U.S. General Services Administration

May 21, 2015

This version of the GSA Building Information Modeling (BIM) Guide 02 - Spatial Program Validation is identified as version 2.0. The main goals of the update are as follows:

- Clarifying and updating GSA's requirements
- Incorporating lessons learned and best practices
- Making the content more accessible through the use of plain language

GSA invites the public to submit feedback on this document, as it will continue to serve as the basis for further development, validation, and professional editing. GSA will continue to issue updated versions to address and incorporate on-going feedback in an open and collaborative process.

Currently, the following BIM Guides are available for download at http://www.gsa.gov/bim:

- GSA BIM Guide 01 - 3D-4D-BIM Overview
- GSA BIM Guide 02 - Spatial Program Validation
- GSA BIM Guide 03 - 3D Laser Scanning
- GSA BIM Guide 04 - 4D Phasing
- GSA BIM Guide 05 - Energy Performance
- GSA BIM Guide 08 - Facility Management

Project teams are encouraged to review all available BIM Guides and apply them as appropriate when creating their BIM Execution Plans. For further information about GSA's National 3D-4D-BIM Program or to submit comments or questions, please visit http://www.gsa.gov/bim.

The National 3D-4D BIM Program
U.S. General Services Administration
1800 F Street NW
Washington, DC 20405

BIM Guide 02
Spatial Program Validation

GSA BIM Guide 02

www.gsa.gov/bim

GSA Building Information Modeling Guide Series

GSA BIM Guide 02 – Spatial Program Validation

Version 2.0 – May 2015

United States General Services Administration (GSA)

Table of Contents

Foreword

In 2003, U.S. General Services Administration (GSA) Public Buildings Service (PBS) Office of the Chief Architect (OCA) established the National 3D-4D-BIM Program. Over a decade later, the calculation of space (e.g., rentable area, usable area) remains one of the most essential business metrics for GSA. GSA has required contractors to submit at least spatial program building information models (BIMs) before final concept presentations and to provide spatial program validation (SPV) at each subsequent design phase submission. This applies to all new and major modernization projects that received funding in Fiscal Year (FY) 2007 and beyond.

The purpose of validating a spatial program using Building Information Modeling (BIM) is to efficiently and consistently assess a building's Program of Requirements (PORs), throughout each of the design phases and throughout construction. The spatial validation process within BIM ensures that GSA is meeting the programming and gross square footage mandates set by Congress.

This guide aims to help GSA contractors create and submit high-quality models to GSA for spatial analysis and SPV. GSA has been working with a number of BIM-authoring software vendors to ensure that architects and engineers (A/Es) are able to comply with the new GSA spatial requirements using a broad range of available software, via the Industry Foundation Classes (IFC) open standard. GSA continues to validate these requirements on projects with A/E teams across the nation.

GSA expects that, in referencing this guide, both GSA and A/Es will be able to gain efficiencies and accuracy in measuring space. By automating spatial validation, GSA can validate space during earlier design stages with more confidence, while allowing A/Es to spend more time on design tasks rather than spatial calculations. GSA welcomes any constructive comments and recommendations to the BIM Guide and spatial validation process. For more information, visit the National 3D-4D-BIM Program webpage at http://www.gsa.gov/bim.

Section 1
Introduction

GSA BIM Guide 02

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1 Introduction

1.1 Purpose of This Guide

Spatial data is a primary component of all building projects and drives project design, cost, and schedule. By requiring a spatial program building information model (BIM), the U.S. General Services Administration (GSA) aims to leverage the use of building information modeling (BIM) and the interoperability among BIM software to optimize and automate the checking of model integrity and design performance relative to the Public Buildings Service (PBS) National Business Space Assignment Policy (NBSAP) and the space program given to the architects and engineers (A/Es).

BIM Guide 02 - Spatial Program Validation is cited in the Facilities Standards for the Public Buildings Service (P100) and all PBS design and construction contracts for new construction and major modernization projects. It is meant to assist design and construction teams in producing and updating BIMs as part of their submissions, which are outlined in Appendix A, Submission Requirements, of the latest version of the P100.

Note: This guide is considered a living document that is constantly changing and being updated as the technology matures. While GSA has tried to highlight the major points of spatial program validation (SPV), GSA cannot take into account all the special cases and changing technology. Therefore, if you have any questions or comments regarding the content of this guide, please contact GSA's National 3D-4D-BIM Program for the most up-to-date information.

1.2 Importance of Accurate Space Inventories to GSA

1.2.1 The Purpose of Spatial Program Validation

GSA PBS manages over 370 million square feet of workspace for the civilian Federal Government.[i] GSA must consistently and accurately measure, classify, and assign its space in order to fulfill its congressional mandate of charging rent to its occupant agencies.

For that reason, GSA requires A/Es to validate their own spatial program against GSA's program of requirements (POR) before the final concept design presentation of any construction or renovation project and at each subsequent design phase submission. In the past, A/Es had to create two-dimensional (2D) polygons in the appropriate locations based on the NBSAP. However, space area calculations from such a manual process were usually neither efficient nor consistent with space area calculations from GSA.

GSA now requires a spatial program BIM through all phases of a project. By validating a spatial program using BIM, GSA aims to efficiently and consistently assess and reconcile a project's POR with space area calculations used for Draft Occupancy Agreements (OAs) throughout the design and construction process. This can enable GSA to easily and consistently track and reconcile different requirements and to calculate the appropriate square footage at any point in the process - a capability needed

to calculate OAs and Tenant Rent Bills and to help ensure GSA is meeting the programming and gross square footage mandates set by Congress.

Figure 1 illustrates how a project team could quickly and automatically adjust and assess a design and its usable area during Concept Design. The designs differ only in the upper left hand space, where one is a stair space, and the other is an office. Traditionally, the spatial data management (SDM) team would have to manually update the usable area polyline in the drawings. A spatial program BIM can automatically update the usable areas when a design change occurs.

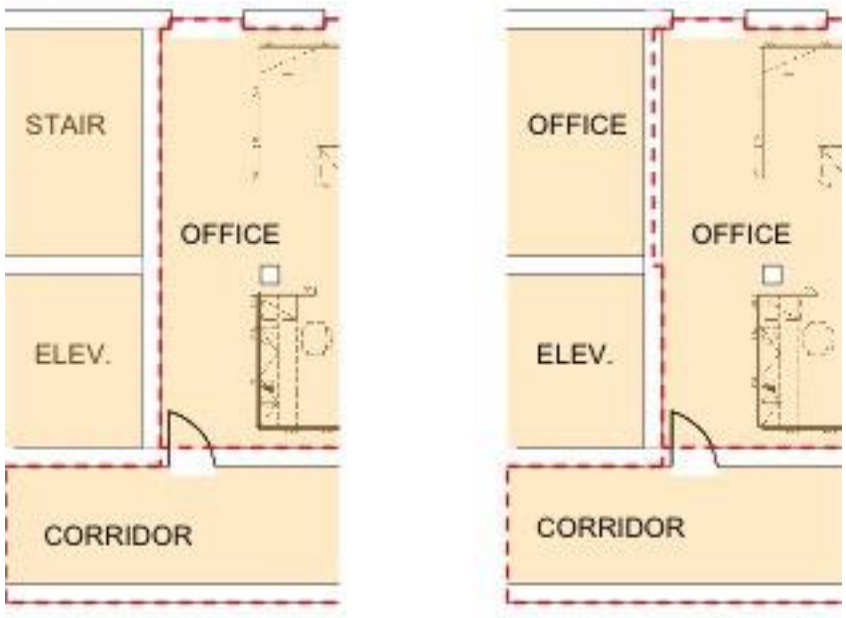

Figure 1. A spatial program BIM can automatically update the usable areas when a design change occurs.

1.2.2 Standards for Space Area Calculation

It is important to set up BIMs correctly, which means correctly applying space area calculation standards and GSA's space definitions as well as assigning space names that correspond to GSA's naming conventions and tenant agencies' PORs right from the start. Just as technology has evolved over time, the standards used for space area calculation have also evolved. There are two common standards within the industry for measuring area in buildings - the ASTM standard and the ANSI/BOMA standards, and there has been confusion over their uses.

- ASTM E1557 **(Uniformat)** - The P100 identifies it as the formatting standard used for **cost estimating** during the design and construction process. **Note**: Instead of using net square footage per ASTM, GSA uses usable and gross square footage for calculating the actual costs.

