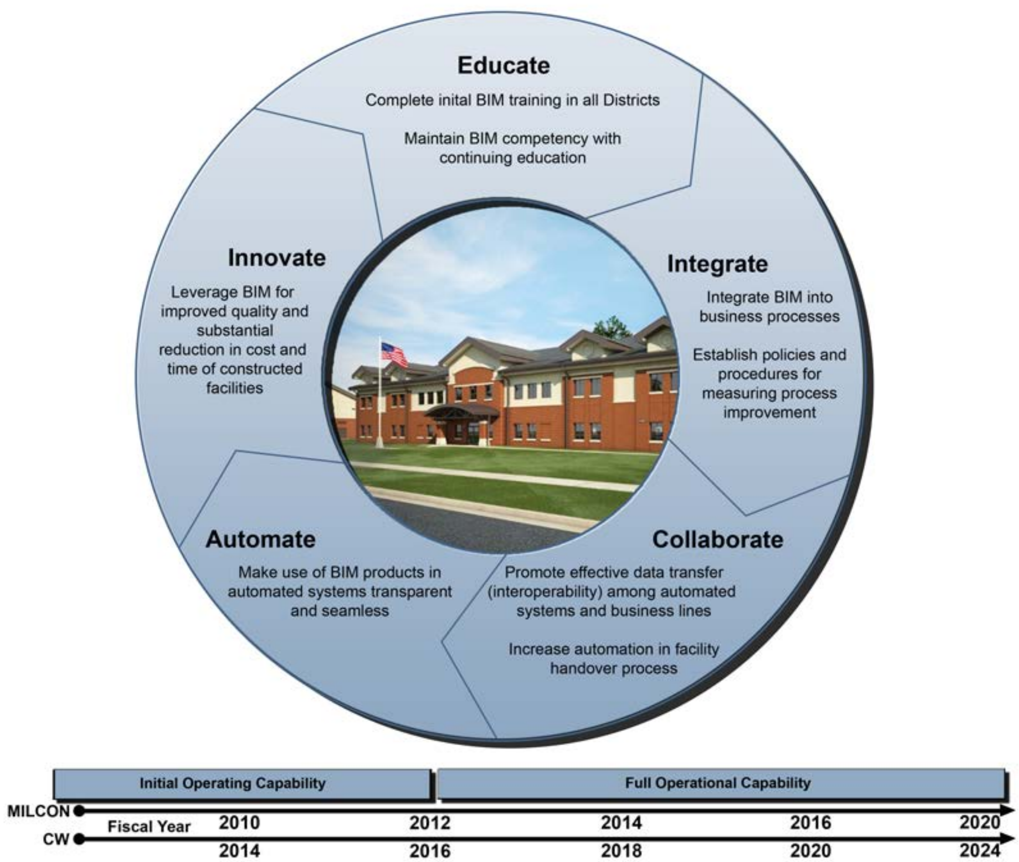

Figure 3. BIM implementation life-cycle diagram for MILCON and Civil Works.

2.1 The major goals

2.1.1 Educate: achieve, maintain, and expand BIM competencies

The entire potential for benefitting from BIM implementation rests on the expertise of the users. Therefore, achieving a high degree of BIM competency is a primary goal.

BIM competency will be achieved and maintained through education, training, and guidance in accordance with standards, technology requirements, and staffing requirements. The purpose of this goal is to transform the USACE implementation of BIM. While substantial benefits have been and will be gained from using BIM simply as a labor- and cost-saving method that results from efficiencies in producing coordinated drawings, much greater benefits and efficiencies are possible as users begin to master BIM as an information framework that can facilitate business process transformation.

2.1.2 Integrate: establish policies and procedures for measuring process improvement

While full life-cycle costs are just beginning to be obtained on BIM pilot projects, there are areas where BIM process improvements are providing significant early payback. The area of initial focus is to establish best practices for integrated coordination checking, and to identify and resolve design clashes in the virtual environment on a "best life-cycle value" basis for the project. In addition, design analyses derived from full design modeling will permit USACE to develop a broad range of virtual building testing protocols that will minimize operation and maintenance costs and allow greater sustainability to be achieved.

2.1.3 Collaborate: promote effective data transfer among automated systems and business lines

USACE will continue to advocate for technology interoperability in the market in order to maintain the broadest options for software selection based on cost-effectiveness and end-user satisfaction. In addition, USACE implementation of COBie and other open data standards will promote further coordination along similar lines for operations-related deliverables. Given the large number of projects under concurrent development, USACE will be well positioned to lead in the development of best practices for potential adoption by both private and public sectors.

Multiple Army enterprise applications contain building information, including the General Fund Enterprise Business System (GFEBS), Computerized Maintenance Management Systems (CMMS; e.g., Maximo, GFEBS), Computer Automated Facility Management (CAFM), Capital Planning/Sustainment Management Systems (SMS) (BUILDER), Building Automation Systems (BAS), and geographic information systems (GIS; e.g., Army Mapper). Many of these systems contain duplicated information, but it is captured in nonstandard formats that impede data integration, interoperability, and standardization among them.

The Army, other Federal departments, and industry face large challenges in progress toward integrating legacy systems and business processes with new information technologies. Early efforts in promoting interoperability standards tended to oversimplify the difficulties of achieving consensus on required information and formats among the many stakeholders.

Many organizations, including USACE, are supporting and working with technical and professional organizations such as the NIBS buildingSMART alliance™, the US Green Building Council (USGBC), Construction Specification Institute (CSI), International Code Council (ICC), Association of General Contractors (AGC), American Institute of Architects (AIA), and the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) to develop standards and guidance that will facilitate the integration of these building information technologies for greatly improved life-cycle management.

2.1.4 Automate: achieve full operational capability using BIM

BIM technology is moving forward in 4D (scheduling) and 5D (cost) modeling derived directly from the design model. The final automation and innovation phases of BIM implementation—2016 and beyond—will focus on continuing to achieve substantial reduction in cost and facility delivery time. A number of promising technologies are emerging from universities and laboratories that will be able to leverage BIM. Examples include further fabrication of building components from BIM (already being used by some constructors), automated site adaptation of buildings, automated construction site monitoring, point-of-use access to operations and maintenance (O&M) documentation, and even robotic construction of facilities. These goals are considered tentative, and they will be pursued only in connection with technologies sufficiently developed to provide an acceptable return on investment.

BIM technology vendors are beginning to create metrics within their software programs that permit life-cycle monitoring. Heating, ventilation, and air conditioning (HVAC) systems and related air-quality systems are expected to be the first area characterized with metrics. It is expected that

USACE will need to specify measurement tools as part of BIM deliverables to promote greater development in this area.

BIM will automate a broad range of cost- and labor-intensive project development and operation tasks. It will continue to drive production and operation costs down, and to shorten schedules from funding through facility handover. It will enable robust and comprehensive measurement of building systems, and will allow for location-specific customization of standard structures.

2.1.5 Innovate: identify downstream technologies and processes to leverage investment in BIM

This is an out-year goal primarily intended to address emerging technologies that USACE and its partners should investigate.

An ever-increasing number of analysis tools, which perform what is known collectively in the industry as *xD analyses*, permit significant refinement of a design with respect to a wide range of life-cycle factors. Some xD analysis tools are already quite sophisticated, and they can significantly enhance the delivery of sustainable projects. As additional pilot projects are completed using these tools, metrics and standardized best practices will be developed.

USACE is well positioned to explore linking groups of models for O&M analysis, and to examine real-time virtual modeling of buildings to address long-term operational and security needs. Planning for long-range goals is proceeding as processes for final model deliverables during the commissioning phase continue to be articulated.

2.2 Incorporation of standard BIM Uses

To help achieve the major BIM implementation goals, USACE is progressively implementing the standard BIM Uses described at the BIM Execution Planning page (http://bim.psu.edu/uses/default.aspx) of the Penn State Computer Integrated Construction Research Program. These are identified in the PxP template, which was described in section 1.5.3.

