U.S. General Services Administration
Public Buildings Service
Office of Design and Construction

December 2011

This version of the *GSA Building Information Modeling Guide Series: 08 – GSA BIM Guide for Facility Management* is identified as Version 1. With its publication, this GSA BIM Guide Series 08 becomes available for public review and comment. Since the area of BIM and Facility Management is emerging and dynamic, the BIM Guide 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 GSA's 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.

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.

The National 3D-4D-BIM Program
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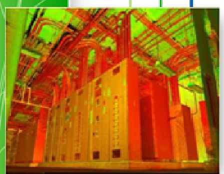
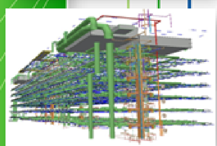
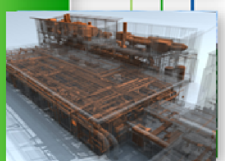
GSA

BIM Guide For Facility Management







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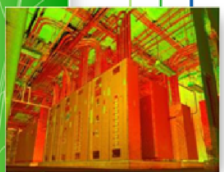
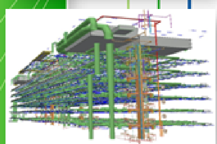
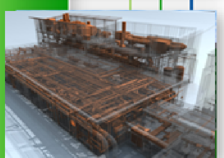

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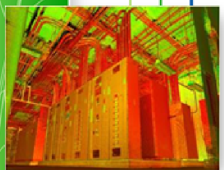
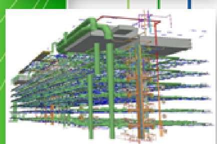
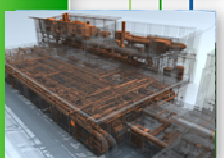
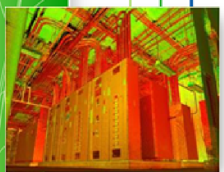
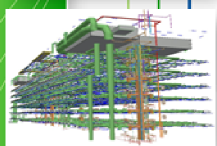
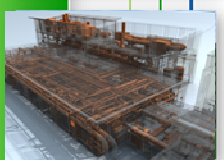
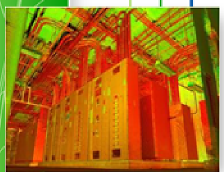
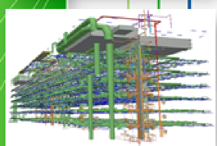
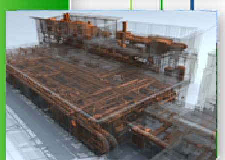
facility management







executive summary: facility management

As one of the largest building owners in the U.S. with a portfolio of buildings designed for 50+ years of use, GSA sees great benefits for developing and maintaining lifecycle data for our facilities. In 2003, the U.S. General Services Administration (GSA) Public Buildings Service (PBS) Office of Design and Construction (ODC) established the National 3D-4D-BIM Program. As part of this program, ODC has evaluated an array of 3D-4D-BIM applications on a number of capital projects.

The ODC, which is responsible for the BIM Program, has been working with its counterparts in the Office of Facilities Management and Services Program (FMSP) and the Office of Portfolio Management's Spatial Data Management Program (SDM) to ensure that the appropriate BIM deliverables are required to address facility management needs upon facility occupancy. This Guide has been reviewed by the GSA BIM and FM Working Group which consists of national and regional stakeholders.

Objective of Using BIM for Facility Management

The overall purpose of utilizing BIM for facility management is to enable GSA to leverage facility data through the facility lifecycle to provide safe, healthy, effective and efficient work environments for our clients. Facility data is created throughout the design and construction process. GSA intends to use and update this data throughout the facility lifecycle – through Small Projects, Operations & Maintenance, and Major Renovations & Alterations. The maintenance of this data will create greater efficiencies such as: having accurate as-built information to reduce the cost & time required for renovations; increasing customer satisfaction; and optimizing the operation and maintenance of our building systems to reduce energy usage.