- **ANSI/BOMA Z65.1 and Z65.3** - Both the P100 and the NBSAP identify these two standards as the standard methods of measurement for both the **POR** and the **Tenant Rent Bills**. In fact, the NBSAP is based on these two ANSI/BOMA standards and in many areas are identical. The NBSAP also captures spaces that are unique to PBS, provides examples, and also includes some implementation guidance. In essence, PBS uses usable and gross square footage for measuring space in its buildings.

In other words, GSA uses net, gross, and usable square footage for different purposes. This guide is focused on using BIM for SDM, and it is therefore focused on usable square footage. Information on working with gross and net square footage is for reference only and does not supersede guidance such as the P100.

For space area calculations, the basic rule of thumb for any GSA project is to adhere to the NBSAP and to consult the GSA project team, including the SDM team, if there are any questions.

1.3 How to Use This Guide

This guide is divided into four major sections:

- Section 1: Introduction - This section explains the importance and overall objective of GSA's spatial program BIM guidelines. A/Es must clearly understand the different standards for space area calculation in buildings and apply them to the BIMs.
    - Section 1.4 defines key terminologies used throughout this guide.
    - Section 1.5 outlines key responsibilities and requirements by team member role and by project phase for GSA associates. Project team members can use these as quick reference guides.
    - Section 1.6 outlines the SDM-related requirements and deliverables for the design and construction teams.
    - Section 1.7 contains a list of GSA reference documents and links for quick access.
- Section 2: Measuring and Classifying GSA Spaces - This section explains the importance of clear and consistent spatial data, how to assign spatial data correctly, and how space is measured and calculated from different perspectives.
- Section 3: Using BIM to Create Space Inventories - This section describes the building elements required in a spatial program BIM, and the high-level modeling requirements for creating the BIM and for the Industry Foundation Classes (IFC) BIM submission.
    - Section 3.2 describes the required Building Elements.
    - Section 3.3 describes the required space, rooms, and areas.
    - Section 3.4 highlights lessons learned and best practices for modeling and creating IFC BIMs.
- Section 4: Checking BIM Models - This section describes the BIM-analysis rules used to check A/E submissions.

1.4 Definitions

For clarity and consistency, this guide uses the following definitions:

- **GSA project team** - The collection of regional and national GSA team members as determined by project needs.
- **Industry Foundation Classes (IFC) specification**- The IFC specification is "… a neutral data format to describe, exchange and share information typically used within the building and facility management industry sector."[ii] For more information, visit buildingsmart-tech.org.
- **Space area calculation -** Computer-based calculation of space area based on design or existing conditions documentation. The result can be usable, gross, or net square footage depending on the need and parameters.
- **Space measurement** – Capturing physical dimensions of spaces within a building and identifying the location of building elements such as walls and windows. Typically associated with Initial Measurement and Validation (IMV), SDM Audits, and SDM Rewalks.
- **Spatial analysis** - Review and analysis of the technical aspects and spatial requirements of the model or drawings to ensure correct development of the model or drawings (objects, areas, placement of lines, rule sets, etc.)
- **Spatial data** - Spatial data, as used by GSA, is a general term that captures the location, size, and geometry of the overall building itself and all the individual spaces within that same building. GSA also includes other attributes such as classification and assignment information with the overall definition.
- **Spatial data management** (SDM) - GSA's national effort to create, update and maintain its spatial data and associated computer-aided design (CAD) floor plans and BIMs, to accurately reflect the national federally owned inventory.
- **Spatial program reconciliation** - The process of reconciling the information derived through SPV to ensure that A/E's and GSA's information is in agreement and accurate based on the NBSAP, BIM, and CAD standards.
- **Spatial program validation** (SPV) - The comparison of a design to the owner's POR in order to verify that designed space meets the stated criteria, including usable and gross square feet, appropriate grouping, and rollup of numbers. The A/E identifies changes and deviations in a design as compared to the approved program and generates reports, drawings, and tables showing changes and deviations. SPV is performed by the A/E and verified by GSA.
- **Spatial validation** - The process of developing and approving the assignment drawings, classification of space, and associated occupancy agreements involving all relevant stakeholders, including SDM, Realty Specialists, Asset Managers, and possibly others.

1.5 Responsibilities of GSA Associates

While a project team will include many subject matter experts (SMEs), this section focuses mostly on those involved with BIM and spatial data. This section outlines the actions different GSA associates should take to help make a project's BIMs easily usable for SDM. When a BIM is developed properly, automated reporting can be utilized to streamline reporting capabilities for multiple business lines.

It is critical to consider SDM through every phase of a project. Before awarding any contract, the project team must ensure that any available BIM templates are in line with the project's global project management (gPM) plan and current standards. At the project kickoff meeting, the appropriate GSA team member(s) should emphasize the need for the A/E team to understand the different standards for space area calculation, their use, and the need to incorporate them into the BIM, such that space area calculation will be accurate after construction. We recommend the project team review at least section 1 of this guide in its entirety during the kickoff meeting.

Table 1 highlights actions and responsibilities for the project team, organized by project phases and team member.

Table 1. Actions and responsibilities for the project team

Project Phase	Team Member	Actions and Responsibilities
Pre-award	Project Manager	• Given the importance of correctly setting up a BIM from the beginning, it is critical to include in the project team a representative from the SDM team. • Ensure the project team includes a BIM SME. • Ensure any available BIM templates are in line with the project's gPM plan and current standards.
	SDM Team	• Discuss with the GSA project team the importance of the current space area calculation standards.
	Contracting Officers (COs) and Contracting Officer's Representatives (CORs)	• Ensure any available BIM template is a part of the contract. • Ensure that BIM Guide 02 is referenced in the contract. • Ensure contracts specify that BIM submissions must include all current modifications to the design and construction model and reflect reconciled spatial data. • Ensure contracts require gross, usable, and net square footage calculations. • Ensure contracts require the A/E to use the naming conventions from the tenant agency's POR in addition to GSA's space naming conventions, where applicable. • Ensure contracts require that the A/E correctly map tenant agency's

Project Phase	Team Member	Actions and Responsibilities
		naming convention from a tenant agency-provided POR to GSA-approved space naming conventions as needed.
Kickoff	SDM Team	• Discuss with the overall project team the importance of the current space area calculation standards.
Post-award of A/E Contract / Execution of Design	BIM SMEs	• Work with the SDM team to review each BIM submission throughout the design and construction process for integrity and adherence to the space area calculation standards.
	SDM Team	• Work with the BIM SME to review submissions. • Extract the space area calculations for OA development, SPV (net, usable, and gross square footage), and project authorization.
	Project Manager	• Ensure that SPV (net, usable, and gross square footage) and project authorization occurs.
Final Construction Documents Submission	BIM SMEs	• Review and recommend acceptance of the final Construction Documents BIM submission for model integrity and conformance to modeling standards.
	SDM Team	• Review and recommend acceptance of the final Construction Documents BIM submission for adherence to the space area calculation standards.
Substantial Completion of Construction	Building Manager	• Confirm room and door numbering scheme.
	Project Manager	• Review and accept the final as-built BIM, including assuring that A/E has updated square footage, room and door numbering scheme. • Initiate spatial validation.
	SDM Team	• Conduct IMV. • Review and recommend acceptance of the final Record BIM submission for adherence to the space area calculation standards.
	BIM SMEs	• Maintain and update BIM models in coordination with regional SDM team, facilities management team, and project teams.

1.6 Requirements and Deliverables

This section outlines the SDM-related requirements and deliverables for the design and construction teams, which include all parties involved during the design and construction phases of a project, respectively. These requirements are in addition to all current deliverable requirements set forth in Appendix A of the latest version of the P100. Information on working with gross and net square footage is for reference only and does not supersede guidance such as the P100. A/Es are also encouraged to provide additional information above the minimum requirements.

