U.S. General Services Administration
Public Buildings Service
Office of the Chief Architect

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This version of the *GSA Building Information Modeling Guide Series 01 – Overview* is identified as Version 0.6 to indicate its provisional status. With its publication, the GSA BIM Guide, for the first time, becomes available for public review and comment. As its provisional status denotes, however, it will continue to serve as the basis for further development, pilot validation, and professional editing. All readers of this provisional guide are encouraged to submit feedback to the National 3D-4D-BIM Program. Updated versions will continue to be issued to address and incorporate on-going feedback in an open and collaborative process.

Currently, *GSA Building Information Modeling Guide Series 02 – Spatial Program Validation*, version 0.96 is also available for review and comment.

For further information about GSA's National 3D-4D-BIM Program, additional BIM Guide Series, or to submit comments or questions, visit the National 3D-4D-BIM webpage at http://www.gsa.gov/bim.

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@ GSA

BIM Guide Overview

GSA BIM Guide Series 01

www.gsa.gov/bim

Version 0.60 – May 2007

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foreword

The United States General Services Administration (GSA), through its Public Buildings Service (PBS), provides and maintains quality workplaces for over a million Federal agency associates in approximately 8,500 owned or leased buildings across the United States. One critical business function PBS performs to support this aspect of its core mission is the planning, design, and construction of new and newly modernized courthouses, office buildings, border stations, and other facilities. To this end, PBS manages over 170 new construction and repair and alternation projects with a current capital investment program that totals over $8 billion and constitutes over 340 million rentable square feet. Insuring that these dollars are invested wisely and effectively is critical to another aspect of PBS' core mission - upholding the public trust.

Working with its construction industry partners, over the past 10 years PBS has set and achieved high standards for both design and construction excellence in its major capital projects. The resulting national awards, professional recognition, and media attention PBS has received have affirmed our commitment and strengthened our resolve to do even better in the future.

The construction industry is ripe for fundamental changes enabled by the same virtual, smart object modeling technology now prevalent in aerospace, automotive, and other industry practice. Just as today's major manufacturers use computer technology to model their products virtually before production, in the future we will first build our buildings virtually on a computer before attempting to build them physically in the field.

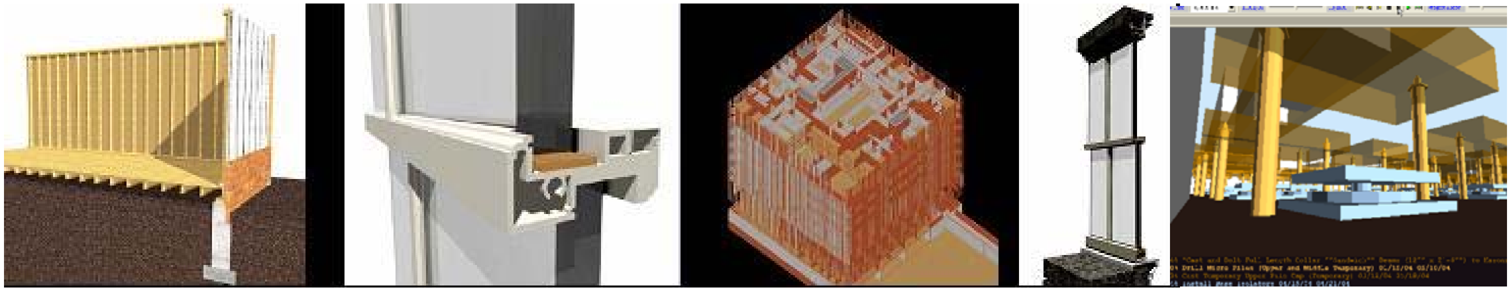

Figure 1: Virtual Construction Detailing from GSA Pilot Project

As this technology has begun to find application in the construction industry, it has acquired a variety of industry-specific names. In titling this guide, OCA has adopted the now predominantly used name, Building Information Modeling, or BIM. BIM is a data rich digital representation cataloging the physical and functional characteristics of design and construction. Its purpose is to make the design information explicit, so that the design intent and program can be immediately understood and automatically evaluated.

In the future, BIM will empower design and construction professionals to work collaboratively throughout the project delivery process, focusing their energy on higher order functions such as creativity and problem solving, while computers do the tedious tasks of counting and checking.

But for real property owners and managers such as PBS, BIM holds great promise beyond improving productivity in the design and construction process. Ultimately, this technology has the potential to enable the seamless transfer of knowledge from facility planning through design, construction, facility management and operation, and recapitalization or disposal. While all parties involved in design and construction stand to gain from the adoption of BIM, it is the owners who will potentially benefit the most, through the use of the facility model and its embedded knowledge throughout the 30 to 50 year facility lifecycle.

This potential can only be realized if the information contained in the model remains accessible and usable across a variety of technology platforms over a long period of time. Given the accelerating pace of technology development, in 20 to 30 years our now state-of-the-art hardware and software applications will be outdated and obsolete. For this reason, it is essential from GSA's perspective to insist that BIM incorporate a universal, open data standard to allow full and free transfer of data among various applications.

Fortunately, there are emerging efforts to create industry standards for BIM data exchange and archiving. Because of our long-term owner's interest, PBS is actively supporting the use of open standards that promote maximum interoperability. As a public institution, PBS views this approach as a governmental imperative. We must ensure that the private sector can compete openly and equally for our business. We should endorse standards that promote interoperability and advance industry efficiency; and, finally, we should encourage the development of a robust system that can evolve and endure beyond the limits of current practice. Use of open data standards and BIM technologies helps us accomplish this goal.

The foregoing paragraphs outline a bright vision for the future for construction industry professionals and real property owner-developers. The issuance of this provisional guide is a major step toward hastening the arrival of that envisioned future. We are committed to promoting the standardization of BIM, increasing its use on our projects as it develops and matures, and encouraging others to do the same. We are convinced that to fulfill our mission of providing a superior workplace for the Federal worker and superior value for the American taxpayer, we can do no less.

introduction

GSA’s mission is to "help federal agencies better serve the public by offering, at best value, superior workplaces, expert solutions, acquisition services and management policies." Within GSA, PBS manages over 342 million square feet of workspace for the civilian federal government. GSA designs and builds award-winning courthouses, border stations, and federal office buildings, while also repairing and modernizing existing facilities. GSA PBS Office of the Chief Architect (OCA) provides leadership and policy direction to all 11 GSA regions in the areas of architecture, engineering, urban development, construction services, and project management. OCA houses the National 3D-4D-BIM Program.

Series 01 (GSA BIM Guide Overview) is intended for GSA associates and consultants engaging in BIM practices for the design of new construction and major modernization projects for GSA. As such, GSA associates administering professional services and construction contracts are its primary audience. Subsequent Series in the BIM Guide are in development and will complement and enhance the information provided in this overview by documenting, evaluating, and encouraging specific applications of 3D, 4D, and BIM-related technologies. In this way, each Series in the BIM Guide is intended to be stand-alone, but related text.

This Series 01 (GSA BIM Guide Overview) is an introductory text serving as a foundation and common starting point to support BIM technology in general and individual BIM applications in specific. As an overview, this Series is an over-arching and executive text to be used as a reference guide for GSA members and associates when determining what BIM applications would be appropriate for their specific project, and throughout the adoption and application of the selected technology. This Guide will also be of general interest to other members of the project teams, including PBS staff, customer agencies, and contracted parties such as architects and engineers (A/Es), construction managers, construction and design-build contractors, and consultants hoping to understand more about BIM technologies and potential applications. In addition, architect, engineering and construction (AEC) industry software solution providers will find this Guide of interest in providing preliminary clarification and promoting further discussion surrounding the development and adoption of various technologies.

This Series O1 guide is divided into the following sections:

Section 1: GSA’s national 3d-4d-bim

- This section introduces the GSA’s National 3D-4D-BIM Program as well as provides background information on concepts, definitions, and expectations underlying 3D, 4D, and BIM technologies, modeling, and models.

Section 2: 3d-4d-bun projects -the basics

- This section provides guidance on best practices regarding the implementation of 3D, 4D, and BIM technologies in different parts of the project lifecycle, and reviews the factors that must be considered before implementing BIM on a project. For specific applications of 3D, 4D, and BIM technologies, please see additional Series Guides.

Current Series

Current Series Guides focusing on specific 3D, 4D, and BIM applications include:

- *Spatial Program Validation*

This Series describes the tools, processes, definitions, and requirements to effectively utilize BIM technologies for GSA's spatial program BIM minimum requirement.

Upcoming Series

Upcoming Series Guides focusing on specific 3D, 4D, and BIM applications include:

- *4D Phasing*

This Series describes the tools and processes to explore how phasing and time-related information (e.g., where the construction zones will be and where and when tenants will have to move to swing space) will affect project development. Potential benefits examined include better understanding projected construction schedules.