Requirements and Deliverables

At a minimum, GSA requires BIMs to have the following objects in a valid 3D geometry representation in support of facility management. GSA BIM Guide Series 08 requirements build upon the existing spatial program BIM modeling requirements defined in GSA BIM Guide Series 02, located on the GSA website at http://www.gsa.gov/bim. Deliverables shall be provided in both native BIM-authoring formats and open-standard formats such as IFC and COBie. Project teams shall develop a BIM Execution Plan outlining how the BIM requirements will be met.

Objects

The following object types are required in the Record BIM for facility management submitted to GSA:

- All objects required by BIM Guide Series 02
- Ceilings
- Lighting systems, fixtures and equipment
- Communications systems and equipment
- Electrical systems and equipment

- Mechanical systems and equipment
- Plumbing systems and equipment
- Irrigation system and equipment
- Fire protection systems and equipment
- Vertical and horizontal transportation equipment
- Furniture and specifications
- Specialty systems and equipment

Spaces and equipment must include the following information:

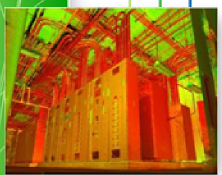
-
-
-

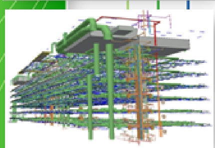
GSA project teams in conjunction with the PBS Service Center should define the minimum list of equipment types and attributes required in the BIM Execution Plan (BEP).

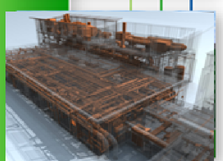
These requirements are in addition to all current submission requirements set forth in Appendix A of the *Facilities Standards for the Public Buildings Service* (PBS P-100). A/Es should also follow the PBS CAD Standards for creating 2-D drawings (www.gsa.gov/cifm). To the greatest extent possible, A/Es should utilize BIM as the authoritative source for building information, and derive 2D drawings from the model.

Conclusions

In referencing this Guide, GSA expects to obtain high-quality BIMs for use in facility management. While full adoption of BIM within facility management will be incremental, this BIM Guide Series lays the foundation for the vision, the technical paths, business processes, as well as the minimum technical requirements. GSA welcomes any expert input, collaboration opportunities and recommendations to this BIM Guide and the process of creating and maintaining facility lifecycle information.







introduction

About this Guide

A facility management BIM allows GSA to use facility information effectively through all phases of a facility's lifecycle. This Series is part of a multi-series document on 3D-4D-BIM applications. Users of this document should also refer to the *GSA BIM Guide Series: 01 – Overview of GSA's National 3D-4D-BIM Program* for program-wide motivations and policies on 3D-4D-BIM applications and the GSA BIM Guide Series 02 for technical requirements of a spatial program BIM. The BIM for facility management requirements in this Guide build on the spatial program BIM requirements.

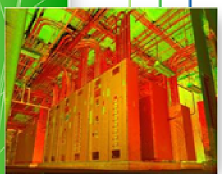
This GSA BIM Guide Series is intended for incorporation by reference in PBS contracts for the design and construction of New Construction, Major Renovation projects, Small projects, and Operations and Maintenance projects. As such, the designers, the contractors, the PBS Project Managers, and Contracting Officers administering the contracts are its primary audience. This Guide has been prepared to assist design and construction teams in producing BIMs to support BIM for facility management contract requirements.

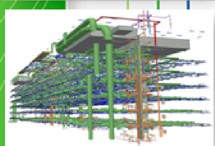
This Series will also be of general interest to other members of GSA project teams, including PBS building managers, staff, customer agencies, and contracted parties such as construction managers, construction and design-build contractors, and consultants. In addition, construction industry software solution providers will find this Guide useful, in particular those who offer BIM-authoring applications and downstream applications which use BIM.