1) The BIM deliverables must include files in the following formats:
   a) BIM file(s) in the native format of the BIM-authoring application(s).
   b) A single BIM file in the latest IFC format.
      i) The Concept Design submission must comply with the "Design to Spatial Program Validation" Model View Definition (SPV MVD) as defined by the National BIM Standard-United States™ (NBIMS-US™).
      ii) All design phase deliverables must continue to include all required data as defined in the MVD. GSA will formalize submission requirements for design stages beyond Concept Design in an updated SPV MVD. Until the updated MVD is published, the deliverables must supplement and develop the data as determined by the GSA national and regional BIM and SDM SMEs, based on the P100, the NBSAP, and project-specific requirements.
      iii) The IFC format for each deliverable must be approved by the GSA project team.
2) At a minimum, A/Es are required to have the following objects in a valid three-dimensional (3D) geometry representation. See section 3 for more details.
   a) Space objects - Note that when spaces are over 9 usable square feet (USF), they must also have the attributes listed in section 2.3
   b) Wall objects, which must have:
      i) Door objects
      ii) Window objects
   c) Slab objects
   d) Beam objects
   e) Column objects
3) For every floor that is included in the GSA Gross Area (see NBSAP for definition), A/Es must create a full building floor space with a space name in accordance with the latest version of the NBSAP and a floor number in accordance with the GSA PBS Region 3 CAD Deliverables Policy. A/Es should consult the GSA project team to determine if additional requirements are necessary.
4) There may be additional zone requirements, depending upon the type of project (e.g., courthouses, historic buildings). A/Es must consult with the GSA project team to determine if additional requirements are necessary.
5) A/Es must also follow the PBS CAD Standards and the P100 requirements for creating 2D drawings.
6) A/Es should pre-check their submissions for compliance with standards. A/Es should discuss with the GSA project team to determine the methodology that will be used for compliance checking; it may be possible for A/Es to gain access to compliance checking tools that GSA uses. A/Es will bear any costs associated with gaining access to these tools. A/Es may also coordinate with the GSA project team, and where available, submit preliminary deliverables for pre-submission checking and feedback to ensure conformance of final deliverables. Consult the GSA Project Manager for more information.

7) After each spatial program reconciliation by the GSA project team, A/Es must ensure that the subsequent presentation or submittal reflects the reconciled spatial data.

1.6.1 Requirements of Design Teams

In addition to the requirements above, this section outlines the actions the design teams should take to help make a project's BIM(s) easily usable for SDM. Design teams should confer with GSA's regional SDM team as needed.

- Comply with GSA's space area calculation standards and their uses.
- Comply with the required deliverables for SPV.
- Comply with the requirements of the SPV MVD as defined by NBIMS.
    - The SPV MVD defines the minimum spatial data requirements for the Concept Design submission.
    - All design phase deliverables must continue to include all required data as defined in the MVD. GSA will formalize submission requirements for design stages beyond Concept Design in an updated SPV MVD. Until the updated MVD is published, the deliverables must supplement and develop the data as determined by the GSA national and regional BIM and SDM SMEs, based on requirements in the P100, the NBSAP, and project-specific requirements.
- If applicable, obtain and use the GSA BIM Template(s). Consult with the regional BIM champion to obtain the available templates or to discuss the choice of authoring software. As of 2014, a GSA BIM template is available only for Revit.
- Include sufficient detail in the design BIM to meet all SDM and other 2D deliverable requirements as specified in the P100. The BIM should be used as the source for details and 2D drawings wherever possible.
- For all spatial elements within the design and construction model, provide spatial data in accordance with the NBSAP.
- Identify changes and deviations in a design as compared to the approved program and generate reports, drawings, and tables showing changes and deviations.
- For any updates made after final design submission, continue to conform to GSA's space area calculation standards and spatial program requirements.
- Submit the project spatial data summary to GSA's regional SDM team for each design deliverable as specified in the A/E scope of work and the P100.

1.6.2 Requirements of Construction Teams

In addition to the requirements above, this section outlines the actions the construction teams should take to help make a project's BIM(s) easily usable for SDM.

- If changes to the design are made during construction, notify the GSA project team for the purpose of capturing such changes in the as-built BIM. The General Contractor will complete any adjustments to the as-built BIM in coordination with the A/E and in accordance with the construction contract.
- Provide spatial data within the as-built BIM in accordance with this guide.

- At project turnover, the SDM team ensures that the IMV process is completed. The GSA project team in coordination with the General Contractor and the A/E ensures the record model is updated to reflect the final SDM measurement data.

1.7 GSA Reference Documents and Links

- National Business Space Assignment Policy (NBSAP)
- Facilities Standards for the Public Buildings Service (P100)
- PBS CAD Standards
- PBS' Pricing Desk Guide
- PBS Region 3 CAD Deliverables Policy

Section 2

Measuring and Classifying GSA Spaces

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2 Measuring and Classifying GSA Spaces

2.1 Overview

Spaces are one of the most important object types in conceptual building design, and modeling spaces accurately is one of the most important tasks in creating building information models (BIMs). As discussed in section 1.2.1, GSA must consistently and accurately measure, classify, and assign its space in order to ensure GSA is meeting the tenant agency's program of requirements (POR), meeting gross square footage mandates set by Congress, and calculating Tenant Rent Bills with accurate square footage data.

A building project and its plans can go through many changes between project conception - when a BIM is started - and project completion - when GSA verifies the final spatial program validation (SPV). When a BIM is developed properly, SPV can help track and reconcile different requirements through each of the design phases and throughout construction.

Architects and Engineers (A/Es) can set up a BIM properly by correctly applying GSA's space definitions as well as assigning space names that correspond to GSA's naming conventions and GSA's tenant agency's POR.

The PBS National Business Space Assignment Policy (NBSAP) is the authoritative policy for space assignment and measurement for GSA. As discussed in Section 1.2.2, the NBSAP builds upon the ANSI/BOMA rules, with some minor variations. Each ANSI/BOMA category is mapped to a specific GSA Space Type and GSA Space Category. Illustrations and descriptions of these types and categories can be found in the NBSAP and ANSI/BOMA Z65.1 and Z65.3 documents.

Properly developed BIMs for GSA projects include sets of spatial data that can be easily confused. Section 2.2 provides brief explanations for the different spatial data, how they relate to one another, and how to assign them correctly. Section 2.3 lists the information that must be included for every space in a BIM. Section 2.4 summarizes how space is measured and calculated differently from different perspectives.

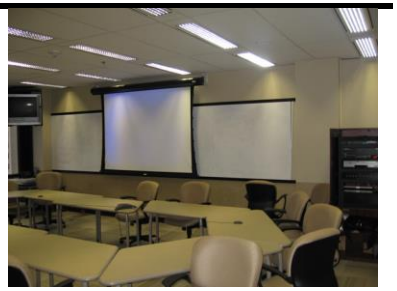
2.2 Spatial Data

Different stakeholders use BIMs for different purposes. The relevant guidelines for the different purposes create situations where, for example, there are usually two sets of space names for a single space in a GSA project - GSA's space assignment room names and GSA's tenant agency POR space names.

The often minor variations among the sets of space names can be easily interpreted and adjusted manually, but it is more efficient if the BIM is set up such that each space is correctly linked to all of its appropriate space names, and the spatial data can be easily updated and extracted from BIMs throughout design, construction, and the useful life of the building.

It is also important to distinguish the independent terms "Room Name", "Space Type", and "Space Category", which GSA applies to every space assignment and uses for spatial validation. The table below summarizes these different space properties and provides examples of how they are used in combination. See the NBSAP for full details.

Table 2. Illustration of how the terms "Room Name", "Space Types", and "Space Categories" can be used in combination.

Photographic Example	Illustrates how two rooms with the same "Room Name" can serve different purposes.		
Room Name	Indicates how the room is used (NBSAP p.45) and reflects GSA's tenant agency's POR.	CONFERENCE ROOM	CONFERENCE ROOM
Space Type	• Identifies how a space is built out. • The PBS inventory system recognizes the three-letter Space Type acronyms. • "Rent billing is based on Space Type, not Room Names." (NBSAP p.5)	TTO	CFT
Space Category	• Identifies a room's status of occupancy. • The PBS inventory system recognizes the two-digit Space Category numbers.	01 or 03	01 or 03
POR Space Name	How GSA's tenant agency's POR identifies the space.	Attorney / Witness Room	Computer Training Room

Note: Data matrices for the application of Space Categories and Space Types are in Appendix A of the NBSAP.

2.3 SDM Labels

For every space in a BIM, A/Es must include sufficient information for generating labels for the various uses indicated in the P100 and in the complete BIM Guide Series. This guide does not supersede other requirements; please consult the GSA project team for more information.