- *3D Imaging*

This Series is focused on identifying, exploring, and documenting the step-by-step process of obtaining and executing 3D imaging services from the commercial market on GSA projects.

- *Energy Performance and Operations*

This Series examines the use of space-based BIM modeling techniques and strategies to strengthen the reliability, consistency, and usability of predicted energy use and energy cost estimates during building design and operation.

- *Circulation and Security Design Validation*

This Series describes the tools, process, and requirements in the development of technologies that automate the checking of top priority circulation requirements and related aspects, such as security.

OCA is developing a GSA BIM Toolkit (see section 1.6.1). This Toolkit will include case studies, best practices, sample contractual language for GSA associates, and guidelines on specific BIM applications (e.g., spatial program validation, 3D imaging, 4D-phasing, energy, and sustainability). GSA associates and project teams shall contact OCA's National 3D-4D-BIM Program (www.gsa.gov/bim) for advice and further information.

section 01:

GSA's national 3d-4d-bim program

section 1: GSA's national 3d-4d-bim program

In 2003, the General Services Administration (GSA) Public Buildings Service (PBS) Office of the Chief Architect (OCA) established the National 3D-4D-BIM Program. 3D, 4D, and BIM applications allow GSA to more effectively meet program, design quality, and construction requirements. The power of visualization, coordination, simulation, and optimization has proven indispensable in other industries and has been used by public and private owners across the U.S. and around the world to promote process efficiency. Under this program, GSA has succeeded in an unprecedented open standard development in the U.S. building industry—engaging multiple competing software vendors voluntarily to incorporate new BIM functionalities valuable to GSA business needs and the industry.

GSA's initiative has led other federal agencies to adopt BIM, elevated the case for open standards, and encouraged the industry and peer owners to establish an owner's BIM and its requirements. Its program achievements have been featured in a number of professional publications (e.g., *Engineering News-Record*), introduced as the theme of industry-initiated forums (e.g., ZweigWhite, Federal Facilities Council, and CIO Large Firm Roundtable), and have been positively received by the international community (e.g., International Alliance of Interoperability and the Workplace Network).

Great opportunity exists for improvements in productivity throughout all phases of the building industry. In current practice, building designs are communicated in terms of dozens, or even hundreds of separate and often inconsistent documents. These documents are designed for specific pre-defined purposes. In particular, Computer-Aided Design (CAD) documents often exclude information needed for effective design evaluation. The information that was sufficient for CAD drawings is often insufficient to meet the requirements of a model–based design process, as industry expectations for analysis using a model-based approach are expanding.

The purpose of BIM is to make the design information explicit, so that the design intent and program can be immediately understood and evaluated. A BIM-based approach supports 'on demand' generation of documents (e.g., drawings, lists, tables, and 3D renderings) from a consistent BIM. In a sense, these documents present views of the current BIM. A BIM model, therefore, can live longer, contribute more to process efficiency, and provide superior accuracy than traditional 2D CAD drawings.

As a shared knowledge resource, BIM can reduce the need for re-gathering or re-formatting information. This can result in an increase in the speed and accuracy of transmitted information, reduction of costs associated with a lack of interoperability, automation of checking and analysis, and unprecedented support of operation and maintenance activities.

All GSA project teams are encouraged to adopt 3D-4D-BIM, when feasible, beyond the minimum requirements (i.e., spatial program BIM for FY2007 and beyond design projects) and to explore the synergies created through multiple applications of 3D, 4D, and BIM.

Few BIM models today include information about design decisions, design intent, analysis calculations, or building code requirements. The capture of such information is part of on-going research at GSA and elsewhere in the industry and academia. Current efforts in these areas are noted where appropriate in this version of the BIM Guide, with the hope that future versions will include additional progress and advancements.

1.1 What are 3D, 4D, and BIM?

3D, 4D, and BIM technologies represent three separate, but synergistic, ways in which computer technologies can aid GSA to manage its facilities throughout a project's lifecycle. 3D geometric models are the geometric representation of building components and typically serve as an aid for visualization and design/construction coordination. 4D models (3D + time) include information that can inform and analyze project phasing, tenant sequencing, and construction scheduling. Building Information Models (BIMs) include not only 3D geometric models (and, therefore are capable of directly generating 2D and 3D drawings), but also more specific information on a wide range of building elements and systems associated with a building (e.g., wall types, spaces, air handling units, geospatial information, and circulation zones).

Public exposure to, understanding of, and adoption of BIM technologies are evolving and expanding. In this process, industry and academic organizations are using a variety of working definitions for BIM. The National Institute of Building Standards (NIBS) puts forward, "BIM is a digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle from inception onward." [1] The Associated General Contractors of America (AGC) focuses on BIM's ability to "[allow] for the 'virtual construction' of such structures through the development and use of intelligent computer software that helps simulate construction."[2] Stanford University's Center for Integrated Facility Engineering (CIFE) espouses "Virtual Design and Construction (VDC) [as] the use of multi-disciplinary performance models of design-construction projects, including the Product (i.e., facilities), Work Processes and Organization of the design - construction - operation team in order to support business objectives." [3]

For purposes of this Guide, Building Information Modeling and the Building Information Model are defined as follows:

> *Building Information Modeling is the development and use of a multi-faceted computer software data model to not only document a building design, but to simulate the construction and operation of a new capital facility or a recapitalized (modernized) facility. The resulting Building Information Model is a data-rich, object-based, intelligent and parametric digital representation of the facility, from which views appropriate to various users' needs can be extracted and analyzed to generate feedback and improvement of the facility design.*

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[1] http://www.wbdg.org/design/bim.php
[2] http://www.agc.org/galleries/pr/06-057.doc
[3] http://cife.stanford.edu/Mission/index.html

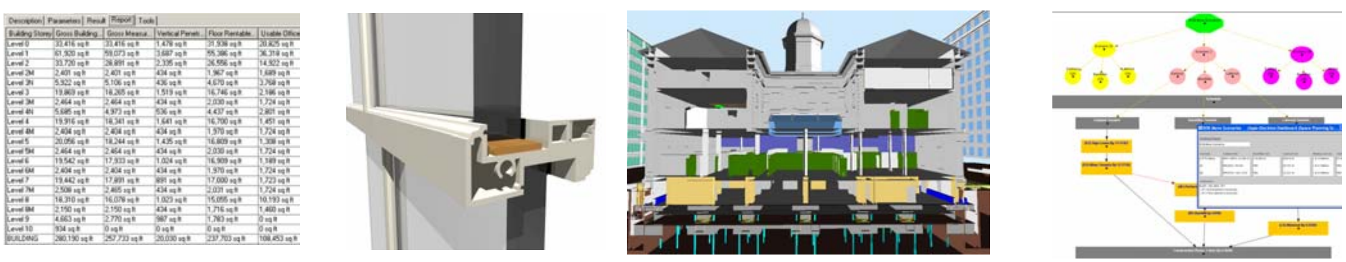
Distinguishing 3D models and BIM

3D geometric models contain very little intelligence. BIM models contain a high level of intelligence. A 3D model includes a three-dimensional geometric representation of the building, whereas a BIM is organized as a prototype of the building, in terms of building floors, spaces, walls, doors, windows and a wide array of information associated with each of these elements. A BIM can normally be viewed in 3D, but the model also includes information used by other building analysis applications, such as cost estimating, energy simulation, daylighting, computational fluid dynamics (CFD), and building code checking.

Although 3D models make valuable contributions to communications, 3D models alone do not qualify as BIM models since a 3D geometric representation is only part of the BIM concept. The rest of the BIM concept is contained in the "I" of BIM, which stands for information. BIM is a data rich digital representation cataloging the physical and functional characteristics of design and construction. It can serve as a shared knowledge base that is directly manipulated (computable). Its importance stems from having an open interchange of information across platforms and a transferable record of building information throughout a building lifecycle. BIM serves as a reliable foundation for decision making and provides a platform for automated analyses that can assist in planning, design, construction, operation, and maintenance activities.

The Potential of BIM

The information in a BIM model catalogs the physical and functional characteristics of the design, construction, and operational status of the building. Multiple instances of these states can demonstrate the dimension of time and/or to capture a rich and searchable data set, which provides a record of design decisions, construction sequencing, operational events, etc. that is not possible using static representation alone. This information may span a number of disciplines and application types. BIM integrates this information in one database in a consistent, structured, and accessible way. As a result, BIMs are multi-purposed and can be evaluated from many different points of view as required to optimize design, construction, and operation of a building. The following images are all examples of information being accessed from BIM models in OCA 3D-4D-BIM Program Pilot Projects.