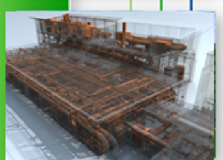
Objective of this Series 08

The main objective of this Series is to provide the vision, requirements, and technology review for GSA's use of BIM for facility management. GSA BIM Guide Series 08, therefore, aims to meet several purposes:

- Identify the work processes and information requirements during facility management. This determines the information that should be included in the Record BIM at the end of construction
- Evaluate methods for capturing and recording information updates
- Provide implementation guidance for GSA associates, solution providers, technology vendors and the broader industry
- Define the scope of information that should be included or updated in the Record BIM at the end of a facility project
    - Take a vendor-neutral approach
    - Identify "core" information that shall be required in every as-built BIM submission
- Define technology requirements for accessing and updating BIMs, by both GSA personnel and external architects and contractors
    - Identify necessary interfaces with existing systems





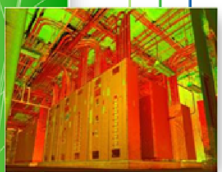


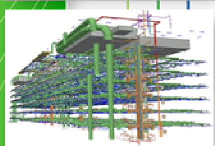
- Document GSA case studies involving BIM and FM

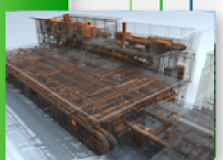
How to use this Series 08 – Facility Management

This series is divided into 5 major sections:

- **Section 1: BIM and Facility Management** – This section describes the overall vision and objectives for using BIM during facility management.
- **Section 2: Implementation Guidance** – This section provides implementation guidance to GSA associates and consultants.
- **Section 3: Modeling Requirements** – This section describes the BIM object and attribute requirements for use during facility management.
- **Section 4: Technology** – This section describes the technology requirements for creating and using BIMs for facility management.
- **Section 5: Pilot Projects** – This section describes on-going GSA pilot projects and implementation approaches.







Key Definitions

Construction-Operations Building Information Exchange (COBie): A vendor neutral, IFC-based data exchange specification that describes the information exchange between the Construction and Operations phases of a project.

Design Intent Building Information Model (BIM): Building information model(s) created by and conformed to the bid addenda by the A/E. Elements are modeled per BIM Guide Series 02 and are accurate in terms of quantity, size, shape, location and orientation. The Design Intent BIM includes the Spatial Program model. Elements also contain unique asset identification numbers that link them to the COBie data. The Design Intent BIM must be submitted in both .ifc and native format.

Construction Building Information Model (BIM): Building information model typically representing a single building system created for purposes of planning, scheduling, coordinating, fabricating components and executing construction. Model elements are accurate in terms of size, shape, location, quantity and orientation and may include fabrication, assembly, detailing and non-geometric information. MEP/FP systems models include Equipment Primary Keys that link them to the COBie data. Construction BIMs are maintained in the native format of the authoring software.

Coordination Building Information Model (BIM): Composite model that includes multiple Design and/or Construction BIMs, registered spatially, used for the purposes of interference checking (clash detection), visualization and additional BIM analyses during construction. Coordination BIMs are maintained in the native format of the modeling software.

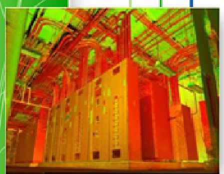
Record Building Information Model (BIM): Multiple Construction BIMs, organized by building system and floor and registered spatially, that represent the final as-constructed building and components configuration, including Architectural Supplemental Instructions, Change Notices, and field changes. Base building model (architectural and structural) conforms to BIM Guide Series 02 specification. MEP/FP systems models include unique asset identification numbers that link them to the COBie data. Record BIMs must be submitted in both .ifc and native format. The Record BIMs will be archived as part of the project record and also copied to the Central Facility Repository as the As-Built Building Information Model (BIM).

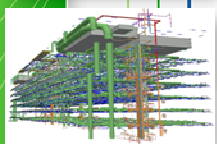
As-Built Building Information Model (BIM): Editable copy of the Record BIM that is constantly updated to represent the current completed state of the building and systems configuration.

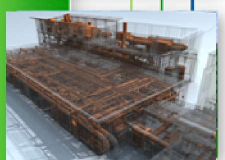
section 01:

BIM for facility management

section 1: BIM for Facility Management







This section provides an overview of the origin and motivation behind the use of BIM during facility management. This section describes various use cases for BIM and facility management.

1.1 Why BIM for Facility Management?

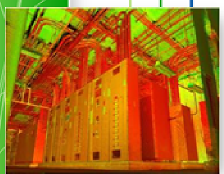
As the largest property owner in the US, GSA manages 362 million rentable square feet in 9,624 buildings in all 50 states, 6 U.S. territories, and the District of Columbia. GSA designs, constructs, operates and manages a variety of facility types including federal office buildings, courthouses, and land ports of entry. As a building owner and property manager, GSA's Public Buildings Service (PBS) analyzes the asset performance of complexes and buildings by operations costs, energy efficiency, and a physical condition survey of major building systems and structural components.