For the spatial validation label, the following minimal information is required:

- Agency Name
- Agency Bureau Code
- Agency Space Assignment (ASA)
- Building Number
- Floor
- Space ID
- Space Type
- Space Category
- Usable Square Footage
- Room Name
- Committed Pending Group
- ANSI-BOMA Code
- Comments
- Lease Number
- Block Number
- Activity Name
- Community ID
- Free Space Indicator

2.4 Measuring and Calculating Spaces

Space measurement and calculation goes through various stages during a project lifecycle. Figure 2 shows some of the key players and purposes of space measurement at different stages of the project. During the Programming phase, the agency, with varying levels of GSA and A/E support, calculates usable square footage using a generic formula. The calculation takes into consideration the net square footage, the functional requirements, and the circulation factors based on agency standards. GSA uses this information to determine the usable square footage and the desired Gross Building Area of the project. As the design and construction BIM develops, GSA utilizes the design information captured in the BIM to perform SPV at each phase of the project lifecycle. At project turnover, GSA uses the spatial information in the BIM to generate Occupancy Agreements (OAs) and Rent Bills. Since the usable square footage calculated during the Programming phase is for planning purposes, the usable square footage from polylined construction drawings and the measured usable square footage may be different.

Figure 2. Space calculation considerations at different phases of the project lifecycle

Section 3

Using BIM to Create Space Inventories

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3 Using BIM to Create Space Inventories

3.1 Overview

A properly structured building information model (BIM) follows a typical containment hierarchy - a project contains a site with a building that has levels or floors; the floors contain spaces and building objects. (GSA does not require the use of a site, so a project may directly contain a building.) Additionally, certain building objects - such as walls, columns, and doors - are expected to meet minimum dimensions.

This section describes the physical and space objects required in a properly structured spatial program BIM and is intended primarily for architects and engineers (A/Es). It describes properties of each object as well as guidelines for creating them. This section is not intended to prescribe a method to create objects, but to highlight best practices for creating a spatial program BIM that can be exported into a functioning Industry Foundation Classes (IFC) BIM.

The following points are the most important modeling requirements for a spatial program BIM. If the following are not defined properly, automatic calculations of other types of areas, including gross, usable, and rentable, will be incorrect.

- A/Es should use the appropriate BIM tool to create objects. For example, "Wall" objects should be created using a "Wall" tool. If an object is not directly supported with an appropriate BIM tool, A/Es should consult with their BIM-authoring vendor to determine the best way to model those objects.
- A/Es should ensure that all names (e.g., space name, occupant organization name) match established GSA naming conventions.
- A/Es should ensure that the IFC mapping in their native BIM authoring tool is correctly configured in order to produce an IFC model that complies with the "Design to Spatial Program Validation" Model View Definition (SPV MVD), as defined by the National BIM Standard-United States™ (NBIMS-US™). Consult the GSA project team for more information.

Section 3.2 and 3.3 discuss modeling objects and spaces in detail, and section 3.4 highlights lessons learned and best practices for modeling and for creating IFC BIMs.

3.2 Objects and Properties Required in a BIM

BIM authoring software can automatically manage the containment hierarchy of model objects, but it is the responsibility of the A/Es to use the appropriate model objects to represent each of these elements. For example, a wall object should be used to create a wall, a slab object to create a slab. Use of model objects for purposes other than what was intended, such as modeling a roof using the slab object, can lead to a breakdown in the model's structure.

Physical elements such as walls and columns (as opposed to spaces) in a building model are objects defined in the IFC BIM schema as Building Elements. In order for these objects to be included as the intended object types when exporting to an IFC BIM, they must be either

(a) Created using authoring tools for the intended object type, or
(b) Created from an IFC-compatible library provided by the vendor or others for the BIM-authoring application, or
(c) Created as a generic object and assigned a Building Element type.

Use option (c) when (a) and (b) are not available, or when object-specific tools are limited in some way (e.g., some applications cannot create sloped beams). At a minimum, A/Es are required to have BIM Building Elements for interior walls, exterior walls, doors, windows, slabs, beams, columns, and spaces. The following sections provide information for each of these required Building Elements.

3.2.1 Walls

Wall elements are used to define the physical boundaries of a space or room. They are also used in GSA's spatial analysis to help define space boundaries. A/Es must differentiate between interior and exterior walls because GSA treats them differently in its spatial calculations.

In conventional building designs, the vast majority of walls are straight and of uniform height. These are easily modeled using the Wall tool found in most BIM-authoring applications. If the BIM-authoring application supports the use of multiple or generic tools for component creation, the user must ensure that components are assigned the correct Building Element types so that they are exported as the correct types to an IFC BIM.

In IFC BIMs, walls must have relationships to their adjoining (connected) walls and the spaces they bound. The 'connected' relationship between walls is typically created automatically by the BIM-authoring application when the walls' base lines are connected. Users should consult with their BIM-authoring application documentation for instructions on how to ensure that these relationships will be included in the export to an IFC BIM.

A. Doors and Windows

Door and window objects should be created using the Door and Window tools, respectively, in the BIM-authoring application. In most cases, Door tools can also model passageways or other access openings that do not necessarily have doors. Doors and windows must be contained by walls and stay within the wall geometry.

Creating a door or window by first cutting an opening in the wall and inserting a door or window may cause problems because the wall object is not linked to the door or window object. BIM-authoring applications must keep track of two different relationships (i.e., opening-wall relationship and door/window-opening relationship). If doors and windows are created using the Door and Window tools, there is only one relationship (i.e., wall-door or wall-window relationship).

Door and window accessories should be associated with doors and windows via properties (i.e., the hardware group for the door or window).

B. Multi-story Walls

To properly bound a space, the walls encompassing a space must have the same base reference, such as a slab or level. Where possible, walls should be modeled separately for each building floor. Spanning or multi-story walls may not properly bound upper story spaces when exported to an IFC BIM, resulting in the inaccurate reporting of areas. Some BIM-authoring applications or 3rd party IFC Exporters may have a setting to split walls by story when exporting to an IFC BIM. This option, if available, should be selected if the model contains spanning or multi-story walls.

C. Curtain Walls, Storefronts, and Large Window Assemblies

Many building designs, such as a storefront, include configurations in which an entire wall or face is filled with windows and possibly also doors (see Figure 3). In these cases, GSA requires that the windows and doors be modeled as 'contained' in a wall object. Make sure that doors and windows don't extend outside the wall area. It is easy to accidentally create such a situation in a building with corner windows or in daylight staircases, where windows can span multiple floors. Pay special attention to setting the relative height for the window.

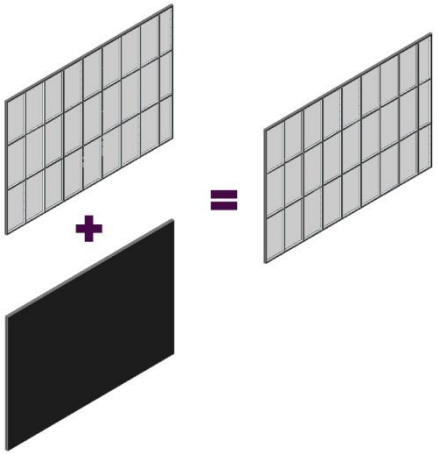


Figure 3. Wall component that is fully covered with windows

In building designs where windows span multiple floors (see Figure 4), windows must be modeled as openings in the walls for each building floor. If the modeler attempts to model the window as a multi-story object, it will not be properly related to a wall and will be an "orphaned" or "floating" object. Such windows will not have the correct bounding relationship to the adjacent spaces, which can cause errors and unexpected analysis results.

As an alternative, multi-story windows can be modeled as multi-story objects if the walls are also modeled as multi-story objects. However, this is usually not recommended.

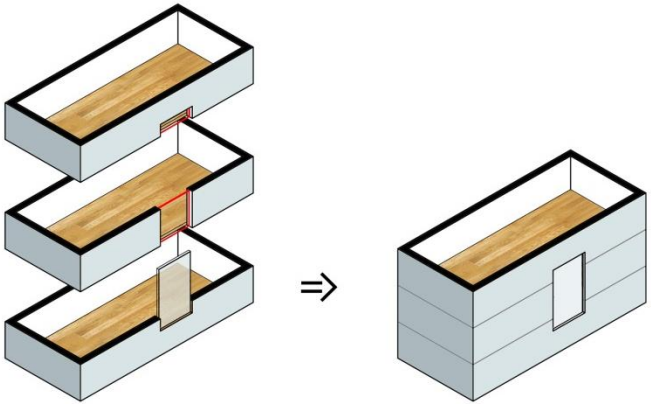


Figure 4. Window that spans multiple floors

D. Protruding Walls

Unless specifically intended, A/Es should make sure that walls are appropriately joined and do not unnecessarily protrude.