BIM Uses applicable to specific project phases are indentified in Table 1, where gray-shaded cells indicate currently mandated BIM Uses. Implementation of elective (non-mandatory) BIM Uses is encouraged for in-house and contracted projects. Because benefits of standardization are substantial, particularly for enabling collaboration and for maximizing BIM benefits for facility owners and managers, it is anticipated that some BIM Uses will be redesignated from elective to mandatory status. To determine which BIM Uses should become mandatory, USACE will perform a yearly evaluation of mission requirements and program goals.

Table 1. Mandatory[1] and elective BIM Uses by project phase.

Plan	Design	Construct	Operate
Programming	Design authoring	Site utilization planning	Building system analysis
Site analysis	Progress reviews	Construction system design	Asset management
	Interference management (3D coordination)	Interference management (3D coordination)	Space management / tracking
	Structural analysis	Digital fabrication	Disaster planning
	Lighting analysis	3D control and planning	
	Energy analysis	Record modeling	Operation & maintenance Record modeling
	Program validation	Field / material tracking	
	Mechanical analysis	Digital layout	
	Other engineering analysis		
	Sustainability (LEED) evaluation		
	Code validation		
Phase planning (4D)	Preliminary construction scheduling (4D)	Construction scheduling (4D)	Building maintenance scheduling (4D)
Cost estimation (5D)	Cost estimation (5D)	Cost estimation (5D)	Cost estimation (5D)
Existing conditions modeling	Existing conditions modeling	Existing conditions modeling	Existing conditions modeling
Construction Operations Building information exchange (COBie)	Construction Operations Building information exchange (COBie)	Construction Operations Building information exchange (COBie)	Construction Operations Building information exchange (COBie)

1. BIM Uses in gray-shaded cells are mandatory. All others are elective.

3 Strategic Plan for BIM in Military Construction

With experience implementing BIM in the COS program and adoption of national information exchange standards, USACE will be well positioned to dramatically improve MILCON business processes by using BIM as the principal communication medium for contract advertisements, awards, and submittals. While innovation may take many different forms, it is important that early steps toward innovation be taken incrementally. These new technologies should be adopted with care and deliberation because they will significantly change conventional business processes for facility acquisition and delivery. In particular, it is currently expected that BIM technology will enable substantial automation of quantity take-offs, scheduling, submittal checking, and criteria-compliance checking within USACE by 2014. Therefore, the use of BIM in the CONUS, vertical MILCON mission area will be expanded to all design and construction activities for which it is economically feasible.

The most significant benefits from BIM will accrue to facility owners and occupants because of the 50–75 year life expectancy of facilities and the potential for accessing as-operated facility data at a moment's notice. However, work is needed to understand and prepare to make use of these benefits at Army installations. Toward this end, OACSIM and IMCOM are continuing to investigate BIM as a life-cycle information management technology.

3.1 MILCON Goal 1 — Educate: achieve, maintain, and expand BIM competencies

MILCON Goal 1 Objectives	Capabilities/Metric
1.1: Achieve focused expertise in MILCON Centers of Standardization	▪ Eight COS trained/productive in BIM by end of 2008
1.2: Develop BIM capability at remaining MILCON districts	▪ All MILCON districts trained by end of 2013
1.3: Establish Division level BIM coordinator	▪ Division level coordination conducted every 3 months
1.4: Establish/Maintain BIM Manager Requirement at each District	▪ One trained BIM Manager per District by end of 2009 ▪ Review process part of official job (review submittal to meet the requirements of Attachment F)
1.5: Develop/Maintain BIM Guidance	
– Division BIM Implementation Plan	▪ Update biennially
– USACE BIM Project Execution Plan	▪ Update biennially

MILCON Goal 1 Objectives	Capabilities/Metric
1.6: Maintain competency in BIM technologies	▪ Maintain BIM competency and learn new capabilities in BIM as they emerge
1.7: Continuing education	▪ Continuing education every 6 months
1.8: Lessons Learned	▪ Develop process for capturing and communicating lessons learned by end of 2013
1.9: Quality Standards	▪ Develop process for accessing quality of deliverables by end of 2013

3.2 MILCON Goal 2 — Integrate: establish policies and procedures for measuring process improvement

MILCON Goal 2 Objectives	Capabilities/Metric
2.1: Capture Life-Cycle Metrics on BIM Process 2.2: Analyze Life-Cycle Metrics on BIM Process	▪ First Division Implementation Plan with required metrics delivered 2010, conduct updates biennially
2.3: Deploy enterprise BIM repository	▪ COS repository implemented by end of calendar year 2011 ▪ Update every 6 months
2.4: Develop configuration control/change management process for maintaining/updating enterprise corporate data sets	▪ Used on all QA/QC checks by end 2011
2.5: Develop collaboration site for USACE BIM community	▪ By end of 2013
2.6: Validate BIM (Data and Model) Quantify design	▪ Use on all projects by end of 2011
2.7: Quantify design quality (Visual check, interference/ clash detection, standards check, model integrity)	▪ Used on all projects by end of 2012
2.8: Change design and construction quality specifications to incorporate performance based deliverables	▪ Used on all projects by end of 2013
2.9: Establish process for integrating BIM and Specifications output	▪ Used on all projects by end of 2014
2.10: Expand BIM use during advanced engineering analysis	
– Conduct structural analysis	▪ Used on all standard designs by end of 2013
– Conduct Eco-Charrette to optimize new designs and site adapt standard designs	▪ Used on all projects by 2013
– Conduct analysis to meet LEED daylighting, IEQ, water efficiency, energy optimization and other required credits	▪ Used on select projects by end of 2013
– Conduct advanced energy simulation for ASHRAE compliance	▪ Used on select projects by end of 2015
– Criteria compliance review	▪ Used on select projects by end of 2014
– Other analysis applications	▪ As they emerge
2.11: Integration with geospatial technologies	
– Conduct area development and site planning for low impact development, storm water management, rainwater harvesting, net zero neighborhood development, microgrids, district power heating and cooling.	▪ Used on select projects where appropriate

3.3 MILCON Goal 3 — Collaborate: promote effective data transfer among automated systems and business lines

MILCON Goal 3 Objectives	Capabilities/Metric
3.1: Ensure that evolving industry standards meet requirements of USACE and its customers	▪ Continue USACE support of the buildingSMART alliance™ ▪ Continue USACE membership in US Green Building Council ▪ Continue ERDC leadership in NBIMS activities ▪ Continue USACE support of the Society of American Military Engineers (SAME) ▪ Continue dialog with AF, GSA, NAVFAC, Dept. of State, FAA, NASA ▪ Continue USACE partnership with industry
3.2: Ensure compatibility with other federal agencies	▪ Pilot projects starting in 2008
3.3: Ensure compatibility with industry standards and practices	▪ -As they emerge
3.4: Demonstrate/deploy interoperability using life-cycle information exchange standards	
– Develop COBie Implementation Plan	▪ By end of 2013
– Incorporate certified information exchange deliverables	▪ COBie deliverable on select projects by end of 2014 ▪ Incorporate exchange standards as they become approved, piloted, and incorporated into USACE business process
3.5: Work with ACSIM and IMCOM to automate facility handover process	▪ Adobe 3D PDF required deliverable by end of 2013 ▪ Conduct pilots at Army installations incorporating life-cycle building information deliverables with corporate Army legacy systems
3.6: Work with ACSIM and IMCOM to develop BIM Roadmap to include installation processes, functions, and technologies, including: – Sustainment Management Systems (SMS -Builder) – General Fund Enterprise Business System (GFEBS) – Geospatial Information Systems (GIS), Army Mapper – Computerized Maintenance Management System (CMMS) – Computer Automated Facility Management (CAFM) – Building Automation Systems (BAS)	▪ Work with installation legacy system program managers to ensure information exchange standards meet their needs
3.7: Work with AFCEE to automate facility handover process	▪ Determine best BIM practices for handover of as-built data, COBie process, contract language, and geo-referencing of facility data as outlined in the AFCEE Flight Plan

3.4 MILCON Goal 4 — Automate: achieve full operational capability using BIM

MILCON Goal 4 Objectives	Capabilities/Metric
4.1: 4D modeling	▪ Required on select projects starting 2014
4.2: 5D modeling	▪ Required on select projects starting 2014
4.3: Seamless integration of BIM and GIS	▪ N/A
4.4: All certified information exchange standards piloted and deployed	▪ Final handover of electronic facility manuals

3.5 MILCON Goal 5 — Innovate: identify downstream technologies and processes to leverage investment in BIM

MILCON Goal 5 Objectives	Capabilities/Metric
5.1: Use BIM to drive virtual reality and other advanced visualization technologies	▪ Standard practice on appropriate projects by 2020
5.2: Integrated installation modeling	▪ N/A
5.3: Building performance modeling	▪ N/A
5.4: xD modeling	▪ N/A

4 Strategic Plan for BIM in Civil Works

To date, the primary focus of USACE BIM implementation has been Military Construction projects in support of MILCON Transformation. USACE also has conducted test projects to explore BIM use in Civil Works, but has not yet begun widespread CW BIM implementation.