Description | Parameters | Result | Report | Tools

Building Storey	Gross Building...	Gross Measur...	Vertical Peneti...	Floor Rentable...	Usable Office
Level 0	33,416 sq ft	33,416 sq ft	1,478 sq ft	31,938 sq ft	20,825 sq ft
Level 1	61,920 sq ft	59,073 sq ft	3,687 sq ft	55,386 sq ft	36,319 sq ft
Level 2	33,720 sq ft	28,891 sq ft	2,335 sq ft	26,556 sq ft	14,922 sq ft
Level 2M	2,401 sq ft	2,401 sq ft	434 sq ft	1,967 sq ft	1,689 sq ft
Level 3N	5,922 sq ft	5,106 sq ft	436 sq ft	4,670 sq ft	3,768 sq ft
Level 3	19,869 sq ft	18,265 sq ft	1,519 sq ft	16,746 sq ft	2,186 sq ft
Level 3M	2,464 sq ft	2,464 sq ft	434 sq ft	2,030 sq ft	1,724 sq ft
Level 4N	5,685 sq ft	4,973 sq ft	536 sq ft	4,437 sq ft	2,801 sq ft
Level 4	19,916 sq ft	18,341 sq ft	1,641 sq ft	16,700 sq ft	1,451 sq ft
Level 4M	2,404 sq ft	2,404 sq ft	434 sq ft	1,970 sq ft	1,724 sq ft
Level 5	20,056 sq ft	18,244 sq ft	1,435 sq ft	16,809 sq ft	1,308 sq ft
Level 5M	2,464 sq ft	2,464 sq ft	434 sq ft	2,030 sq ft	1,724 sq ft
Level 6	19,542 sq ft	17,933 sq ft	1,024 sq ft	16,909 sq ft	1,189 sq ft
Level 6M	2,404 sq ft	2,404 sq ft	434 sq ft	1,970 sq ft	1,724 sq ft
Level 7	19,442 sq ft	17,891 sq ft	891 sq ft	17,000 sq ft	1,723 sq ft
Level 7M	2,508 sq ft	2,465 sq ft	434 sq ft	2,031 sq ft	1,724 sq ft
Level 8	16,310 sq ft	16,078 sq ft	1,023 sq ft	15,055 sq ft	10,193 sq ft
Level 8M	2,150 sq ft	2,150 sq ft	434 sq ft	1,716 sq ft	1,460 sq ft
Level 9	4,663 sq ft	2,770 sq ft	987 sq ft	1,783 sq ft	0 sq ft
Level 10	934 sq ft	0 sq ft	0 sq ft	0 sq ft	0 sq ft
BUILDING	280,190 sq ft	257,733 sq ft	20,030 sq ft	237,703 sq ft	108,453 sq ft

Figure 2: Images from GSA Pilot Project applications of 3D, 4D, and BIM technologies

Today, BIMs are normally created in BIM-authoring applications. In the future, as model servers become more prevalent, BIMs will accumulate information from a number of different applications. This could begin with the initial Space Program (or PBS "Housing

Plan") from one application, continue with the addition of architectural elements in a second application, and then with building services elements in a third, and so on.

1.2 OCA's Business Need for 3D-4D-BIM

There are great opportunities for improvement in design and construction industry productivity. As measured over the past four decades, the U.S. construction industry has failed to keep pace with steadily increasing productivity in other industrial sectors. While other industries have benefited from new technologies and innovations such as supply chain management and concurrent engineering during this era, facility planning, design, and construction methods and practices have seen relatively little change.

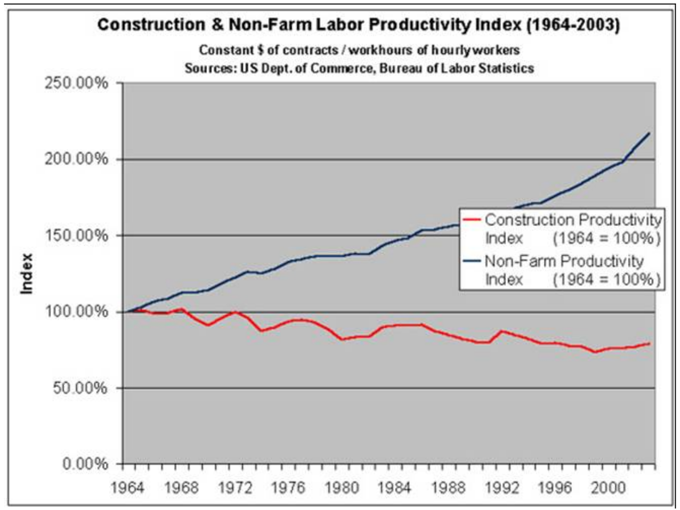


Figure 3: Labor productivity index for US construction industry and all non-farm industries from 1964 through 2003. Credit: Paul Teicholz, Ph.D. Professor (Research) Emeritus, Dept. of Civil and Environmental Engineering, Stanford University

A study performed for the National Institute of Standards and Technology (NIST) estimated that in 2002, $15.8 billion were lost due to "significant inefficiency and lost opportunity costs associated with interoperability," in the capital facilities industry. Moreover, building owners and operators bore the majority (2/3) of these costs.[4] When applied to GSA's $11 billion of construction program currently in the pipeline, NIST's findings equate to $460 million of waste or rework on GSA projects. This waste and rework comes from many different sources: inaccurate as-built drawings, miscommunication among stakeholders and inefficient and inconsistent analysis of designs (e.g., spatial analysis, energy analysis, etc). 3D, 4D and BIM technologies can aid

[4] http://www.bfrl.nist.gov/oae/publications/gcrs/04867.pdf

OCA in reducing this waste by influencing project earlier in the project delivery phase. This allows OCA to analyze and predict the performance of the building to achieve high-performing building. It also allows OCA to validate and meet our customer's needs.

OCA is committed to the adoption of BIM methods and technologies in our capital construction program, with the intent of achieving major quality and productivity improvements like those that have been realized in other industries over the past four decades. The following excerpt from a December 2003 internal PBS memorandum summarizes this commitment:

> *Cost overruns and claims can be reduced on our construction contracts by improving the quality of our design product. New technology now affords us the opportunity for quantum improvement in design quality by building our buildings virtually before building them physically. Other industries have achieved major quality and productivity improvements through the use of object model technology based on open standards for interoperability... Interoperable object model technology also allows automated standards checking and cost estimating to better control project scope and cost. Beyond the expected improvements in design quality, this technology will enable full transfer of design information into construction, facility management, and operations-maintenance. The Office of the Chief Architect (OCA) will work with the regions to implement this new technology in our capital construction program as soon as possible. The goal will be to provide [interoperable] building information models in support of all national office concept reviews on projects receiving design funding in [FY 2007] and beyond. OCA will develop and issue additional guidance, including regional pilot project opportunities, to make this goal a reality.*

1.3 Benefits of 3D-4D-BIM Program for GSA

GSA is poised to leverage the value of "building virtually" before building in reality. 3D-4D-BIM applications aid GSA project teams in better visualization and analysis of project information. For instance,

- 3D laser scanning and advanced scanning technologies allow for better documentation of as-built drawings and existing conditions. 3D visualizations allow customers to see historic preservation and site context with respect to the new project. They also allow for 3D coordination to reduce RFIs, errors, and omissions.
- 4D models allow customers to visualize and optimize project phasing and construction sequencing.
- BIM models allow GSA to automatically calculate relevant space data (e.g., GSA net area and efficiency ratio). During preliminary and final concept design, GSA can validate spatial program requirements more accurately and quickly than using traditional 2D approaches. All major projects that receive design funding in FY2007 and beyond are required to submit a spatial program BIM to OCA prior to final concept presentation. BIM-based energy models allow project teams to conduct more efficient, accurate, and reliable energy simulations to predict building performance during facility operations.

On a project level, the pilot program has proactively improved the delivery of a number of ongoing capital projects—from uncovering and mitigating errors and omissions, predicting potential obstacles and their project impacts, introducing better design solutions, enhancing tenant and contractor communications, and optimizing budget and schedule options. In the pilot involvement, using BIM technologies has contributed to an optimized construction schedule (e.g., reduce duration by 19% in Los

Angeles Federal Office Building), improved as-built documentation and major design savings through optimization of the mechanical system design (e.g., 26 Federal Plaza in New York), uncovered design errors and omissions (e.g., envelope and coordination omissions in Houston Federal Office Building), and improved the means for communications (e.g., with tenant agencies and during pre-bidding conferences). While specific contract value and project costs vary from pilot to pilot, the cost saving on one of the pilot projects has already paid start-up costs of the program.

1.4 OCA Status Report

OCA's 3D-4D-BIM Program has given guidance and assistance to over 50 GSA capital projects in the past 3 years. In particular, OCA has completed 10 pilot projects. It has 11 pilot projects underway in its current capital program, while assessing and supporting 3D, 4D, and BIM applications in over 25 ongoing projects across the nation. This section gives a program overview and elaborates on specific 3D-4D-BIM initiatives the program currently supports.