3.2.2 Slabs, Beams, and Columns

Slabs, beams, and columns should be created using their respective tools in the BIM authoring software. If a specific tool is not available or is insufficient, generic model objects can be used. However, these generic objects must be properly mapped to the appropriate IFC object type so that the model object is exported properly to the IFC file format.

A. Slabs

Slabs must be properly joined to walls and bound spaces to ensure model integrity. For model consistency, it is essential that the floors are modeled as slab objects and that the joints between walls and slabs are modeled as accurately as possible, with the information known at that time. In some BIM-authoring applications, if the joints between walls and slabs are missing, the space may not be properly bounded. For example, modeling a wall above a slab but failing to connect the wall to the slab could result in the BIM not detecting the wall as a bounding element for the space.

B. Columns

Columns can be modeled in three ways:

- As a single piece structural column (e.g., a steel column)
- As a single form-based structural column (e.g., concrete column)
- As an enclosure (e.g., a column enclosed with drywall)

For more information on how these different columns are analyzed according to the BIM-analysis rules, please see section 4 of this guide.

3.3 Spaces, Rooms, and Areas

In addition to the building elements discussed above, GSA requires the use of space objects in a spatial program BIM. This section defines space as well as several related concepts both from a GSA perspective and a model authoring software perspective.

3.3.1 Definitions

The following definitions are provided here for easy reference. As mentioned in section 2.1, however, the NBSAP is the authoritative policy for space assignment and measurement for GSA. Refer to the NBSAP for any questions or inconsistencies.

3.3.1.1 Space

GSA defines a space as a theoretical area that may or may not be bound by physical elements, such as walls. Any area 9 square feet or greater when measured to the inside of a surface must be designated as a space. Areas under 9 square feet should be included in the adjacent space.

In BIM authoring applications, a space represents a region for which a volume is calculated for use in building performance calculations.

3.3.1.2 Room

GSA defines a room as an area that represents a physical construction.

BIM authoring applications define a room as a region that has bounding elements such as walls, floors, and ceilings.

3.3.1.3 Area

GSA uses the definitions and equations in Table 3 for different types of areas. See the NBSAP for additional information. This guide is focused on using BIM for spatial data management, and it is therefore focused on usable square footage. Information on working with gross and net square footage is for reference only and does not supersede guidance such as the P100.

Table 3. Definitions and Calculations for Different Area Types

Term	Definition	Calculation
Gross Area	The total constructed area of a building measured to the outside of the exterior enclosing walls. This may include partially enclosed areas, but it does not include Voids.	Rentable Area + Nonassignable space - Open to Below (Void)
Gross Measured Area	The Gross Area minus the Construction Area.	Gross Area - Construction
Rentable Area	The total amount of space an occupant can occupy or use within a building and the respective share of Common Area related to the Usable area.	Common area + Usable area or Usable area x Building R/U Factor
Usable Area	The space that is assignable to a specific Occupant and Joint Use areas that can be used by all occupants.	Assignable space + Joint Use space
Building R/U Factor	A building's Rentable to Usable ratio.	Rentable Area / Usable Area
Nonassignable Space	Measured area that is not considered usable, categorized as Unmarketable within a building, and is included in the Gross Area. This includes the following PBS Space Types: Circulation Vertical (CRV); Structured Parking (STP); Unsuitable for Occupancy (UFO); and Construction (CON).	Gross Area - Rentable Area + Open to Below (Void)

3.3.2 Boundaries

3.3.2.1 Room Boundaries

Room boundaries are used by BIM applications to calculate the area, perimeter, and volume of a room.

3.3.2.2 Space Boundaries

Space boundaries are a sequence of straight and or curved line segments that create a closed area. They are used to define a GSA space for area measurement as well as providing a graphical display of where one space begins and another ends. See Table 5 in Section 4.3.2 for rules on locating space boundaries.

3.3.2.3 Space Boundaries - Unique Cases

A. Multi-Story Spaces

According to the NBSAP, physical spaces that are higher than one story are measured differently based upon their usage. Therefore, multi-story spaces must be modeled as one space per floor. Make sure there are no gaps or overlaps in the vertical direction between these spaces so that the total volume remains accurate. For example, spaces in upper floors should be given a base elevation equal to the top of the space below, not starting at the next floor datum.

- The space boundary of the lowest level space is drawn based on the space's ANSI/BOMA Category and Space Type and included in the Gross Area.
- The physical spaces above a tenant space, such as a courtroom, have a Space Type of "TFC Tenant Floor Cut". These spaces are included in the Gross Area.
- A space containing stairs must have the Room Name "STAIR (1 - 99)", with one space in each building floor. All of the spaces for one set of stairs must have the same Room Name, such as "STAIR 1", even though they are on different floors. They should all have the Space Type "CRV Circulation Vertical". Similarly, spaces containing elevator shafts and pipe shafts also have a Space Type of "CRV Circulation Vertical". These spaces are included in the Gross Area.
- For a multi-story atrium, the space on the bottom floor should have the Room Name "LOBBY" and the Space Type "CRH Circulation Horizontal". The upper floors of the atrium should have the Room Name "ATRIUM" and the Space Type "OTB Open to Below (Void)". The upper floor spaces are not included in the building's Gross Area.

Figure 5 and Table 4 illustrate these common examples of multi-story spaces, and they provide the appropriate Room Names and Space Types for each space. For more details, please consult the NBSAP.

* The "VERT PEN" spaces are an example of a pipe shaft.

Figure 5. Multi-Story Space Example

Table 4. Spatial Data for Multi-Story Space Example

Space ID	Room Name	Space Type
1001	CHILD CARE	CLD
1002	LOBBY	CRH
1003	STAIR 1	CRV
1004	VERT PEN*	CRV
2001	COURTROOM	CRJ
2002	CAFETERIA	FDS
2003	ATRIUM	OTB
2004	STAIR 1	CRV
2005	VERT PEN*	CRV
3001	OPEN TO BELOW	TFC
3002	CONF.	CFT
3003	OPEN TO BELOW	OTB
3004	ATRIUM	OTB
3005	STAIR 1	CRV
3006	VERT PEN*	CRV

* The "VERT PEN" spaces are an example of a pipe shaft.

B. Parking Areas and Stalls

A partially or fully enclosed parking area within a building or a standalone parking structure must have the Room Name "PARKING" and the Space Type "STP Structured Parking".

C. Spaces Without Bounding Elements

In many cases, two adjacent spaces are not separated by a physical bounding element such as a wall, partition, floor, or ceiling. All of the major BIM-authoring applications typically model this condition through the use of area, room, and/or space boundary lines, and the IFC schema supports this modeling concept. Make sure there are no gaps or overlaps (horizontally or vertically) between these spaces. Figure 6 shows three adjacent spaces - Reception, Security Check, and Entry Lobby - with no physical bounding element separating them.

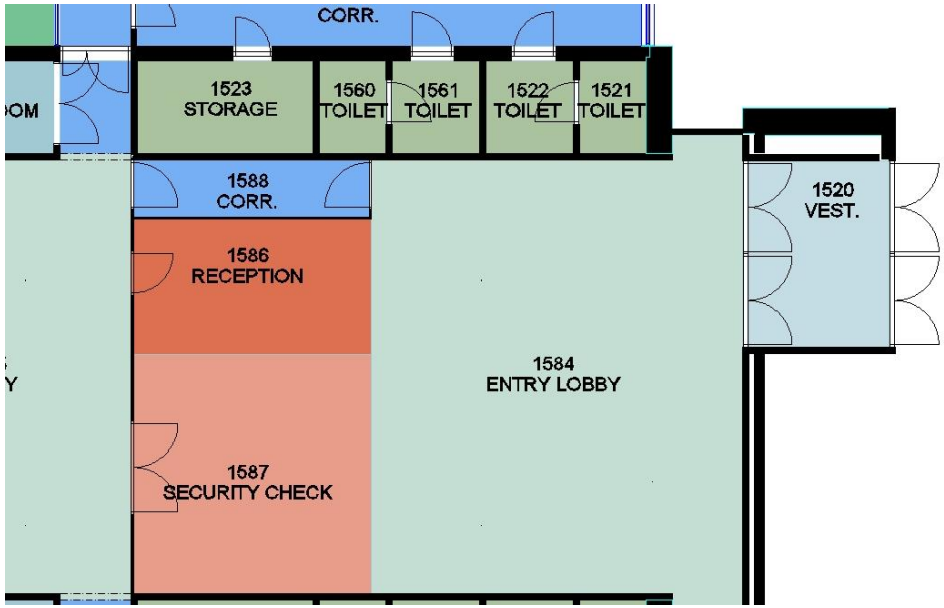


Figure 6. Separate Functional Areas with no Physical Bounding Element Separating Them

D. Balconies and Terraces

Covered balconies within the building line should be modeled as spaces. Their heights should be bounded by the ceilings (as with other spaces) or other surfaces above. Terraces for single or multi-occupant use should also be modeled as spaces. Their heights

should be bounded by the surfaces above. If there isn't a surface above, the height should be set equal to the height of adjacent spaces in the same building floor.