Compared with MILCON projects, USACE has a more comprehensive role in the life cycle of CW projects. In MILCON projects, USACE serves as the design and construction agent, with hand-over to the Army or Air Force upon completion of construction—typically a period of 5 years from budgeting to building commissioning. The USACE role in CW projects, however, has typically covered the entire facility life cycle—planning, design, construction, operation, and decommissioning. These inherent differences between MILCON and CW project-development processes strongly imply that USACE could derive enhanced benefits by formally implementing BIM for Civil Works.

From budgeting to completion of construction, a typical CW project has historically lasted approximately 22 years. This project duration includes requirements for comprehensive planning, economic analysis, and Environmental Impact Statement (EIS) coordination. For each of those activities, time is required to obtain congressional authorization; complete complex design efforts; negotiate and finalize sponsorship agreements; and manage the multi-year construction budgeting and funding stream. Those processes will be shortened as USACE implements planning modernization. However, that improvement will not change the comprehensive USACE role in CW facility management, and project-development timeframes will remain much longer than they are for MILCON projects. The long life cycle of a CW project facilitates the management of structured electronic facility data—an inherent byproduct of the BIM process—which offers many opportunities to maximize the potential benefits of BIM to USACE.

Other BIM benefits expected for the CW program include

- better multi-discipline coordination and client understanding of design intent from using BIM 3D modeling features.

- clash or interference detection in structural, mechanical, electrical, and plumbing (MEP) components, which has proven to reduce change orders and rework during construction.
- BIM-driven prefabrication, making it possible to create more facility components in controlled factory conditions, with less material waste and safer working conditions than onsite fabrication.
- downstream use of BIM data and the integration with the Facilities & Equipment Maintenance (FEM) System and other legacy systems.
- integrated and well structured building information that can be used to more effectively manage CW assets throughout the facility's life cycle.

BIM used during the life cycle of a CW project is highly suited to support long-term management of critical facilities. Implementation, however, will be challenging. The integration of horizontal and vertical construction practices, the extent and scale of existing CW facilities, and the long duration of new CW projects will require, and may benefit from, a slower adoption strategy than is being targeted for BIM in MILCON. A phased approach on select projects will permit a more incremental, cost effective, and realistic approach to BIM CW implementation while supporting further alignment with evolving BIM technologies.

Several Districts with a CW mission have applied BIM to projects such as a lock and dam facility, miter gates, a fish passage facility, pump stations, and culvert transition monoliths. The diversity of CW structures and the level of BIM complexity will impose a unique set of graphical and data requirements. In addition to the traditional structural, mechanical, and electrical components of CW projects, BIM supports horizontal projects such as dams and flood risk-management structures. Three-dimensional digital terrain modeling software, along with design and construction BIM and geospatial applications, will make it possible to virtually construct the project for better client understanding. It will provide the tools needed to efficiently eliminate interference among the many facility or structural components, reducing change orders, cost overruns, and delays.

USACE BIM experience indicates that a phased approach on select projects is needed. In many cases, it may be best to model only portions of the project or specific trades. Partial BIM applications, versus the creation of comprehensive models, are likely to be the way many users are introduced to BIM technology. Such partial applications would be much less daunting to create than comprehensive models because they are less costly and time intensive. This approach will allow an appropriate time for newer users to acquire the skills needed to develop larger models in subsequent phases.

Civil Works Districts are now in a position analogous to that of the MILCON COS Districts in 2006. Districts that are designated CW Centers of Expertise, or Districts in distinct mission-related areas, should select projects that they construct or manage most often. Each BIM team needs to collaboratively undertake projects in small steps while developing its data repositories and workflow strategies.

Many critical lessons learned and best practice solutions have emerged from application of BIM in MILCON Districts. Therefore, CW Districts will not be starting with a "blank slate." However, they may have to augment the currently available contract language, Project Execution Plans, and other guidance to ensure that CW requirements are met (see section 1.4). Districts should follow their Division BIM implementation plans for detailed guidance on selecting appropriate BIM applications for both new and existing projects.

Following is a phased set of strategic goals and objectives developed to derive the greatest benefit for Districts and their industry partners in managing BIM technology and business-process risk within the CW mission area.

4.1 CW Goal 1 — Educate: achieve, maintain, and expand BIM competencies

CW Goal 1 Objectives	Capabilities/Metric
1.1: Achieve focused expertise on Civil Works (CW) projects	▪ In-house District use of BIM on selected projects and/or "partial use" projects by 2013
1.2: Establish Division level BIM coordination	▪ Division level coordination conducted every 3 months
1.3: Establish/Maintain BIM Manager Requirement at each District	▪ Maintain one trained BIM Manager per District ▪ Review process part of official job (review submittal to meet the requirements of Attachment F)
1.4: Develop BIM Implementation Guidance	
– Division BIM Implementation Plan	▪ Update Implementation plan yearly
– Contract Submittal Language	▪ Ensure language meets requirements of CW projects
1.5: Saturation of BIM capability at remaining CW districts	▪ All CW districts trained by end of 2014
1.6: Maintain competency in BIM technologies	▪ Perform all appropriate in-house projects and/or "partial use" projects in BIM
1.7: Continuing education	▪ Continuing education every 6 months
1.8: Lessons Learned	▪ Develop process for capturing and communicating lessons learned
1.9: Quality Standards	▪ Comply with existing tri-service data standards

4.2 CW Goal 2 — Integrate: establish policies and procedures for measuring process improvement

CW Goal 2 Objectives	Capabilities/Metric
2.1: Capture Life-Cycle Metrics on CW Process	▪ Available to Districts/partners by end of 2015
2.2: Analyze Life-Cycle Metrics on CW Process	▪ Provide yearly updates
2.3: Deploy enterprise CW project repository	▪ Repositories implemented for select project types and/or "partial use" projects as required
2.4: Maintain enterprise CW corporate data set	▪ Update every 6 months
2.5: Validate BIM (Data and Model)	▪ BIM used on all QA/QC checks for all project types by end of 2014
2.6: Quantify design quality (visual check, interference check, standards check, model integrity, against engineering decisions)	▪ Use on all applicable projects by 2014
2.7: Establish process for integrating BIM and specifications output	▪ Use on all applicable projects by 2015
2.8: Expand BIM use during advanced engineering analysis	
– Conduct structural analysis	▪ Use on all applicable projects by 2013
– Conduct quantity take-off analysis	▪ Use on all applicable projects by 2015
– Conduct eco-charrettes to optimize designs	▪ Use on all applicable projects by 2015
– Conduct analysis to meet LEED and/or appropriate energy optimization	▪ Use on all applicable projects by 2016
– Conduct advanced energy simulation for ASHRAE compliance	▪ Use on all applicable projects by 2017
– Criteria compliance review	▪ Use on all applicable projects by 2018
– Other analysis applications	▪ As they emerge
2.9: Integration with geospatial (GIS) and 3D terrain modeling technologies	
– Site planning, storm water management, microgrids, district power heating and cooling	▪ Use on all projects by 2018