> *Note: Currently, for all projects receiving design funding in Fiscal Year 2007 and beyond, a spatial program BIM will be the minimum requirement for all major (new and modernization) projects submitted to the Commissioner of the Public Buildings Service for Final Concept approvals. For additional information, see the BIM Guide Series 02- Spatial Program Validation.*

In addition, the program is exploring the use of computer models and simulations using a variety of 3D, 4D, and BIM applications throughout project lifecycles. In particular, the program is investigating the role of BIM in the following areas: spatial program validation, 4D phasing, 3D imaging, energy performance and operations, and circulation and security design validation. GSA's long-term vision is to have these and other technologies advance the seamless transfer of knowledge from facility planning through design, construction, facility management and operation, and recapitalization or disposal.

OCA has drafted 3D-4D-BIM contract language for a number of projects. The contract language is an incremental approach for introducing 3D-4D-BIM requirements into ongoing projects, while also fitting appropriately with the many GSA project and procurement requirements. OCA has been working with project teams to evaluate specific 3D, 4D, and BIM implementation opportunities and challenges, and then customizing specific contract language for the project.

At the same time, OCA is in the process of issuing standard 3D-4D-BIM solicitation and scope of work to the regions. The contract language specifically references the GSA BIM guide, in which required deliverables are defined. For the past three years, GSA has developed a nomination process in which regions can nominate BIM advocates to attend BIM-related training programs. OCA then selects and sponsors nominated regional BIM advocates to attend these programs.

Besides internal training, OCA has presented at various national and international conferences, such as AIA, ASCE, AGC, CMAA, CURT, CSI, FFC, FIATECH, and IAI, as well as at universities, such as Georgia Tech, Harvard University, and Stanford University. By presenting both internally and externally, OCA hopes to fully advocate and publicize our 3D-4D-BIM initiative.

Additional highlights from the National 3D-4D-BIM Program:

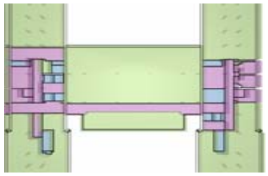
- Established policy to phase in 3D, 4D, and BIM adoption for all major projects
- Leading 3D-4D-BIM pilot application on current capital projects
- Providing expert support and assessment for ongoing capital projects to incorporate 3D, 4D, and BIM technologies
- Assessing industry readiness and technology maturity
- Developed GSA-specific incentives for 3D-4D-BIM
- Developed solicitation and contractual language for 3D-4D-BIM services
- Partnered with BIM vendors, professional associations, open standard organizations, and academic/research institutions

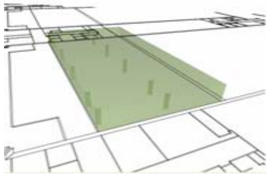
OCA has been working with peer owners, academia, and the industry both within the US and internationally (e.g., with Finland, Norway, and Iceland) to exchange best practice experiences.

1.5 Current Program Areas

Currently, the program is evaluating the role of BIM in the area of spatial program validation, 4D phasing, 3D imaging, energy performance and operations, and circulation and security design validation. Details of each area of investigation are provided below:

- Spatial Validation



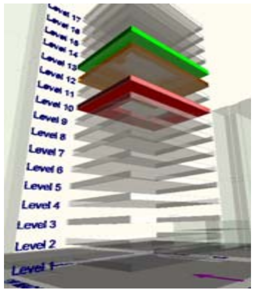


The National 3d-4D-BIM Program has chosen to focus first on using BIM for spatial validation because spatial validation is a universal problem on all projects. For all projects receiving design funding in Fiscal Year 2007 and beyond, a spatial program BIM will be the minimum requirement for all major (new and modernization) projects that will be submitted to the Commissioner of the Public Buildings Service for Final Concept approvals. In preparation for this requirement, OCA is working with a wide array of stakeholders (e.g., software vendors, A/E teams, and spatial data management professionals). See *BIM Guide Series 02 - Spatial Program Validation.*

The overall purpose of validating a spatial program using BIM is to efficiently and accurately assess design performance in regard to spatial requirements. Using BIM to model and analyze space allows project teams to spend less time understanding the details of complex space standards and regulations and to spend more time doing a value-adding activity: *design*. Available technologies are used to define a space once, and to then automatically validate whether or not the proposed design meets all relevant spatial requirements.

OCA has developed a “GSA Concept Design View” of the requirements for spatial data management. The GSA Concept Design View is a model view of the IFC BIM modeling data standard that was developed and published by the IAI. The GSA Concept Design View of IFC is currently supported by Autodesk Revit and Architectural Desktop, Bentley Architecture, Graphisoft ArchiCAD, Onuma Planning System, and Solibri Model Checker. These applications have gone through four rounds of validation testing using a GSA test case building.

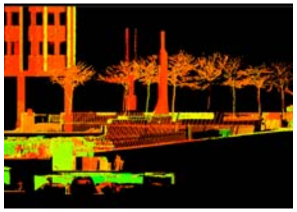
- 4D Phasing



4D models combine a 3D model with time. These models allow project teams and GSA associates to communicate the proposed project phasing to all stakeholders. With 4D modeling, these stakeholders are able to better understand how the project will affect them (e.g., where the construction zones will be and where and when tenants will have to move to swing space). GSA is also able to use 4D models to understand projected construction schedules for funding purposes.

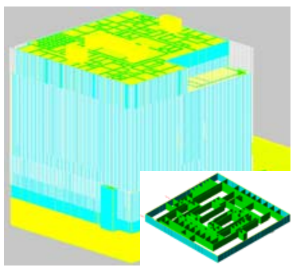
OCA is currently using 4D models on several GSA projects across the nation and is encouraging, documenting, and evaluating 4-D phasing technologies on a project-by-project need basis.

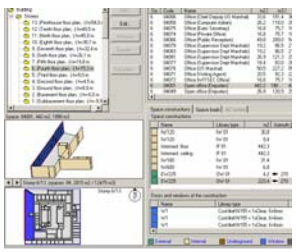
- 3D Imaging



3D imaging and laser scanning has become an emergingly prominent vehicle for acquiring building spatial data in three dimensions with high fidelity and low processing time. The rapid collection of 3D information serves several purposes across GSA business lines, including historical documentation, facility condition documentation, construction as-built development, and BIM development. OCA is partnering with other agencies and organizations, such as NIST, ASTM, FIATECH, and SPAR Point to develop best practices and standards. Awarded with funding and support through a GSA-wide Venture Capital Program, OCA is currently using laser scanning technologies for pilot projects in Brooklyn, New York; Atlanta, Georgia; and Miami, Florida.

- Energy Performance and Operations

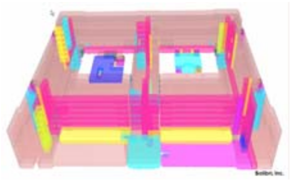




OCA is currently exploring the benefits of using BIM-based energy modeling (space-based) and comparing the technology's methods and results to more traditional energy modeling practices (zone-based). The increased specificity of inputs provides an opportunity to use more detailed assumptions, which are better equipped to deal with the variability and uncertainty surrounding building operation. Using BIM, it is possible to increase the level of automation and computability in energy analysis and other sustainability related analyses (e.g., LEED and daylighting). The intended outcome is to produce streamlined processes, which ultimately will result in improvements in actualized building performance and sustainability.

Specific benefits to project teams may include: more complete and accurate energy estimates earlier in the design process, improved life-cycle costing analysis, increased opportunities for measurement and verification during building occupation, and improved processes to learn from high performance building. Two on-going pilot projects at OCA compare BIM-based energy modeling methods and results to more traditional energy modeling practices.

- Circulation and Security Design Validation



OCA is working with research teams and industry members to develop technology that automates the checking of top priority circulation requirements and related aspects, such as security. The program will address applicability for requirements from a variety of building types as set forth in other PBS design guides, using the U.S. Courts Design Guide as its primary foundation. This work builds on existing efforts, particularly previous spatial validation work.

1.6 OCA's Vision and Strategy for the National 3D-4D-BIM Program

OCA is committed to a strategic and incremental adoption of 3D, 4D, and BIM technologies. OCA will continue to strive towards a vendor neutral, open standard for data models while strategically and incrementally expanding our 3D-4D-BIM program. In 2005, OCA issued an RFI to companies providing 3D, 4D, and/or BIM services to provide not only contact information, but to show their experiences and specific case examples. Through this RFI, as well as an open and on-going exchange with the building industry, OCA is able to assess the current state and maturity of 3D-4D-BIM services in the U.S. AEC industry. OCA is compiling lists of technical and professional consulting companies that have demonstrated business and technical expertise in 3D, 4D, and BIM services.

With the understanding that BIM is still maturing into the mainstream of the U.S. construction industry, OCA is promoting an evolutionary approach to its adoption. This BIM Guide Series is intended to begin to illustrate, document, and evaluate real-world implementation of 3D, 4D, and BIM technologies. OCA will continue to monitor the maturity of BIM-analysis applications, and to collaborate with the industry, vendors, academia, and consultants to determine when and how BIM guidelines should be further developed and when other 3D, 4D, and BIM applications should be explored or adopted by the GSA.