E. Compound Objects or Assemblies

In some BIM-authoring applications, it is possible to use parametric components to model objects such as stairs, balconies, and bathrooms. In such cases, these assemblies are modeled as a single special 3-D object instead of an assembly of semantically correct BIM objects such as walls, doors, windows, and curtain wall. This can lead to improper exporting and incorrect space calculations. To achieve proper exporting of such objects and their associated properties to an IFC BIM, make sure to map the design objects to the desired IFC object types. Contact the BIM-authoring application vendor for instructions if this becomes a problem.

F. Spaces Between Walls

Spaces between walls (e.g., furrings, unknown spaces behind walls) should be considered walls. Thus, instead of having a space between two walls, the entire void will be considered one thick wall. Walls configured to create voids that enclose building services shafts, columns, or other non-occupied spaces are typically referred to as cavity walls.

The appropriate level of model detail and information is dependent on the process and intended use of the BIM, and the optimal method for modeling such conditions is often dependent upon design circumstances. As it is GSA's intention to leverage as much information from BIMs as possible, it is critical that the method of "constructing" the BIM does not give false information about the building (existing or to be built). The BIM must provide the proper level of detail and document any assumptions used in developing the BIM. Two basic ways to model such wall/void conditions are shown in Figure 7.

Figure 7. Alternate Methods for Modeling Cavity Walls

Method A and Method B provide different levels of detail to BIM analysis tools. Method A is appropriate for new construction. It would also be appropriate for existing construction if exploratory demolition was used or reliable as-built documentation was available to accurately verify and document the wall cavities. The individual thicknesses of the walls, which create the assemblage of the perceived thick wall, would also be field verified. This method suggests that the walls are accurately modeled

and that there are columns and a cavity. If this cavity is over 9 square feet, a separate space object along with associated spatial data must be created.

Method B is appropriate if a BIM was constructed based solely on information that was readily visible. For example, if exploratory demolition was not used, it is still possible for one to measure the overall exterior dimensions of a building. Then the interior face-to-face dimensions would supply enough information to complete the model at this level of detail. Method B would NOT be appropriate for new construction, except when the wall is intended to be monolithic - as with concrete. For example, if a column is being planned inside the cavity and it is NOT shown in the BIM, then information about the structure of the new construction would be incomplete and potentially misleading.

G. Pilasters and Columns Touching Walls

Pilasters touching the exterior wall are deducted from the space measurement. In Figure 8, the Net Area boundary (and dominant portion) would alternate along the wall. Columns touching walls (but not embedded) are treated the same as any other column. Columns partially embedded in external walls are partly included in the usable area.

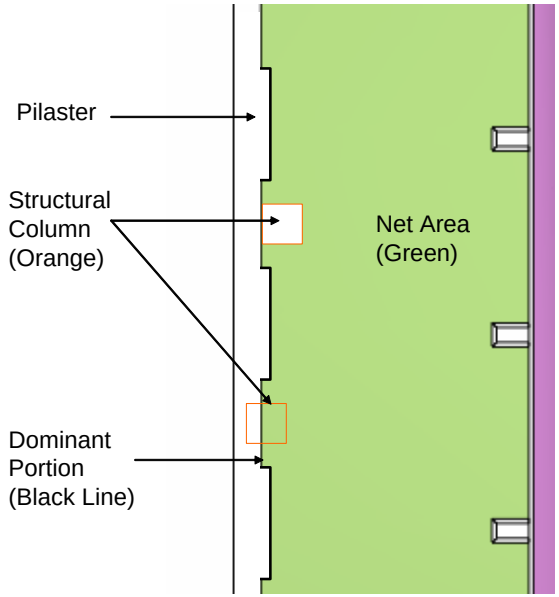
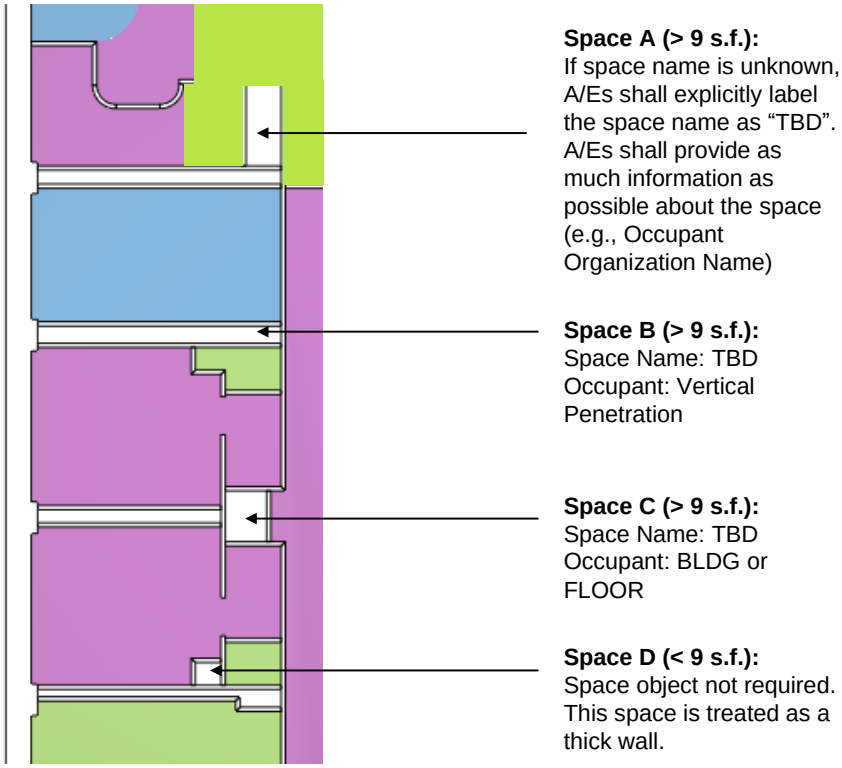


Figure 8. Pilasters and columns touching walls

H. Spaces with Unknown Space Functions

A/Es must define a space for any area over 9 square feet. For areas under 9 square feet that do not have a defined space object, the BIM-analysis rules will treat this area as a wall. Areas with unknown space functions next to vertical penetration spaces (e.g., Space D in Figure 9), without a defined space object, should be included in vertical penetration areas. Figure 9 shows an existing bathroom layout in which some spaces are unknown.

Note: A/Es should attempt to label all spaces with a specific approved space name according to the space function. As a last resource, if the space name cannot be determined, A/E may use "TBD" as the Space Name. GSA expects "TBD" space functions to be resolved prior to any submission.



01- OFFICE
02- BLDG COMMON / 03- FLOOR COMMON
04- VERTICAL PENETRATION

Figure 9. Empty Areas and Voids

I. Parallel Walls

If there are two parallel walls next to each other (with no space in between), both walls should be totally included in their respective neighboring space, for usable area calculations. For example, in Figure 10, if the yellow space is a vertical penetration, then all of the tan walls would be included in the usable area calculation. If the red space is an office space, then the green wall will be included in the red usable area. No additional calculations (e.g., mid-points between walls) are necessary.