4.3 CW Goal 3 — Collaborate: promote effective data transfer among automated systems and business lines

CW Goal 3 Objectives	Capabilities/Metric
3.1: Ensure that evolving industry standards meet requirements of USACE and its customers	▪ Continue USACE support of the BuildingSMART alliance™ ▪ Continue USACE membership in US Green Building Council ▪ Continue ERDC leadership in NBIMS activities ▪ Continue USACE support of the Society of Military Engineers (SAME) ▪ Continue support of spatial data standards efforts (SDSFIE) ▪ Ensure compliance with ISO 9000
3.2: Ensure compatibility with other Federal/State/Local agencies	▪ Develop dialog with Federal/State/Local authorities
3.3: Ensure compatibility with industry standards and practices	▪ Continue USACE partnership with industry

CW Goal 3 Objectives	Capabilities/Metric
3.4: Demonstrate/deploy interoperability using life-cycle information exchange standards	
– Incorporate COBie deliverable in contract documents	▪ COBie required deliverable on all projects by end of 2017
– Incorporate certified information exchange deliverables	▪ Incorporate exchange standards as they become approved, piloted, and incorporated into USACE business process
3.5: Work with CW Directorate to automate facility handover process	▪ Adobe 3D PDF required deliverable of 2013 ▪ Investigate Industry Foundation Class delivery ▪ Investigate COBie and/or open standard for information delivery to FEMS-Maximo, GFEBS, OMBIL, REMIS… ▪ Investigate delivery of SDSFIE objects to geospatial viewers for applications ▪ Investigate delivery to Sustainment Management Systems ▪ Investigate strategy for use of BIM on existing facilities by 2015
3.6: Incorporate BIM on existing facilities infrastructure	▪ As determined by mission criticality and other factors

4.4 CW Goal 4 — Automate: achieve full operational capability using BIM

CW Goal 4 Objectives	Capabilities/Metric
4.1: 4D modeling	▪ Use on all projects starting 2015
4.2: 5D modeling	▪ Use on all projects starting 2015
4.3: Fabrication of components	▪ Use on all projects starting 2015
4.4: Seamless integration of BIM, eGIS, and/or 3D terrain modeling	▪ Use on all projects starting 2015
4.5: Seamless transfer of BIM data to CW Directorate	▪ Use on all projects starting 2018
4.6: All certified information exchange standards piloted and deployed	▪ As they emerge

4.5 CW Goal 5 — Innovate: identify downstream technologies and processes to leverage investment in BIM

CW Goal 5 Objectives	Capabilities/Metric
5.1: Use virtual reality technology and BIM	Standard practice on new and/or existing facilities as they emerge
5.2: Emergency response modeling	N/A
5.3: Safety, vulnerability, and security assessment modeling	N/A
5.4: Performance modeling of facilities and structures	N/A
5.5: xD modeling (O&M)	N/A

5 Conclusion

This report documents the current status of the USACE BIM implementation strategy. The strategy has been updated to

- incorporate the progress that has been made since publication of the 2006 BIM Roadmap.
- disseminate revisions of the Roadmap made necessary by advances in BIM technology or changes in USACE policy.
- more formally address BIM implementation within the Civil Works program.

The initial benefits of BIM have been most conspicuous in terms of labor and time savings arising from the technical efficiencies BIM provides in developing coordinated drawing sets. At the present stage of USACE BIM implementation, the vision is to realize the expanded life-cycle benefits that BIM will provide when it becomes fully established as a comprehensive and integrated information network. Accordingly, this revision of the strategy focuses on fuller integration of BIM technologies into USACE planning, design, and construction processes, and also into the Army's O&M processes.

The major thrust of the implementation strategy now is to integrate BIM into all applicable USACE business processes involved in the Military Construction (MILCON) and Civil Works programs, including work with USACE industry partners, software vendors, and standards-development organizations. USACE envisions that this phase of BIM implementation will permanently transform conventional business processes in the direction of unprecedented levels of coordination and efficiency.

The 2012 Roadmap provides updated goals and timelines for BIM implementation. For documentation and reference purposes, a report on implementation progress since 2006 is presented in Appendix A; District-level BIM implementation guidance, which was provided in the initial Roadmap, is included in Appendix B.

Appendix A: BIM Implementation Progress, 2006 – 2012

The initial version of the BIM Roadmap incorporated a phased set of strategic goals intended to derive the greatest benefit from BIM implementation while effectively managing technology and business process risk. This balanced approach allowed a focus on adoption tasks that serve near-term needs while clearly communicating the longer-term direction and goals. As BIM technology and interoperability standards have developed within the industry, these goals have been reviewed and revised to reflect the updated technology horizon. The updated long-term strategic plan includes new timelines and goals for both MILCON and Civil Works projects. These are summarized in Chapters 3 and 4, respectively.

Figure A1 shows the 2006 BIM Roadmap long-term strategy for implementing BIM in support of MILCON Transformation.

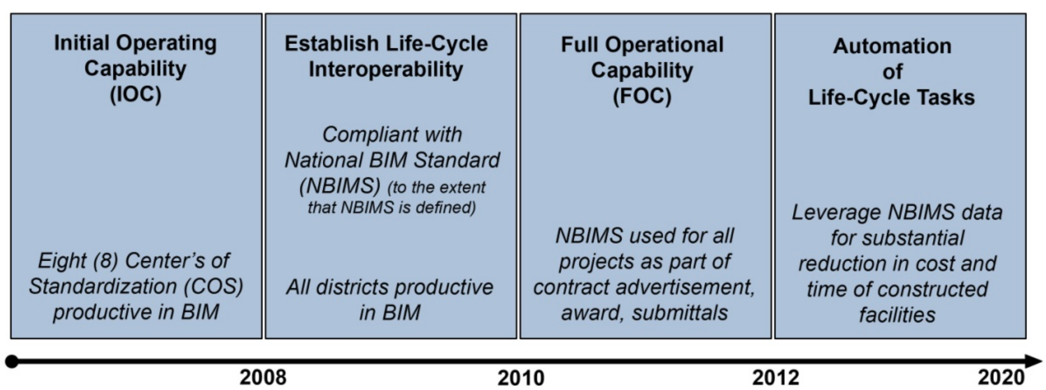

Figure A1. Initial USACE long-term strategic goals for BIM (2006).

The goal of the first phase was to establish an Initial Operating Capability (IOC). The intent was for the eight USACE MILCON Centers of Standardization to gain experience with BIM by implementing the technology on standard facility types. Some limited use of BIM on Civil Works projects was encouraged as well. The intent was not to apply BIM to all design work across USACE, but to achieve process improvements through reusability of models, or what has been termed *adapt-build*. There was a choice to be made between developing in-depth BIM capabilities in-house, or relying on external consultants to furnish BIM needs, or a combination of external consultants with in-house supplementation. Regardless of the implementation approach, all Districts needed to become familiar with BIM principles and effectively manage business process changes in order to progressively take advantage of BIM as new benefits became available.

Preparing USACE Engineer Districts to implement BIM required many different tools and skills. Although BIM originates in traditional design processes, it represents a new paradigm for facility acquisition and operation. It involves a wide spectrum of activity, including education, training, process management, technology acquisition, data, and standards. Significant IOC milestones achieved in the first 5 years include the following:

- Enterprise License Agreements (ELAs) were negotiated and awarded to both Bentley Systems and Autodesk.
- The transition to ACE-IT created new processes for technology acquisition, maintenance, and replacement of hardware, network, and other components such as printers/plotters/copiers.
- The USACE/Industry BIM Advisory Committee was created in 2006 to develop contract language requirements in collaboration with multi-platform design, construction, academic, and legal professionals.
- A USACE BIM Project Execution Plan (PxP) Template was developed for organizations to use in establishing their general means and methods for meeting the scope and requirements in the contract language.
- A corporate dataset of standardized BIM objects was developed for COS Districts and their Architectural Engineering and Construction (AEC) partners.
- BIM training was required for COS District architects and engineers, and specialized workshops were established to train District BIM Managers. This training was funded through ELAs under contracts administered by the CAD/BIM Technology Center.
- In FY 2009, HQUSACE directed each District Office to have a trained BIM Manager by the end of 2009.
- In FY 2010, HQUSACE directed each Division Office to develop a comprehensive and coordinated plan that documents division-level procedures and processes for implementing BIM. The plan serves as a foundation document for communicating the BIM strategy within the Division and across USACE. In addition, data documented in the plan serve as the baseline for developing metrics to measure the success of BIM within the Division and throughout USACE.
- A USACE Minimum Modeling Matrix (M3) was developed to clarify minimum modeling requirements, document and communicate the

scope of modeled content within the BIM deliverables, and help the project team organize the content by using common classification systems such as OmniClass, UniFormat and MasterFormat.