To promote the incremental adoption of innovative technologies, GSA's National 3D-4D-BIM Program is implementing a top-down, as well as bottom-up approach. GSA has set minimum requirements for implementation of technologies that have demonstrated viable business cases for improvements in quality, accuracy, coordination, and/or efficiency during a building's life-cycle. In addition, the National 3D-4D-BIM Program is encouraging the implementation of various technologies above the minimum requirements on a project-by-project basis.

Steps being taken by the National 3D-4D-BIM Program can be loosely categorized as 1) identify salient project area business needs within GSA, 2) identify potential pilot projects, 3) implement an interactive and collaborative process with the industry, vendors, consultants, and academia to perform trials of technologies, 4) promote standardization and best practices, and 5) continually work to advance the high-level goal of the seamless exchange of information. GSA efforts are intended to be sensitive and responsive to industry changes while simultaneously promoting the advancement of BIM related technologies.

While the starting point for BIM implementation has been focused on spatial data management, GSA intends to expand this property set in the future to incorporate other IFC-supported properties (e.g., building systems and building elements). GSA would like to move from a document-based to model-based delivery of designs. Future editions of the Guide will extend this foundation to other BIM-analysis applications, such as space analysis, energy simulations, detailing and fabrication, construction tolerance, and commissioning. GSA implementation of BIM will gradually expand to include additional objectives and extend to successive stages of design and eventually through the project life-cycle.

On-going program areas, which promote improvements in coordination, optimization, planning, communication, and the general decision making process include:

- 4D Phasing
- 3D Imaging
- Energy Performance and Operations
- Circulation and Security Design Validation

These areas have forthcoming BIM Guide Series (see section 1.5 for additional information).

Future program areas of focus include but are not limited to:

- Visualization
- Cost estimating
- Quantity take-offs
- Lighting
- Acoustics
- Structure
- Building elements
- Ingress, egress and traffic
- Facility operation and management

These BIM Guides represent OCA's practical first step toward realizing a long-term vision for improving capital project delivery. The primary goal of the National 3D-4D-BIM Program is to promote value-added digital representation technologies to increase efficiency throughout building lifecycles on government projects and beyond. The long-term objective is to use innovative 3D, 4D, and BIM technologies to complement, leverage, and eventually supersede existing technologies and their associated limitations with industry interoperability and the achievement of a seamless transfer of knowledge.

1.7 OCA's "One-stop Shop" for the National 3D-4D-BIM Program

One goal of GSA's National 3D-4D-BIM Program is to provide a "one-stop" shop for assisting project teams that are interested in adopting new 3D, 4D, and BIM building technologies. Since all projects and existing technologies have unique criteria, capabilities and limitations, OCA will work with project teams on a project-by-project basis to develop custom strategic advice and technology alignment.

As part of the on-going efforts to support the adoption of 3D-4D-BIM technologies on GSA projects and beyond, the National 3D-4D-BIM Program is in the process of developing a BIM Toolkit. GSA Project Managers electing to implement emerging technologies are the target audience although any individual interested in learning more about related BIM technologies may also find the Toolkit useful. Resources of the BIM Toolkit include:

- BIM Guide Series (Best practices and guidelines for project-specific areas)
- Sample language related to
  - Solicitation of Services
  - Scope of Work
- Hardware and Software requirements for specific technologies
- Case Studies and lessons learned

section 02:

3d-4d-bim projects --the basics

section 2: 3d-4d-bim projects --the basics

2.1 Overview

GSA projects have a unique set of constraints and opportunities. All projects are subject to federal requirements: design and construction phases must follow prescribed procedures for fair and open competition, specified federal project milestones must be met, and consultants must be selected based on design talent rather than other means or methods. The following section provides an overview of the process for integrating 3D, 4D, and BIM technologies into the existing project delivery process for GSA projects.

Significant issues face project teams attempting to adopt unfamiliar or emerging technologies. GSA associates need to evaluate and analyze each available technology on a case-by-case basis before beginning a 3D-4D-BIM project. In particular, costs versus benefits, availability of resources, reliability and maturity of technology, stakeholder “buy-in,” introduction of uncertainty, and schedule impacts may all require analysis. The goal of this section is to begin to address some of these questions and concerns as well as to begin to define a formal process for GSA adoption of 3D, 4D, and BIM technologies. Contact OCA’s National 3D-4D-BIM Program (www.gsa.gov/bim) for project-specific advice and further information.

The following figure highlights the steps and iterations that are recommended for technology adoption on a specific project. GSA project teams should first examine the business needs of the project and explore candidate 3D, 4D, and BIM technologies. This should be the basis for defining the scope of the 3D-4D-BIM project. In general, this part of the process should be iterative and GSA project teams should interact with OCA to determine the best 3D-4D-BIM project. After the scope has been defined, GSA project teams should develop an implementation plan to carry-out the project. During the project, GSA project teams should regularly evaluate the project with the metrics established in the implementation plan. The following sections describe these steps in detail.

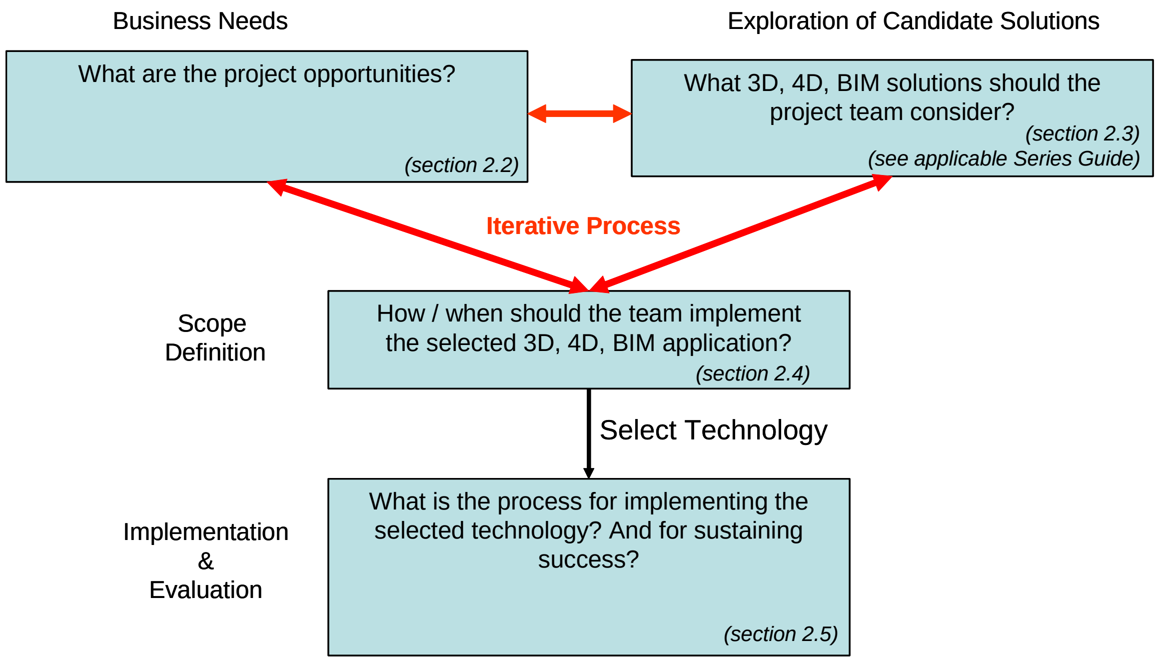


Figure 4: Process for adopting 3D, 4D, and/or BIM technologies

2.2 What are the project opportunities?

All projects face a unique combination of constraints and project challenges. The following table shows some project areas that 3D, 4D, and BIM technologies may support. While this list is not exhaustive, it demonstrates the extent of opportunities that may be available on a project. In general, opportunities in each project area include improved quality, accuracy, coordination, and efficiency.

Technology →	Project Area →		Improvements in:
3D Laser Scanning	• As-built Information	• As-Constructed Information	• Quality • Accuracy • Coordination • Efficiency
3D Geometric Models	• Site • Architectural • Structural	• MEP • Fabrication/Construction Tolerance	
Design and Construction Coordination	• Coordination between disciplines	• Clash Detection	
4D Models	• Project Phasing • Tenant Phasing	• Construction Sequencing • Traffic Studies	
BIM Models	• Site • Architectural – Space – Zone/Circulation	• Structural • Mechanical • Equipment Information • Maintenance Schedules	
BIM-analysis Applications	• Program/Asset Management • GIS • Energy Analysis • CFD Analysis	• Acoustic • Cost Estimating • Equipment Inventory • Facility Management	

Figure 5: 3D-4D-BIM applications can be used for a wide variety of project areas

These project areas also occur throughout the project lifecycle. A rich, diverse, and potentially limitless range of information is generated about a building throughout all stages of its lifecycle and could be captured in a BIM. Regardless of which type of application is used, project teams can incorporate these technologies at different points throughout the project lifecycle.