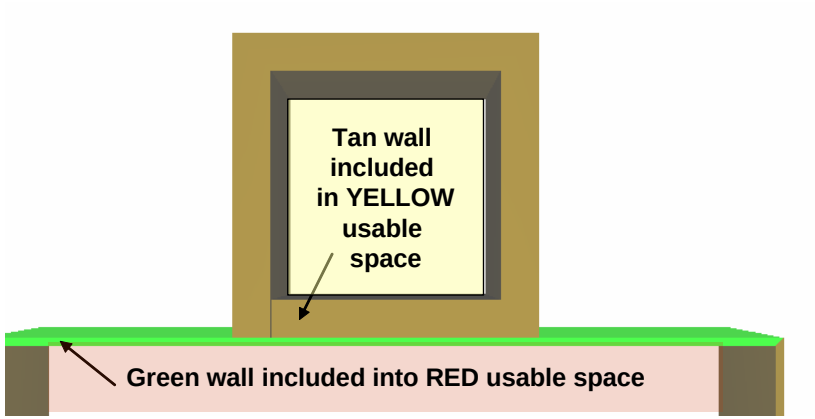


Figure 10. Parallel walls

J. Handling Uncertain Information

A/Es should model the building to the best of their knowledge. For major renovations, however, this may not be possible. If an unknown area is over 9 square feet, A/Es should create a space for the unknown area and label it "TBD." For a space with an unknown function (i.e., unknown Space Name) under 9 square feet, the entire space will be treated as a wall, unless the adjacent space is a vertical penetration. In such cases, the unknown space will be considered part of the vertical penetration space. A/Es should provide as much information as possible about these spaces (e.g., if the tenant is known, please indicate appropriately under Agency Full Name).

Note: A/Es should attempt to label all spaces with a specific approved space name according to the space function. As a last resource, if the space name cannot be determined, A/E may use "TBD" as the Space Name. GSA expects "TBD" space functions to be resolved prior to any submission.

K. Private Stairs and Elevators

Private stairs and elevators, such as Sally Ports and Judge's elevators, are considered vertical penetrations. Per the NBSAP, they are classified as ANSI 01-Office Space and treated as ANSI 04-Vertical Penetrations. They typically include the enclosing walls

unless the adjacent space is also ANSI 04-Vertical Penetration. In order to do this correctly, the BIM-analysis rules will first treat vertical penetrations as "regular" (04 category) penetrations when defining the space boundary, but will then use the provided spatial information to assign the correct category.

L. Vertical Penetrations in Spaces

Building services shafts greater than 9 square feet must be defined as their own space. This means that spaces with large shafts in them should be modeled such that they do not include the large shaft from a space calculation point of view. This is accomplished differently in different BIM-authoring applications. Appendix A of this guide provides examples on how this is done by some BIM-authoring applications.

For vertical penetrations, GSA defines any space greater than 9 square feet as its own space, as opposed to the 10 square feet standard used by ANSI/BOMA. See more details in the NBSAP.

M. Alcove Spaces

The Net Area of alcove spaces (and all spaces) are drawn to the bounding walls between the corridor and office areas. A/Es should note, however, that the usable area of this space is calculated differently from the typical rules. Consult the NBSAP for details.

3.4 Lessons Learned

While most BIM-authoring tools can export models into IFC BIMs, the resulting IFC BIMs are not always perfect. This section highlights lessons learned and best practices for modeling and for creating IFC BIMs.

A. Exporting Linked BIMs

If a full BIM is created by linking separate BIMs that represent different disciplines, some BIM-authoring tools may not correctly export the building elements from the linked models to an IFC BIM. For example, a structural model containing beams and columns may be linked to an architectural model that contains spaces, doors, windows, and slabs. When the architectural model is exported to an IFC BIM, the beams and columns from the structural model may not be exported. Users should consult with their BIM-authoring application documentation for instructions on how to ensure that all building elements, including those from linked models, will be included in the export to an IFC BIM.

B. Exporting Building Elements that have Sub-components

Typically, BIM-authoring applications export building elements such as doors and windows as part of their standard IFC export. However, some BIM-authoring applications may not properly export a building element unless its sub-components, such as frames and panels, are also exported to the IFC BIM. In such cases, a building element's sub-components must map to the proper IFC object to ensure the building element is exported correctly to the IFC BIM.

C. Including Furring Columns in Area Calculations

The default setting for most BIM-authoring applications is to use walls as bounding elements to define space objects. For furring columns less than 9 square feet, it is important to disable the enclosing walls as bounding elements so that the column is included in the space area calculation as required by the NBSAP.

Section 4

Checking BIM Models

GSA BIM Guide 02

www.gsa.gov/bim

4 Checking BIM Models

4.1 Overview

Having a properly structured model is important because space and building area calculations are derived from the model. If a model is not properly structured, the calculations will be incorrect. GSA calculates and reports areas using information contained in the building information model (BIM), so it is important to verify that the model meets GSA requirements.

This section describes the rules GSA uses to analyze the spatial program BIM that architects and engineers (A/Es) submit and highlights some special cases and rules that may affect modeling or spatial information assignment. These rules are based on the following:

- The latest version of the Public Buildings Service (PBS) National Business Space Assignment Policy (NBSAP)
- ANSI/BOMA Standard Method for Measuring Floor Area in Office Buildings (ANSI/BOMA Z 65.1 and Z 65.3)
- GSA PBS Region 3 CAD Deliverables Policy (October 1, 2010)
- Guidance from the GSA PBS Office of Real Property Asset Management
- "Design to Spatial Program Validation" Model View Definition (SPV MVD) as defined by the National BIM Standard-United States™ (NBIMS-US™)

Model checking software can validate that models are properly structured and is therefore a recommended tool for GSA project teams in terms of quality control. Specifically, it can check the following:

- The model contains a building with levels.
- All building objects are contained on a level.
- The model has spaces.
- Model elements make sense dimensionally by meeting minimum and/or maximum dimensions.
- The intersection of building objects, such as walls intersecting with other walls or a beam intersecting with a column, are sound.
- Building objects are properly located. For example, doors and windows must be contained in walls.

GSA generally uses Solibri Model Checker (SMC) to check models for compliance with GSA requirements. The GSA extension to SMC can be made available to A/Es who wish to pre-check their models using this tool. (Although at this time there is no charge for the GSA extension to SMC, any costs associated with using SMC will be borne by the A/E.) Consult with the GSA project team for more information on accessing and using SMC.

4.2 Checking Space Properties

GSA verifies that all spaces have the minimum required spatial properties and validates the values of certain spatial properties - such as Room Name, Space Type, and Space Category - against a list of GSA approved values. Using a GSA-approved BIM template will help to ensure that property values in the BIM match GSA's approved values.

4.3 Checking Space Boundaries

It is important to check space boundaries for conformance to the rules outlined in Section 3 because GSA's reports and building calculations, such as Gross Area, Rentable Area, and Usable Area, are generated based on the BIM.

To ensure that all space is accounted for, GSA also validates that all areas 9 square feet or greater are included as a space and that all spaces and areas are included in a floor's gross area.

To determine the location of space boundaries, three main factors must be considered: the dominant portion of the wall, the space's ANSI/BOMA Category, and the space's Space Type.

4.3.1 ANSI/BOMA Dominant Portion

GSA uses the ANSI/BOMA definition for dominant portion: "the portion of the inside, finished surface of the permanent, outer, building wall, which is 50% or more of the vertical floor-to-ceiling dimension at the given point being measured horizontally along the wall." Space boundaries must be drawn along the dominant portion of the wall.

4.3.2 ANSI/BOMA Category and Space Type

The space boundary between adjoining spaces is determined by each space's ANSI/BOMA Category and Space Type. Table 5 below summarizes the rules for identifying the location of the space boundary between adjoining spaces, but the NBSAP is the authoritative standard and guideline for space assignment and measurement for GSA. A/Es must refer to the NBSAP for details. A/Es must also consult the NBSAP and the GSA project team for a list of unique cases not covered by Table 5 below.