The following sections provide a status update on the goals and objectives outlined in the 2006 BIM Roadmap.

2006 Goal 1: Establish metrics for success

Goal 1 Objectives	Metric
1.1: Create Lean Six Sigma for Building Information Modeling process	
1.2: Capture Metrics from BIM projects	

Objective 1.1 has not been completed as other goals were assigned a higher priority.

Work toward Objective 1.2 is in progress. The USACE Division BIM Implementation Plan outlines the Baseline Project Metric reporting requirements. Each Division shall maintain a listing of BIM projects (planned, designed, and/or constructed). This information will be reported to HQUSACE as part of the HQ Directorate Management Review (DMR).

2006 Goal 2: Establish Initial Operating Capability for BIM no later than 2008

- *Focus*: Reuse of BIM for faster planning and design.
- *Metric*: 15 percent reduction in planning and design time and cost.

Goal 2 Objectives	Metric
2.1: Achieve focused expertise in MILCON Centers of Standardization	Eight COS trained and productive in BIM by 2008
2.2: Establish BIM Capability at remaining geographic districts	One BIM per geographic district by 2008
2.3: Develop enterprise repository(ies) for BIM	Repository will contain a minimum of eight facility type in BIM by 2008
2.4: Prepare standard facility types for adapt-build reuse using best design/ construction practices from BIM transformation projects	Eight standard facilities in BIM by 2008 (one per COS)
2.5: Use BIM in Planning/Design Charrettes	COS use BIM in at least one Planning Charrette and one Design Charrette by 2008
2.6: Conduct automated design analysis using BIM	Used on 50% of projects

Objective 2.1 has been accomplished.

An Initial Operating Capability (IOC) was established at the eight USACE MILCON Centers of Standardization (COS) by the end of 2008. The purpose was to gain experience in BIM by implementing the technology on selected COS standard facility designs in support of the Army's MT program.

Objective 2.2 has been partially accomplished.

All eight COS Districts (Huntsville, Louisville, Norfolk, Omaha, Mobile, Savannah, Fort Worth, and Honolulu) were trained by May 2007 in the Bentley BIM platform by May 2007, and each completed at least one standard facility project during the BIM training. To date, at least 50% of USACE Districts have had onsite BIM training using either the Bentley or Autodesk platforms, or both.

It was determined that a well trained BIM Manager at each District was necessary for starting and completing BIM projects. A requirement was established to have a trained BIM Manager at each District by the end of FY09. A COS BIM Technical Coordinator was established in 2011. BIM Managers from 41 sites (USACE districts, laboratories, and centers) have been trained in courses offered by the CAD/BIM Technology Center. Six BIM Manager Workshops and one Advanced BIM Manager Workshop have been conducted to date. A Civil Works-focused workshop was offered in 2011, and repeats of previous workshops were offered as needed.

Objective 2.3 was accomplished later than the 2008 target date. In FY11, the COS Management Board directed the COS to place the standard facility designs/models on the newly developed Military Construction Requirements and Standardization Integration (MRSI) site at https://mrsi.usace.army.mil.

Objective 2.4 has been accomplished.

Objective 2.5 has been accomplished in some areas. With the high priority placed on energy-efficient and sustainable design solutions, sustainability-driven charrettes for conducting daylighting analysis, optimizing site orientation, and determining LEED credits, and etc., are being held for select Army's COS standard facility designs.

Objective 2.6 has been accomplished. Conflict detection and structural analysis are used on many projects. Lighting and energy calculations are being performed using early design energy analysis software.

2006 Goal 3: Establish facility life-cycle interoperability no later than 2010

- *Focus*: Interoperability using NBIMS (NIBS 2007), must ensure that USACE requirements are met with NBIMS.
- *Metric*: 90 percent compliant with NBIMS (NIBS 2007).

Goal 3 Objectives	Metric
3.1: Ensure that National BIM Standard meets the requirements of USACE and our customers	
3.2: Use NBIMS to control cost, quality and validation of design, Construction, and O&M submittals	90% compliant with National BIM Standard
3.3: Establish Interoperability with life-cycle information technologies	Define and demonstrate capability

Objective 3.1 has not been accomplished. The NBIMS specifications and guidelines had not been sufficiently developed for USACE to measure compliance to date.

NBIMS Version 1 – Part 1 (V1P1), came out in December of 2007. It was written by a team of 30 subject matter experts and established the approach for developing open BIM standards, but was not a consensus standard.

On 17 May 2012, the buildingSMART alliance™ (National Institute of Building Sciences) released the first consensus-based standard governing BIM for use in the United States.

"The National BIM Standard-United States™ (NBIMS-US™) Version 2 (V2) covers the full life cycle of buildings—from planning, design and construction to operations and sustainment. Part of an international effort, the NBIMS-US™ V2 will serve as the kick-off point for a number of other countries around the world to adopt as their own BIM standard." [NIBS News Release, May 2012, http://www.buildingsmartalliance.org/index.php/bsa/newsevents/news/Entry/nbimsv2-release]

The previous version, NBIMS Version 1 – Part 1 (V1P1), came out in December of 2007. USACE, primarily through ERDC, has actively participated in the creation of the information exchange specifications and guidelines that are a part of the NBIMS-US™ and will continue to do so for future releases of NBIMS- US™ to ensure that USACE requirements are being met. Objectives 3.2 and 3.3 have been accomplished to a limited extent. A key focus area of the BIM Roadmap is a move toward vendor neutrality through open information exchange standards. Although not part of the NBIMS Version 1, four "COBie[1] challenges" were conducted to demonstrate the benefit of digital information exchange at construction operations handoff. COBie has since been added as a reference standard in NBIMS-US™ V2.

Other interoperability projects in this area have been and are being conducted through the Installation Technology Transfer Program (ITTP) under the Technology Standards Group (TSG) of the Office of the Assistant Chief of Staff for Installation Management (OACSIM). ITTP promotes innovative, cost-effective technologies that improve installation infrastructure design and life-cycle operation, maintenance, and sustainability through field implementation at Army installations. Projects conducted under the ITTP starting in FY08 have addressed best practices for early design energy analysis using BIM, capturing as-built BIM for existing facilities, and COBie for facility handover-related strategies.

USACE began pilot tests of the COBie standard during FY11, and if successful, is on track to make COBie a required deliverable in FY14. COBie is an international open data specification that denotes how information may be captured during design and construction for effective transfer to facility operators. COBie transforms building information into a digital framework for delineating building information throughout the full life cycle.

A USACE team consisting of headquarters personnel, BIM experts, and cost engineers from the Huntsville Engineering and Support Center and other Engineer Districts are working at differing levels of involvement with Bentley, Inc., Autodesk, and Project Time & Cost (PT&C, Atlanta, GA) to automate the cost-estimating process to the maximum extent feasible between BIM products and quantity take-off cost estimating software. The

[1] COBie: Construction Operations Building information exchange (data specification).

initial phases have utilized the Bentley BIM products and the Micro-Computer Aided Cost Estimating System – Generation Two (MII). However, Autodesk is also involved in the process now to help USACE pursue the ultimate goal of interoperability with other products through open standards. The BIM classification systems being set up are based on commercial and industry-standard work-breakdown structures, and the process can be utilized irrespective of software platform. Due to funding constraints, pilot tests of an interface application between Bentley and/or Autodesk BIM and MII have been rescheduled to FY14.