All GSA projects are encouraged to deploy technologies at strategic project phases in support of specific project opportunities. The following figure shows how 3D, 4D, and BIM technologies can be implemented throughout the project lifecycle. 3D, 4D, and BIM applications are arranged from top to bottom according to maturity of the application. Thus, laser-scanning and 3D geometric models would be the simplest application to use, while intelligent, integrated BIM models and applications would be the most complex.

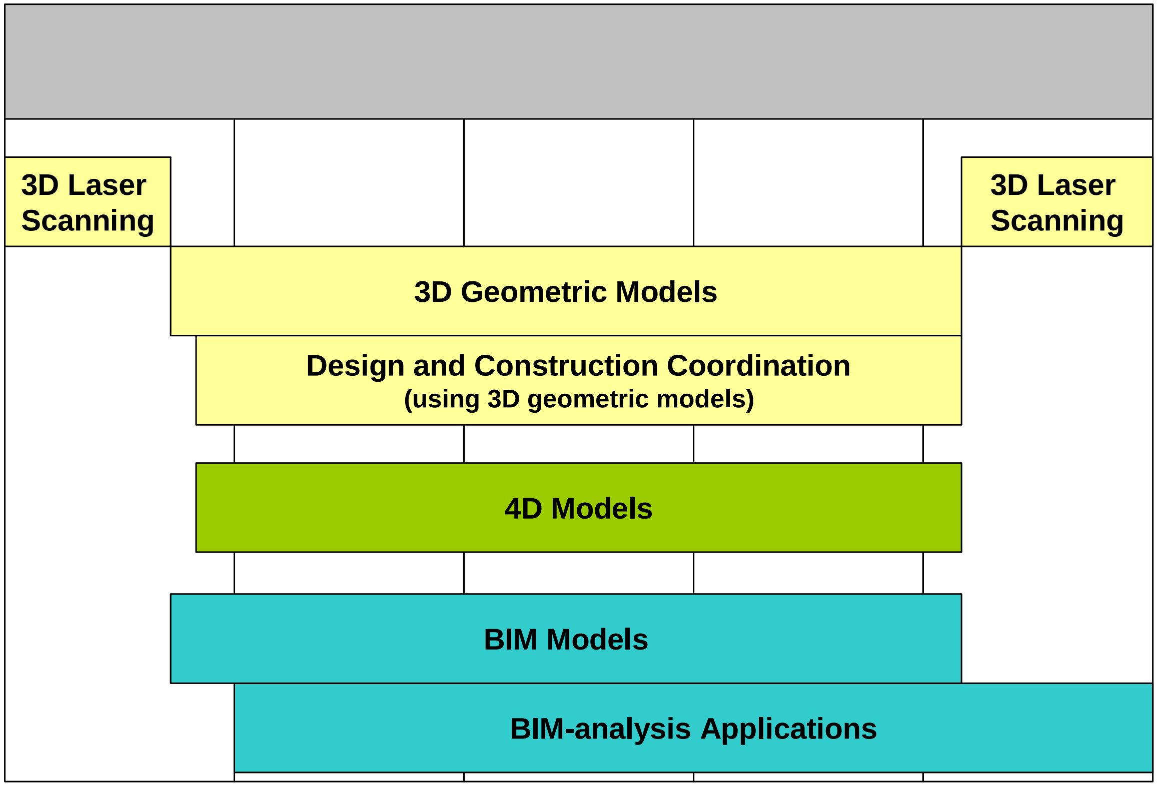


Figure 6: 3D, 4D, and/or BIM applications throughout the project lifecycle.

2.3 Exploring candidate 3D, 4D, and BIM solutions

A variety of 3D, 4D, and BIM technologies exist and are currently available on the market. In addition, a vast number of 3D, 4D, and BIM technologies are under development or available as prototype technologies. The National 3D-4D-BIM Program is both implementing market ready technologies and collaborating with vendors to apply their prototype technologies in GSA pilot project applications. The following sections provide information regarding industry maturity related to the implementation of 3D, 4D, and BIM technologies.

2.3.1 BIM Information Exchange Standards

The GSA encourages the use of open standard for information exchange. As such, a standard is not yet widely supported by software applications. OCA is still using proprietary data formats for many 3D-4D-BIM applications.

One example is the Industry Foundation Classes (IFC) data model developed by the International Alliance for Interoperability (IAI) (www.iai-international.org). The IFC specifications define the content and structure for BIM exchange between software applications and participants in a building project. The IFC model schema is based, in part, on the ISO 10303 Product Data Modeling standard. The IFC specifications have been submitted for consideration as a new ISO standard and are currently in international review for such standardization.

IFC defines a structure for BIM data that is independent of individual applications. IFC is used to exchange BIM data among different applications and participants in a building project. To begin this exchange, a sending application translates its internal representation of the building model from its native data structures to IFC BIM structure. The model is then typically persisted in one of two file formats: .IFC or .IFX (the latter being an xml format). To complete the exchange, a receiving application then loads the IFC BIM file and translates objects from IFC structures to its native data structures for internal representation. The vendor-neutral IFC schema for BIM is the backbone of a process and technology that enables software vendors and end user organizations to achieve interoperability between a wide array of application types for the building industry.

> *Notes:*
> *There are additional standards for data exchange supported in some applications, including CIMSteel Integration Standards/Version2 for structural steel design models and Green Building (gbxml) for energy simulation analysis models. GSA does not require submissions to comply with these standards.*
>
> *IFC viewers (e.g., IFCStoreyView and DDS Viewer) are available, which allow users to view IFC files.*

Although IFC is one example of an open standard for exchange, OCA is also monitoring and supporting other standards such as American Society for Testing and Materials (ASTM) for 3D laser scanning, Extensible Markup Language (XML), National BIM Information Modeling Standard (NBIMS), etc. The appropriate standard will be determined based on available technologies, information need, industry direction, and other factors.

2.3.2 Software and Hardware Requirements

A wide variety of software is available that is 3D, 4D and/or BIM capable. In some cases, project teams may already be using the required software within their own business practices. In other cases, project teams may need to hire a consultant or invest in the required software and hardware. If more than one software is required (e.g., use of a 3D modeling software and separate 4D modeling software), the interoperability of models, files, and software may not be an “off-the-shelf” process. GSA project teams should ensure that the information transfer between these softwares is feasible (see section 2.3.1).

If GSA associates would like to take a more “hands-on” approach, some softwares have viewers to review, but not edit, the model. GSA project teams shall consult OCA to determine applicable software and hardware requirements and the best way of procuring 3D-4D-BIM services, required software, and associated hardware.

2.4 Scope Definition

To select the proper 3D, 4D, and BIM technology or technologies, project teams should perform a comprehensive evaluation to determine which, if any, technology is best suited to the project. When analyzing feasibility, GSA project teams should take into account three major areas: 1) the experience of the project team, 2) the maturity of the technology, and 3) the resource availability (e.g., funding). Related to these core aspects, the project team also must consider how 3D-4D-BIM information will be exchanged between team members, how to procure 3D-4D-BIM services, and when during the project life-cycle 3D, 4D, and BIM technologies should be adopted. If any one of these factors is not considered, it could jeopardize the success of implementing 3D-4D-BIM on the project. After initial analysis, GSA project teams should confirm that they will be able to commit to these 3D-4D-BIM services. In some cases, GSA project teams may not be able to follow-through with the proposed 3D, 4D, and BIM application and should think about whether another 3D, 4D, and BIM application may align with the project better.

The following figure demonstrates the balancing act that is the selection process of a 3D, 4D, and BIM technology for a GSA project.

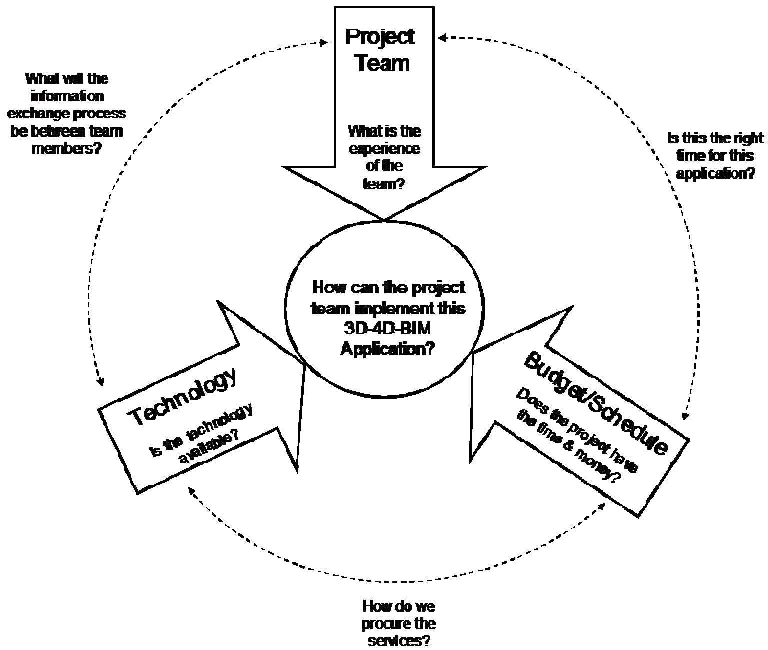


Figure 7: Feasibility of implementation.