Table 5. Location of Space Boundary Based on ANSI/BOMA Category and Space Type

One Side of the Wall	Other Side of the Wall	Location of Space Boundary
ANSI 01 - Office	ANSI 01 - Office	Center of the wall
ANSI 01 - Office	ANSI 02 - Building Common	Building Common takes the wall
ANSI 01 - Office	ANSI 03 - Floor Common	Floor Common takes the wall
ANSI 01 - Office	ANSI 04 - Vertical Penetration	Vertical Penetration takes the wall
ANSI 01 - Office	ANSI 05 - Construction (CON)	Construction (CON) takes the wall
ANSI 01 - Office	ANSI 05 - Unsuitable for Occupancy (UFO)	Unsuitable for Occupancy (UFO) takes the wall
ANSI 01 - Office	ANSI 05 - Open to Below - Void (OTB)	Open to Below - Void (OTB) takes the wall
ANSI 01 - Office	ANSI 05 - Structured Parking (STP)	Structured Parking (STP) takes the wall
ANSI 02 - Building Common	ANSI 02 - Building Common	Center of the wall
ANSI 02 - Building Common	ANSI 03 - Floor Common	Center of the wall
ANSI 02 - Building Common	ANSI 04 - Vertical Penetration	Vertical Penetration takes the wall
ANSI 02 - Building Common	ANSI 05 - Construction (CON)	Construction (CON) takes the wall
ANSI 02 - Building Common	ANSI 05 - Unsuitable for Occupancy (UFO)	Center of the wall
ANSI 02 - Building Common	ANSI 05 - Open to Below - Void (OTB)	Open to Below - Void (OTB) takes the wall
ANSI 02 - Building Common	ANSI 05 - Structured Parking (STP)	Structured Parking (STP) takes the wall
ANSI 03 - Floor Common	ANSI 03 - Floor Common	Center of the wall
ANSI 03 - Floor Common	ANSI 04 - Vertical Penetration	Vertical Penetration takes the wall
ANSI 03 - Floor Common	ANSI 05 - Construction (CON)	Construction (CON) takes the wall
ANSI 03 - Floor Common	ANSI 05 - Unsuitable for Occupancy (UFO)	Center of the wall
ANSI 03 - Floor Common	ANSI 05 - Open to Below - Void (OTB)	Open to Below - Void (OTB) takes the wall
ANSI 03 - Floor Common	ANSI 05 - Structured Parking (STP)	Structured Parking (STP) takes the wall
ANSI 04 - Vertical Penetration	ANSI 04 - Vertical Penetration	Center of the wall
ANSI 04 - Vertical Penetration	ANSI 05 - Construction (CON)	Construction (CON) takes the wall
ANSI 04 - Vertical Penetration	ANSI 05 - Unsuitable for Occupancy (UFO)	Vertical Penetration takes the wall
ANSI 04 - Vertical Penetration	ANSI 05 - Open to Below - Void (OTB)	Center of the wall
ANSI 04 - Vertical Penetration	ANSI 05 - Structured Parking (STP)	Center of the wall
ANSI 05 - Construction	ANSI 05 - Construction (CON)	Center of the wall
ANSI 05 - Construction	ANSI 05 - Unsuitable for Occupancy (UFO)	Construction (CON) takes the wall
ANSI 05 - Construction	ANSI 05 - Open to Below - Void (OTB)	Construction (CON) takes the wall
ANSI 05 - Construction	ANSI 05 - Structured Parking (STP)	Construction (CON) takes the wall
ANSI 05 - Unsuitable for Occupancy	ANSI 05 - Unsuitable for Occupancy	Center of the wall

One Side of the Wall	Other Side of the Wall	Location of Space Boundary
(UFO)	(UFO)	
ANSI 05 - Unsuitable for Occupancy (UFO)	ANSI 05 - Open to Below - Void (OTB)	Open to Below - Void (OTB) takes the wall
ANSI 05 - Unsuitable for Occupancy (UFO)	ANSI 05 - Structured Parking (STP)	Structured Parking (STP) takes the wall
ANSI 05 - Open to Below - Void (OTB)	ANSI 05 - Open to Below - Void (OTB)	Center of the wall
ANSI 05 - Open to Below - Void (OTB)	ANSI 05 - Structured Parking (STP)	Center of the wall
ANSI 05 - Structured Parking (STP)	ANSI 05 - Structured Parking (STP)	Center of the wall

4.4 Properties Derived from A/E Inputs

When these properties are included in the 3D space objects and the building elements bounding these spaces are also modeled in 3D, BIM-analysis applications (and some BIM-authoring applications) can use "rules" to derive and populate spatial data based on the NBSAP processes (Table 6).

Table 6. Properties Derived from A/E Inputs

Derived Property	Example	NBSAP Source
Occupant Organization Abbreviation	GSA	Agency Bureau Abbreviation
Occupant Organization Code	4700	Agency Bureau (AB) Code
Occupant Sub-Organization Code	PMAC	Organizational Unit Code
Occupant Billing ID	TX0063720	Agency Space Assignment (ASA)
Space Category	02 (Building Common)	PBS Space Category
ANSI/BOMA Category	01 (Office)	ANSI/BOMA Category

4.5 Using IFC BIMs to Check GSA Spaces

BIM-analysis applications allow users to automate the generation and evaluation of a spatial program based upon the design proposal (e.g., a Concept design scheme) and the established requirement [e.g., GSA Program of Requirements (POR)]. BIM-analysis applications use the required BIM objects (see SPV MVD as defined by NBIMS-US™) to generate a spatial program based upon rules in the NBSAP. These applications can then automatically evaluate the spatial program based upon GSA's POR. The BIM-authoring application provides the following properties for each space automatically:

- Global Unique Identifier (GUID)
- Building Floor (via containment hierarchy)

- Space Areas (Net Area, GSA Usable Area, GSA Rentable Area, GSA Design Gross Area, GSA Building Common Area – all calculated based on space geometry)
- Space Volume (via geometry)
- XYZ Coordinates (via geometry)

By requiring IFC BIM submission, the development of BIM-analysis applications can be founded upon one common and extensible data standard. This minimizes the inconsistency or variance when dealing with BIMs generated from different BIM-authoring applications. To ensure these space objects (and calculated areas) are accurate, BIM-analysis applications will validate that such space objects are modeled precisely in relationship with the geometry of the surrounding Building Elements (as discussed in sections 2 and 3 of this guide).

GSA's BIM spatial program analysis tools currently perform the following functions:

- Verifies the BIM model structure, completeness, and integrity.
    - Verifies the information model structure relative to the industry-standard IFC BIM schema.
    - Verifies completeness (of the object set and properties) relative to the requirements of the SPV MVD defined by NBIMS and of this GSA BIM Guide (e.g., room naming, unique room numbers).
    - Verifies geometric integrity by checking for proper fit and alignment of object geometry (e.g., space objects are aligned with the surrounding walls without gaps or overlaps. Such gaps or overlaps can be flagged for resolution by the A/E.
- Assesses the Design Program relative to the space program defined by a GSA Housing Plan or a POR pertaining to the building.
- Calculates, reports, and visualizes a variety of metrics based on ANSI/BOMA, the NBSAP, and the GSA BIM Guides.

Conclusion

Spatial data is an important piece of building information and a critical part of any project. It needs to be a part of project planning and execution. The use of spatial program BIMs throughout a building's lifecycle continues to increase. GSA is increasingly able to leverage the use of BIM and the interoperability among BIM software to optimize and automate the checking of model integrity and design performance relative to the NBSAP and the space program given to the A/Es. GSA will continue to maintain and update this guide as well as support the continued refinement of the "Design to Spatial Program Validation" MVD as defined by NBIMS-US™ to make the construction, use, and sharing of spatial program BIMs more seamless and reliable. GSA is committed to working with the industry to develop new software technologies, design, construction, and operational strategies, and user functionality. This Guide is a step in that direction, and GSA welcomes industry collaboration to improve current and future design, construction, and operational requirements.

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GSA

Charles Matta, FAIA, Deputy CIO, GSA Office of Public Buildings IT Services
Faith Zahm, Expert Resources - Courthouse Programs, PBS Office of Design and Construction
Fernando Rocha, Program Manager, PBS Spatial Data Management
Ilana Hellmann, National BIM Program Expert, GSA Office of Public Buildings IT Services
Michael Tinsley, SDM Regional Program Manager, PBS Northwest / Arctic Region
Patricia Cheng, PBS Office of the Chief Greening Officer
Peter Koenig, Computer Integrated Facilities Manager, PBS Greater Southwest Region
Richard Gee, LEED AP, GSA Great Lakes Region

Consultants

Kristine Fallon Associates, Inc., Chicago, IL

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For further information about GSA BIM Guide 02 – Spatial Program Validation or to submit comments or questions, please visit the National 3D-4D-BIM webpage at http://www.gsa.gov/bim. Note that this document may not be completely accessible. For assistance, please contact BIM@gsa.gov.

[i] "Public Buildings Service." *U.S. General Services Administration*, February 2015. <http://gsa.gov/portal/content/104444> (29 April 2015).
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