2006 Goal 4: Achieve Full Operational Capability using NBIMS based e-commerce no later than 2012

- *Focus*: Use of NBIMS as part of contract advertisement, award, and submittals
- *Metric*: NBIMS used for all projects

Goal 4 Objectives	Metric
4.1: Expand number of NBIMS-based models	All COS standard facility designs in BIM
4.2: Conduct business transactions using NBIMS	All medium to long term sustainable projects will use NBIMS

This goal has been reevaluated due to the delay in NBIMS development. Revisions of the associated BIM Roadmap goals are discussed in Chapters 3 and 4.

2006 Goal 5: Use NBIMS in asset management and operations and maintenance (O&M) of facilities no later than 2012

- *Focus*: Computerized Maintenance Management and Asset Management per President's Management Strategy
- *Metric*: Demonstrate substantial return on investment (ROI) for clients

Goal 5 Objectives	Metric
5.1: Seamlessly transfer NBIMS information into computerized maintenance management systems	
5.2: Scheduling of maintenance actions based on NBIMS	
5.3: Repository for O&M documentation (commissioning and client)	
5.4: Point of service access to O&M information (e.g., RFID, IBR)	

New BIM standards for computable building information could serve as the foundation for automation and transformation of many current Installation Management Command (IMCOM) activities. As with any emerging technology, there is a question about when adoption of BIM across the IMCOM enterprise makes the most economic sense. ERDC, HQUSACE, OACSIM, and IMCOM are investigating strategies and processes of generating and managing building data at the installation level. Leadership at all levels will be required.

2006 Goal 6: Leverage NBIMS to automate life-cycle tasks no later than 2020

- *Focus*: Identify downstream technologies to leverage investment in the NBIMS data
- *Metric*: Substantial reduction in cost and time of constructed facilities

Goal 6 Objectives	Metric
6.1: Fabricate components from NBIMS data	
6.2: Automate site adaptation of standard facilities	
6.3: Automate construction site progress monitoring	
6.4: Robotically construct facilities based on NBIMS model	

This out-year goal is intended primarily to address emerging technologies that USACE and its partners should proactively investigate.

Some of the listed objectives have already been accomplished in industry. Several facility components are well suited to be fabricated directly from BIM, such as structural steel framework, ductwork, window systems, and cabinetry. Robotic construction is being selectively accomplished in the industry, primarily for creation of furniture and cabinetry.

ERDC research and development (R&D) in the infrastructure mission area continues to focus on integrated facility life-cycle management of information. Research areas include an integrated framework for predicting, monitoring, and controlling activities in a building and the resources needed to support those activities. The intended result of this work is to deliver a “building control room,” at no additional cost, along with the keys to the building.

Appendix B: District-Level BIM Implementation Guidelines

Barriers and opportunities

Whenever people are required to adopt new methodologies and tools—in this case, moving from CAD to BIM—resistance should be expected. This was certainly the case during the transition from hand-drafting techniques to CAD. It took time for people to see the value and savings that resulted from the use of CAD technology. Ask most users whether they would give up their current CAD application to return to hand drafting and you would probably have a fight on your hands.

Do not expect managers or CAD users to immediately embrace all aspects of BIM. Keep in mind that BIM data will not only benefit the people who deal with 2D CAD drawings; the benefits will extend to other systems and their users.

In order to lead a successful BIM implementation plan, certain user requirements must be met, opportunities must be recognized, and negative myths about BIM must be credibly addressed.

Requirements

Leadership Buy-In is Crucial. Without management support in adopting a new technology or process, the effort typically fails. HQUSACE is aggressively advocating the implementation of BIM within USACE. But leadership at the Division and District levels is essential to ensure that BIM is adopted at the project level.

Manage Expectations. BIM requires a learning process like any profession or advanced trade. Make sure that teams do not immediately expect a full-featured BIM on the first project that can be used throughout the whole project life cycle. Model development is iterative. Experience and lessons learned will accumulate with each project and over time.

Establish Metrics. Create metrics for project success. Define realistic goals for your first BIM. On your next project, raise the bar for success with the help of what you learned on the first project. Most importantly, define what your client wants from the BIM process. After each project, analyze your successes and discuss the achievement of goals with your client. Be sure to document your BIM efforts and successes so others can learn from them. As part of division-level BIM implementation plans, HQUSACE will collect data for HQ-level metrics.

Opportunities

Process Improvement. One misconception about BIM is that it is just a tool or just another CAD package. BIM is in fact a process that creates a digital model which contains high-value information for use across a facility's entire life-cycle. The utility of BIM data extends beyond the design process, and it is augmented throughout the project's life cycle — particularly the O&M phase, during which costs can be significantly reduced through building monitoring developed as part of the design modeling phase.

Enhanced Teamwork. In the development of a BIM, the placement of virtual construction elements instead of symbolic representations of elements promotes rapid design development. This benefit, accompanied by the power of immediate and continuous visualization, provides for a high level of informed communication that promotes quick design decisions. If a BIM team trains and works initially in one location, the process will enable remote teams to work on design issues with onsite staff, removing communication gaps inherent in current CAD practices. This enhanced teamwork concept may lead to increased labor charges early in the project, but it will also result in shorter project schedules as specialized design information is added much earlier in the design process than conventional Design-Bid-Build architectural design development permits.

Myths

Myth 1: Moving to BIM Means a Loss of Valuable Experience. Many people mistakenly think that a move to BIM means abandoning their acquired 2D and 3D CAD skills. This belief could not be further from the truth. 2D and 3D CAD skills greatly enhance the preparation of BIM. In the development of 2D construction documents from the BIM, CAD skills are still essential to completing the project.

Myth 2: BIM is for Vertical Construction Only. One widespread misconception is that BIM does not apply to structures such as locks and dams since it is intended only for buildings. This is emphatically not true. Any Civil Works project involving structural components can be created as a model using BIM. Once created, that BIM will contain more information than any ordinary CAD drawing. BIM is *intelligent*, meaning that the individual elements depicted in a plan (a beam, window, wall, etc.) contain full specifications that can be read from the model simply by scrolling over a design feature. It is also *parametric*, meaning that a change made in one design feature in any model view will automatically be updated in every other view and schedule within that model, so mismatched detail error is virtually eliminated. Additionally, BIM has been shown to provide a positive return on investment (ROI) to the building industry. Applying BIM to Civil Works projects will provide an even greater ROI to USACE for two reasons. First, USACE is its own customer for Civil Works. Typically, determining which data to track for O&M purposes is tricky, but USACE has legacy data for all Civil Works projects, which makes it much easier to determine the most beneficial data to model. Second, the life cycle of Civil Works structures is significantly longer than those in the building industry generally, and this inherently offers a substantial ROI over the design life.

Myth 3: BIM Design is Much Harder Than CAD. This is incorrect. The entire process of creating objects such as doors, windows, and walls takes much less effort than with CAD because many common design elements exist as standard model details to be added as needed. The number of steps required to use elements is also greatly reduced with BIM. By modeling with intelligent data, schedules, plans, elevations, sections, details, and reports can be created almost effortlessly as plan views are developed.

Myth 4: BIM is Simple. Some attempts to rebut Myth 3 may unintentionally produce another myth—that BIM is simple. That is not accurate either. Because BIM tools are powerful and sophisticated, it takes some time for the practitioner to learn how to use them and gain proficiency. However, the benefits of BIM implementation may include unprecedented improvements in project management effectiveness, with tools that greatly facilitate critical analysis and coordination activities (e.g., clash detection, energy analysis, structural analysis). BIM technology makes it possible to develop initial designs and to explore many alternatives much more rapidly and effectively than possible with traditional methods and CAD. It also can provide real-time cost and schedule information for the project team to consider as part of “virtual value engineering.”

Applicability

This Implementation Guideline has been developed for use by all team members involved in BIM. The initial audience is assumed to be Engineering Management and BIM Managers, but because BIM communication tools extend benefits to decision makers, building owners, project managers, planners, designers, engineers, O&M personnel, and the construction workforce, this document is expected to serve a broader audience.