The following case studies are examples of successful identification, exploration, and implementation planning for BIM technologies on Pilot Projects at the GSA.

GSA Pilot Project Case Study

Project Type: Federal Building Modernization
Project Phase: Concept Design and on-going
Technology: Autodesk ADT and Commonpoint 4D

What are the project opportunities?

The project, a Federal Building modernization, was in the concept design phase during scoping of 3D, 4D and/or BIM services. One area of the project was extremely dense in the amount of mechanical, electrical and plumbing (MEP) work in the space. The project team realized that the MEP coordination of the space would be difficult. The project also had to report weekly to the tenant regarding the layout and tenant space during and after the renovation. Since swing space was to be utilized within the building, it was important to phase the tenants properly within the building.

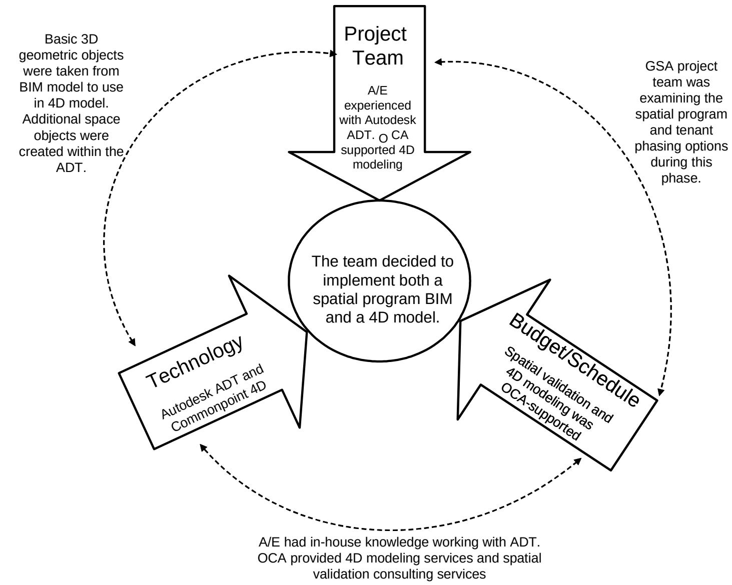
What 3D, 4D, BIM solutions should the project team consider?

The project team saw three opportunities to use 3D, 4D, and BIM:

- 3D modeling for MEP coordination
- 4D modeling for analysis of tenant phasing
- BIM modeling for spatial program validation

How/when should the team implement the selected 3D-4D-BIM application?

The project team considered the make up of the Project Team, available Technology, and Budget and Scale of the project when selecting which applications to implement and how/when:



Project Team

The A/E was experienced in Autodesk ADT and was already modeling the project in ADT. The regional GSA project managers were supportive of using 3D, 4D and/or BIM services.

Funding

The project team was able to acquire OCA support for both the BIM modeling for spatial program validation and 4D modeling. The modeling of the MEP coordination, however, was halted during this stage due to lack of funding and resources. This opportunity may be re-evaluated at a later stage of the project.

Timing

Since the project team was looking at various phasing alternatives during this time, it was the appropriate time to use the 4D model. In addition, since they were also updating their spatial program on a weekly basis, this was also the appropriate phase for using BIM for spatial program validation.

Technology and Information Exchange

The information used for the 4D model came both from the proposed schedule provided by the GSA project team, as well as the BIM model provided by the A/E. The 4D model only utilized the 3D geometric exterior wall objects. The software (Commonpoint 4D) was available from OCA.

The information used for the spatial program BIM came from the required spatial program from the GSA project team. This information was used to define and create intelligent space objects within the existing BIM model. The software (Autodesk ADT) was available and already being used by the A/E.

The technology for both 4D modeling and spatial program BIM modeling was accessible and available to the project team. Since the A/E already had the project in a BIM, it was relatively easy to extend their work to 4D and for space.

GSA Pilot Project Case Study

Project Type: New Courthouse Design and Construction
Project Phase: Concept Design
Technology: Riuska, Navisworks DOE-2

What are the project opportunities?

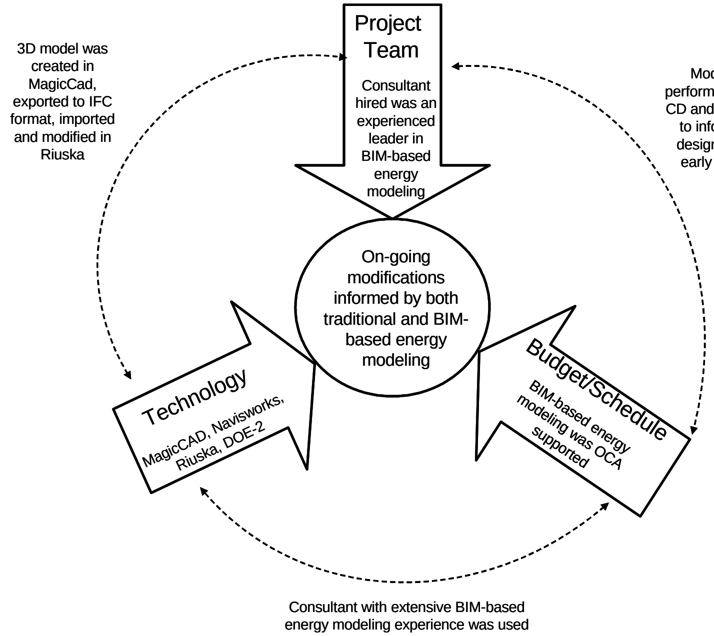
The goal of using BIM-related energy modeling techniques is to provide a prediction of building energy performance using a space-based modeling approach. The project is a New Courthouse Design and Construction. As a Federal Facility, it is required to meet the Facilities Standards for the Public Buildings Service (P-100). In particular, the project must demonstrate compliance with the prescribed energy conservation standards using computer simulations. Initial energy modeling was performed by a sub-consultant using traditional energy modeling practices (VisualDOE interface with a DOE-2 engine) to inform the design and to demonstrate compliance. Additional opportunities include using BIM technologies to input more detailed, space-based assumptions to verify performance estimates and provide additional information to inform design decisions.

What 3D, 4D, BIM solutions should the project team consider?

Traditional energy modeling relies on a zone-based input approach to create a thermal model of the building. A BIM-based approach was selected to create a flexible and comprehensive model based on the 3D geometry of the architectural design. The specific technology used was a Ruiska interface with a DOE-2 engine.

How/when should the team implement the selected 3D-4D-BIM application?

OCA hired a separate consultant to perform the BIM-related energy modeling. The consultants performed these services over an 8 week period during the end of Concept Design / beginning of Schematic Design phase of the project to incorporate feedback regarding energy performance as early as possible into the design process. The scope of work included the creation of a 3D BIM model from 2D drawings provided by the architect, the creation of a spatially-based (Ruiska) energy model, and iterative model simulations.



What is the process for implementing the selected technology?

Using existing, architect-developed 2D CAD drawings, the consultant created a 3D BIM model in Architectural Desktop. Data from this model was exported, and a new IFC compatible 3D model was created using Navisworks. This geometry and data was imported to Ruiska*, an interface to the DOE-2 energy simulation engine. Finally, detailed inputs and modifications regarding thermal zoning, thermal characteristics, and other mechanical load and schedule assumptions were added to the model using the Riuska interface. As is standard industry practice, model inputs and assumptions were based primarily on a variety of national and GSA standards as well as engineering judgment.

The result of the implementation of BIM energy modeling was the creation of a flexible, robust, and predictive energy model of the proposed design based on a space-by-space model. The project is still underway and a variety of model iterations are being developed to provide detailed predictions of the impact of various design decisions on building energy performance.

** Note: Several DOE-2 interface softwares exist and are available. The OCA is open to all available technologies.*

It is important to note, however, that many BIM technologies are not fully matured and cradle-to-grave BIM technologies do not fully exist in most areas of focus. As a result, although theoretically unbounded, current applications are limited by the viability, compatibility, and development of available technology. Nonetheless, valuable BIM technologies already do exist and are accessible to GSA projects.

Note: A spatial program BIM is required on all major GSA capital projects (new or renovation and alteration projects that need to undergo Final Concept approval by GSA Central Office) receiving design funding in FY2007 and beyond. For additional information, see the BIM Guide Series 02- Spatial Program Validation. If you have concerns regarding the implementation of this requirement, please contact OCA.