Integration

The integration of BIM into USACE's business practices requires a well defined implementation plan. The plan should consider changes in the business process, changes in workflow, reassignment and relocation of staff, and a temporary decrease in certain design activity productivity.

Any implementation plan must begin with leadership buy-in and commitment. BIM requires complete commitment from management, project leaders, and designers. There will be losses in productivity during the initial implementation of BIM. However, that productivity will quickly recover and exceed current levels of productivity during design and construction of modeled facilities.

The following presents recommended steps for sites to implement BIM. Deviations may be required for this plan due to variations in District size organizational structure.

Set up a District BIM Transition Team

1. Who should be on the BIM Transition Team?
    a. *District Sponsor* – The District Sponsor should be the Chief of the Engineering function. The Chief of the Engineering function may designate someone to serve as the District Sponsor, but that individual must be someone with the authority to create positions and set office priorities.
    b. *Senior Designer* – The Senior Designer should be either a Branch Chief with design responsibilities or a Section Chief with Architectural responsibilities. This person should be able to manage BIM workloads, project schedules, and personnel assignments.
    c. *Current CAD Manager*

2. What are the responsibilities of the BIM Transition Team?
    a. Designating projects to be modeled using BIM technology
    b. Creating an Implementation Team that includes the following roles:
        (1) BIM Manager (for more information on this position, see the section “BIM Team Organization”)
        (2) CAD Manager
        (3) Lead Technician (for more information on this position, see “BIM Team Organization,” below)
        (4) Architect
        (5) Mechanical Engineer
        (6) Structural Engineer
        (7) Electrical Engineer
        (8) Cost Engineer
        (9) Civil Engineer
    c. Organizing and creating a BIM action plan:
        (1) Set modeling goals – end deliverables for use of the completed 3D model (including 4D, 5D, and xD analysis suited to the project needs)
        (2) Set performance expectations for BIM implementation, including the District’s vision and expectations for the BIM process to maximize best life cycle value delivery
        (3) Clearly communicate the BIM vision to the Design Team staff
        (4) Assign workload allocations to accommodate the Implementation Team’s needs
    d. Mentoring and supporting the process
    e. Communicating results and metrics to HQUSACE:
        (1) Division Implementation Plan
        (2) Populate the Technical Excellence Network (TEN) site with lessons learned and best practices for BIM (https://ten.usace.army.mil)
    f. Degree of effort: 15 calendar days

Initiate the Implementation Team

1. Select a BIM Manager
    a. BIM Manager Training prerequisites (for further information, see the training information in the vendor-specific BIM Roadmap Supplements)
        (1) ACE-IT required training for applicable desktop/server administration
        (2) If feasible, attend another District’s BIM workshop

        (3) BIM Manager's Workshop training course offered by the CAD/BIM Technology Center
    b. BIM Manager Tasks
        (1) Managing the BIM implementation process
            (a) Managing the co-located and remote meetings
            (b) Facilitating the *BIM Pit* (for further information, see "BIM Pit" in the section "Team Organization," below
        (2) Communicating the BIM vision through, for example:
            (a) Brownbag meetings
            (b) Presentations demonstrating the ease of design development and visualization using BIM
        (3) Joining the USACE BIM Sub CoP
            (a) Deploying/developing/maintaining the District/COS dataset and/or corporate template file
            (b) Acquiring the corporate template dataset and/or corporate template file from ERDC
            (c) Communicating dataset and/or file changes back to ERDC
        (4) Serving as the POC for all external BIM-related inquiries
            (a) A-E
            (b) Construction
            (c) Owner/Installation
            (d) O&M
            (e) Decommissioning
2. Coordinate/schedule the BIM Workshop (see "Training," below)
    a. Set BIM Workshop/project expectations
        (1) What disciplines are involved?
        (2) How far are they going to take the BIM?
        (3) What output is anticipated (plans, elevations, schedules, QA, sustainability analysis, etc.)
    b. Scope the BIM Workshop
        (1) Determine length and type of BIM Workshop (3 or 5 weeks)
            (a) Discuss with other District BIM Managers/ERDC
            (b) Contact Bentley Enterprise Licensing Agreement (ELA) coordinator (https://cadbim.usace.army.mil/bentleyela) or Autodesk ELA coordinator (https://cadbim.usace.army.mil/Autodesk).
        (2) Submit training request to Bentley or Autodesk regarding BIM Workshop
    c. Assign students (10–12 students maximum)
        (1) Project Designers/Engineers
        (2) Lead Technicians

        (a) Responsible for project output (contract docs, specifications, quantity reports, QA, renderings, etc.)
    (3) Draftspeople
        (a) The Draftspeople are those pursuing Lead Technician positions
    (4) BIM Manager
    (5) CAD Manager

3. Estimate degree of effort (Note: this estimate assumes that a new BIM Manager and a new BIM team are involved. This estimate also assumes that all disciplines will complete a BIM for a COS standard facility design and are starting with an accepted floor plan. This model can be structurally analyzed at the completion of the project, if applicable. Also, this estimate covers output of plans, schedules, and details [to approximately 1/4"= 1'-0" scale model detail accuracy].)
    a. 30 calendar days for the BIM Manager training
    b. 180 calendar days for BIM Manager oversight
    c. 175 calendar days maximum for BIM Workshop(s) (12 students x 15 days) (more for the 5-week training option)
    d. 2 hours per week for Implementation Team meetings
    e. On the Job Training (OJT) productivity loss – approximately 12 weeks
4. Estimate cost of effort (Note: these are estimated costs, could be more or less depending on the District)
    a. Training costs –training can be acquired through the use of ELA credits or direct district funding.
    b. BIM Manager - $150K in labor costs
    c. Other costs - $75K - $100K, these include:
        (1) Lost productivity
        (2) Dataset coordination, development, and implementation
        (3) A-E team coordination

Training

Successfully introducing BIM into the design process requires technical training and organizational changes. USACE established an ELA with Bentley Systems in 2006. In FY11, a similar ELA was established with Autodesk. These ELAs provide USACE with access to nearly all of the Bentley and Autodesk products. The ELA also provides each District with credits that can be used to obtain training. This training includes both standard classes as well as USACE-specific training and workshops. If enough credits are allotted to the District, BIM workshops are available within the ELA, and are highly recommended for organizations implementing BIM for the first time. Complete details on both ELAs as well as Bentley and Autodesk Supplements to the BIM Roadmap are available from the CAD/BIM Technology Center at https://cadbim.usace.army.mil/. Vendor-specific implementation supplements are available for MILCON projects. Supplements for Civil Works projects are in preparation.

BIM Workshops: BIM workshops consist of onsite training followed by coaching. This approach allows students to train on the BIM applications and immediately use the technology on a live project with instructor support and oversight. Within USACE, this approach has had great success and is strongly recommended.

- **5-week BIM Workshop** – For sites with little or no BIM experience, the 5-week BIM workshop is highly recommended. It is strongly recommended that this workshop be conducted in concert with a new BIM project that has management support.
- **3-Week BIM Workshop** – For sites familiar with BIM applications, the 3-week workshop offers abbreviated training or abbreviated coaching at the discretion of the site.
- **Customized Option** –This training is often used by Districts that require additional training/support for a particular project, discipline, or application.
- **BIM Manager Training:** BIM implementations require some staffing changes or reassignments. The critical staff member is the BIM Manager. (See "BIM Team Organization," below, for more on the roles and responsibilities of the BIM Manager.) Training requirements for the BIM Manager, in addition to the vendor-specific recommendations offered in the BIM Roadmap Supplements, include the workshop noted next.
- **USACE BIM Managers Workshop** – This 4-day course is designed specifically for new BIM Managers. It covers the roles of a BIM Manager and an overview of BIM. Instruction is also given on installing the BIM products, as well as configuring for use within USACE. If you are interested in a future workshop, please contact the CAD/BIM Technology Center (cadbim@usace.army.mil).
- **Additional User Training**
    - *Project Manager Training* – Because BIM represents a change in process, the entire Project Delivery Team must receive training. Project Managers must have a level of training that enables them to

set appropriate expectations for their in-house and A-E BIM teams. This can be accomplished with "brown bag" sessions.

- *A-E Orientation*: Assuming that the in-house District team is trained, time should be spent preparing the A-E firms that will do District work with the USACE datasets or files. The BIM Manager should be ready to guide them using these resources.

Software/system environment

USACE minimum system requirements for a BIM workstation are the standard ACE-IT configuration for a Performance 64 laptop/desktop. See the Bentley and Autodesk BIM Roadmap supplements for more information on configurations and requirements.

BIM team organization

Just as the shift from CAD to BIM requires some adaptation and adjustment, so too does the development of a BIM Team. Most sites will tend to assign their CAD Manager as the lead BIM Coordinator. However, based on BIM experience at various sites, this is not the most effective way to implement BIM. At each site, there are three duties related to BIM: BIM Manager, Lead Technician, and Designers.

BIM Pit

The "BIM Pit" (a term coined by Louisville District) is an environment where the architects and engineers are in a single room collaborating at the same time on BIM development and analysis. This is where all the immediate communication and collaboration on the models will occur. This is a fundamental shift in design philosophy within USACE since, typically, the separate disciplines have been physically located in separate areas, each working on their own part of the design. Networked desktop computers should be set up for each Designer in the BIM Pit with access to a projector, whiteboard, and conference phone. This BIM Pit should be comfortable for all the Designers to work in, including excellent ambient lighting, temperature control that factors for hardware heat generation, and ability to allow small and large group modeling review at shared terminals and with large screen projection. All team members must have secure access to both the model and the Internet.

BIM Manager

Each site needs to designate someone to serve as the BIM Manager. For the first 6 months of implementing BIM, this person should be allowed to devote 100 percent of his or her time to the BIM implementation. Depending on the BIM workload after 6 months, this may taper off to 50 percent. If BIM workload is heavy, a BIM Manager's time dedicated to BIM should remain at 100 percent. As mentioned above, the impulse to designate the current site CAD Manager as the BIM Manager should be avoided because of the inefficiency of retraining for the more complex modeling processes of BIM. If the CAD Manager is ultimately designated to serve as the BIM Manager, then the CAD Manager's work needs to be assigned to another person. The person appointed to be the BIM Manager should also not be someone who has active production responsibilities at the site.

The BIM Manager's duties remain the same throughout all life-cycle phases. They include:

- Reviewing BIM contract and in-house submittals
- Supporting design team lead in utilizing BIM to perform design reviews
- Supporting design team with QA/QC process (i.e., model standards checks, CAD standards checks, visual checks, and interference management checks)
- Supporting design team with the development of the Project Execution Plan (PxP) and Minimum Modeling Matrix (M3)
- Coordinating with ACE-IT to ensure BIM capable hardware/software solutions meet design team requirements
- Coordinating the BIM Pit
- Arranging for BIM training
- Configuring and upgrading BIM related datasets/files
- Ensuring that newly developed project data are evaluated and potentially added to District and/or corporate template datasets or corporate template files
- Supporting District with Division and HQUSACE BIM related requests.

Lead Technician

Designating someone to be a Lead Technician at a site is highly recommended. Again, the person assigned to be the Lead Technician should not be the same person assigned to be the BIM Manager. Also, Designers should not take on Lead Technician duties—keep your Designers designing. The junior Architect or Engineer are good candidates for Lead Technician duties.

The Lead Technician's duties include:

- Managing the model formatting and access processes
- Handling extractions/quantity take-offs/spec generation from the model
- Ensuring that all BIM work follows the A/E/C CAD Standard and the national BIM IFC exchange requirements and standardization guidelines that are available for the specific project systems that will be designed
- Ensuring data quality assurance by using project validation products.

Designers

The Designers are the architects and engineers assigned to design the BIM. These are the people coordinating work in the BIM Pit. In BIM, design decisions are constantly and rapidly being made. Architects and engineers should be active participants in the BIM Pit and not just directing a drafter to make changes in the model.

The Designer's duties include:

- Being responsible for design requirements for his/her design discipline
- Executing the design and design changes in a 3D environment.
- Analyzing data derived from xD design tools and using it to refine designs to obtain best life-cycle value.

Additional lessons learned

Other lessons learned from successful BIM implementations with regard to the BIM team organization:

- The skill set of the person selected to be a BIM Manager, Lead Technician, or Designer is not as important as their attitude. A site's BIM adoption effort can be undermined by selecting a person who does not care about the ultimate implementation goal. If you are considering someone who is not 100 percent dedicated to learning BIM or is not collaborative in nature, then select someone else.

- Get your people serving as BIM Manager, Lead Technician, and Designers trained as soon as possible. Then immediately assign them to a project. The ideal situation would be to use the project as the subject of the exercises during the training. Once the team has trained in BIM and completed a live project, those people should be used as mentors for the next class of new BIM designers. That way, skills and lessons learned are being passed on from one team to the next.

Support from management

Team buy-in and management expectations

Management needs to understand the scope of issues at stake in the transition to BIM. BIM is expected to solve many problems associated with the design and construction process. However, the current USACE design and construction process is unique because of the massive number and size of projects that USACE undertakes concurrently. The current process can be very cumbersome for typical Civil Works and MILCON projects. To effectively use BIM, a District will have to change its current business processes, which probably were established when 2D CAD use was implemented. Ultimately, however, the BIM process will streamline projects for both Civil Works and MILCON projects with its own unique business processes that are expedited because BIM can deliver design information and data faster and more thoroughly than 2D CAD capability.

A District just beginning to implement BIM may find it beneficial to create a District Data and Skill Set Expectation Plan. This plan should include milestones that support the USACE BIM Roadmap. More importantly, it should reflect the needs and the timing of projects under development within the District. For example, if the District's goals are to get A-E firms on board and working on pending projects, that should be stated so the BIM team can prepare to support that element early in their development instead of focusing on mentoring other teams within their discipline.

In the transition to new processes, management should anticipate that productivity of some aspects of project development will decline temporarily. This is the case with the adoption of any new technology, software, or process. This productivity decline will be offset by the value of the modeling developed through the use of BIM throughout all phases of the project life cycle, which will drive down construction and operations costs and create greater user satisfaction with the completed structure. Data will no longer have to be recreated at each life-cycle phase because data created in Project Models is available for use during the complete life cycle of the project.

Team building

A District has a much higher probability of success if the BIM process is adopted and the team members are unified in undertaking its use. BIM involves too many complexities to allow team members to digress onto tangents. BIM is a team effort that requires daily contact between its key members. Ideally, the team will work in close proximity with each other in the BIM Pit. At most sites, this close work proximity will be a completely new concept. However, success in adopting it will result in unprecedented levels of teamwork and camaraderie in project development.

Weekly modeler meetings, when the members are not in a BIM Pit, are a good way to keep BIM deliverables focused. These meetings can cover modeling, project, and workload issues.

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This report incorporates, by reference, separate vendor-authored supplements to reflect the USACE vendor-neutrality policy on BIM tools that meet USACE requirements.

14. ABSTRACT

Building Information Modeling (BIM) technology has rapidly gained acceptance throughout the planning, architecture, engineering, construction, operations, and maintenance industries. The challenge for the US Army Corps of Engineers (USACE) is to extend BIM use beyond its basic labor- and time-saving benefits to become a fully realized information network that permanently transforms conventional business processes to unprecedented levels of efficiency and organization.

This document describes the current USACE strategic plan, reflecting progress made toward the goals of the original 2006 USACE BIM roadmap as published in Engineer Research and Development Center (ERDC) Technical Report TR-06-10 (October 2006). This update of the strategic roadmap focuses on fuller integration of BIM technologies into USACE planning, design, construction, and operations and maintenance (O&M) processes. It describes how USACE will meet or exceed the vision of its customers, including the Office of the Secretary of Defense (OSD), the Army, and the Air Force. The scope of this plan is BIM implementation within the business processes of the Military Construction (MILCON) and Civil Works programs, including processes for working with USACE industry partners and software vendors.

15. SUBJECT TERMS

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