2.4.1 Contractual Language

To assist and encourage the implementation of BIM applications throughout the building delivery process, including construction and possibly facility operation, the OCA has developed generic Statement of Work and Solicitation of Services language for use by GSA project leaders. Additional BIM applications (e.g., structural/MEP modeling, simulation, coordination, and phasing studies) should be further defined with the assistance of OCA prior to issuance of any scope of work.

The GSA project team can take several approaches to a 3D, 4D or BIM application scope of work. GSA project teams should first evaluate the design team's BIM background/capability during negotiation stage, and then pick and choose from the following "tiers" of BIM adoption above and beyond Tier 1, e.g.:

Tier I: Minimum Requirements:

- spatial program BIM

Tier II: 3D Geometry and Applications

- additional 3D geometric models for visualization
- use of 3D geometric models for 4D analysis
- design and construction coordination

Tier III: Object Intelligence and BIM Applications

- use of smart objects and specific BIM applications

GSA associates shall contact OCA for assistance in defining scopes of work, sample contract language, and advice on project-specific customization.

2.4.2 Ownership and Rights in Data

Frequently, questions regarding model and information ownership arise around technologies that promote interoperability. For all GSA projects, PBS has ownership of and rights to all data and other deliverables developed and provided by the A/E in accordance with the applicable provisions of the A/E contract. These rules extend to Building Information Models and associated data developed for GSA projects.

The following is a partial list of "Rights In Data" clauses that may apply.

- FAR 52.227-1 AUTHORIZATION AND CONSENT (JUL 1995).
- FAR 52.227-2 NOTICE AND ASSISTANCE REGARDING PATENT AND COPYRIGHT INFRINGEMENT (AUG 1996).
- FAR 52.227-3 PATENT INDEMNITY (APR 1984).
- FAR 52.227-17 RIGHTS IN DATA - SPECIAL WORKS (JUN 1987).
- GSAR 552.227-70 GOVERNMENT RIGHTS (UNLIMITED)(MAY 1989).

A/Es shall also abide by PBS 3490.1- Document security for sensitive but unclassified paper and electronic building information.

2.4.3 Metrics

GSA project teams should also determine the metrics by which to measure the success of an implemented 3D, 4D, and BIM applications. Metrics typically compare the traditional way of work with the 3D-4D-BIM way of work. These metrics should stem from the business needs and evaluate how implementation of a given technology provides a value-added service. For example, if a project team was using a 3D geometric model for MEP coordination and clash detection, one metric would be to measure the number of clashes found in the design stage and to compare this with the typical number of clashes found in the design stage on other similar projects. Other metrics may include:

- Planning and design time
- Value-engineering magnitude
- Number of errors and omission
- Number of change-orders
- Construction duration
- Design costs
- Construction costs
- Operation costs
- Maintenance costs

2.5 Implementation and evaluation

Once project teams have decided to implement a 3D-4D-BIM application, GSA project teams still need to ensure sustaining success throughout the duration of 3D-4D-BIM use through interation between implementation and evaluation. Project stakeholders need to understand their own role and responsibility as well as the role and responsibilities of other team members. These responsibilities should be clearly defined in the scope of services and reviewed with all parties concerned. For GSA project managers, their involvement in 3D-4D-BIM technologies can range from integral involvement to remote management depending on individual interest, availability, and comfort level with the technology. As a result, the inclusion of 3D-4D-BIM on the project level can have a varying impact on the role of a project manager.

During implementation planning and implementation of 3D-4D-BIM services, project teams should reference the applicable BIM Guide Series for the specific best practices and guidelines for technology-specific information. A Series on spatial program validation is currently available (please refer to Series 02- *Spatial Program Validation: Section 1.2 The Spatial Program BIM Requirement*). Subsequent volumes in this series are intended to complement and enhance the information provided in Series 01- *GSA BIM Guide Overview* by documenting, evaluating, and encouraging *specific* applications of 3D, 4D, and BIM technologies (see section 1.4.1).

Finally, during implementation, GSA project teams should regularly evaluate the 3D-4D-BIM project based upon the metrics established during implementation planning (see section 2.4.2). In addition, lessons learned and applicable project data should be captured in order to develop best practices for future projects. This is the best way to ensure sustaining success for both current and future 3D-4D-BIM projects.

acknowledgements

The development of this provisional version of the PBS Building Information Modeling Guide has been a collaborative effort among a cadre of very knowledgeable consultants, working with a number of PBS associates in the Office of the Chief Architect and the different GSA regions. Significant contributors are listed below:

GSA Public Buildings Service

- Charles Matta, FAIA
  Director, Center for Federal Buildings and Modernizations
  Office of the Chief Architect
- Calvin Kam, Ph.D.
  National 3D-4D-BIM Program Manager, Center for Federal Buildings and Modernizations
  Office of the Chief Architect
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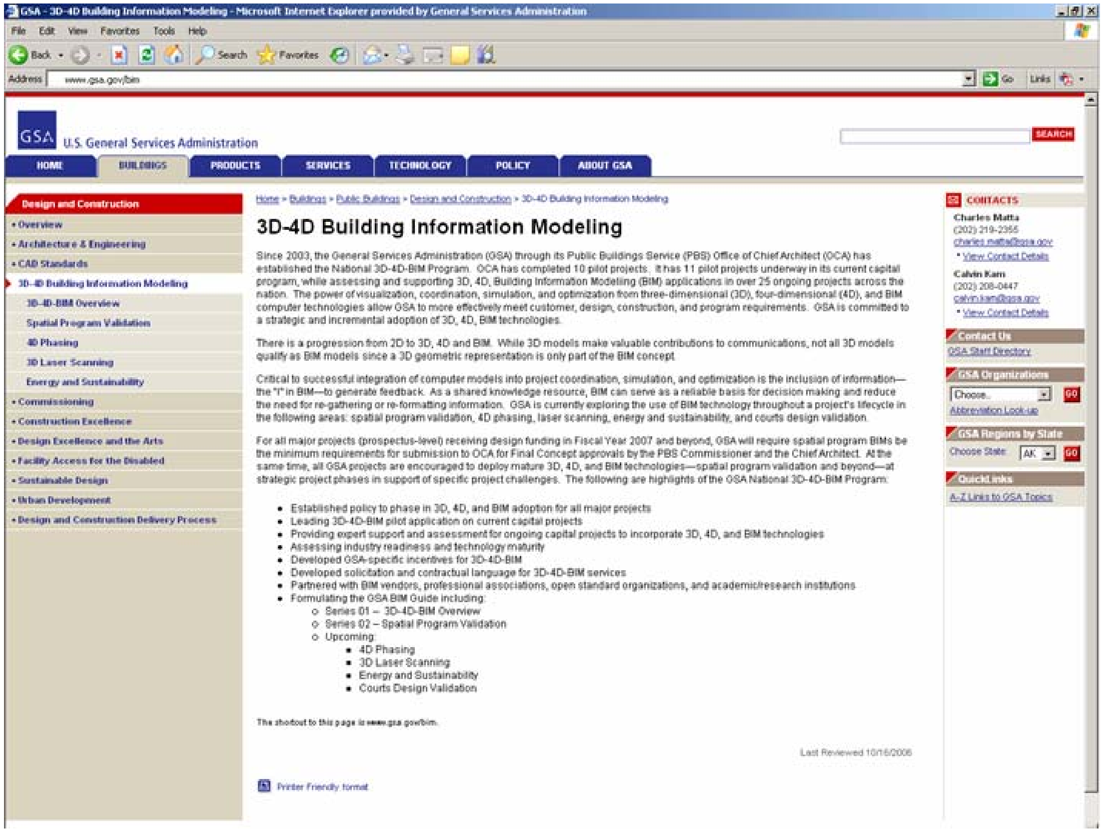
glossary of acronyms

Following are the acronyms and abbreviations used in this Guide Series with their full names:

2-D	Two-dimensional
3-D	Three-dimensional
A/E	Architect/Engineer
AEC	Architecture-Engineering-Construction
AGC	Associated General Contractors of America
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
BIM	Building Information Model or Building Information Modeling
BOMA	Building Owners and Managers Association
CAD	Computer Aided Drafting
CIFE	Center for Integrated Facility Engineering, Stanford University
FAR	Federal Acquisition Regulation
GSA	General Services Administration
GSAR	General Services Acquisition Regulation
GUID	Global Unique Identifier
HVAC	Heating, Ventilating and Air Conditioning
IAI	International Alliance for Interoperability
IFC	Industry Foundation Classes
IFC BIMs	Building Information Models compatible with IFC data standard
IFX	IFC-XML (see XML below)
ISO	International Standards Organization
NIBS	National Institute of Building Standards
NIST	National Institute of Standards and Technology
OCA	Office of the Chief Architect
PBS	Public Buildings Service
P-100	Facilities Standards for the Public Buildings Service
XML	Extensible Markup Language



For further information about this GSA BIM Guide Series: 01 – Overview or to submit comments or questions, please visit the National 3D-4D-BIM webpage at http://www.gsa.gov/bim or contact:

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