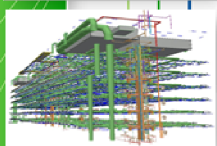
Facility management provides safe, healthy, and efficient work environments for our clients. Achieving such work environments requires the ability to track facility components accurately, identify inefficiencies in building operations, and respond quickly to client requests. Each facility component or asset has a cost associated with the installation, replacement and/or scheduled maintenance for the component. An accurate equipment inventory is essential for budgeting repair/replacement and maintenance costs. Facility management activities depend on the accuracy and accessibility of facility data created in the facilities' design and construction phases and maintained throughout the operations and maintenance phase. Lack of this information can result in cost overruns, inefficient building operations, and untimely resolution of client requests.

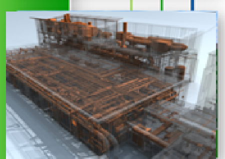
The National Institute of Standards and Technology (NIST) study Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry (NIST GCR 04-867) shows that all stakeholders in the capital facilities industry – designers, contractors, product suppliers, and owners – waste a huge amount of money looking for, validating, and/or recreating facility information that should be readily available. The total cost of these activities within the capital facilities industries was conservatively estimated at $15.8 billion in 2002, with two-thirds of that cost occurring during the facilities' operations and maintenance phase. When applied to GSA's $18 billion construction program in 2010, NIST's findings equate to an annual $774 million of waste and rework on GSA's facilities before adjustment for inflation.

A BIM for facility management provides visualization, access to the precise location and relationships of building systems and equipment, and access to accurate existing condition attribute data. Building Information Modeling provides several advantages over traditional 2D drawings. BIM is a data-rich, object-based, intelligent and parametric digital representation of the facility.

- BIM objects know:
  - What they are, (walls, doors, spaces, lights, plumbing fixtures, etc.)







   - Where they are located

- BIM provides a unique identifier that can be used to link the components in the Model files with other facility management systems.
- BIM software tools support the creation of zones that can identify areas serviced by common components. For Example: Rooms 1, 2, and 3 are supplied by Air Handling Unit 21, or supplied electrical service from circuit panel L-1.
- BIMs capture building system relationships. For example: each electrical panel knows which transformer supplies its power.

The purpose of defining a BIM for facility management is to specify the information needed to be passed from design and construction to operations and maintenance. A BIM for facility management can automate the creation of equipment inventory lists, populate facility management systems such as a Computerized Maintenance Management System (CMMS), and reduce redundancy in the maintenance of facility data for facility management activities. The potential benefits are not only a reduction in operating costs, but also quality gains in responding to tenants faster.

1.2 The Business Need for BIM for Facility Management

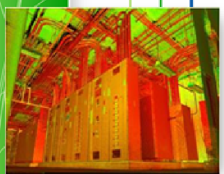
The NIST study on the Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry noted the importance of effectively maintaining facility data for improved building services. Effective facility data maintenance enables more effective work processes at multiple levels of PBS and across business lines.

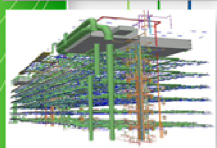
For GSA Maintenance Workers:

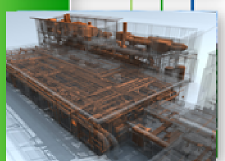
- Reduces time by eliminating additional trips to the same location to carry out unscheduled work orders by providing accurate field conditions and maintenance information before leaving the office
- Increases completeness in preventive maintenance work orders through accurate equipment inventory
- Reduces costs for repairs by providing faster response times to emergency work orders (e.g., a major leak in the wall and the water needs to be shut off immediately)
- Mobile access to BIM and other linked/integrated data in the field allows access to all documentation without making trips back to the office.

For GSA Building Operators:

- Reduces the operations and maintenance (O&M) contract costs from incomplete equipment inventories. An accurate equipment inventory can reduce O&M contracting costs from 3% to 6% by identifying and tracking facility equipment and facility square footage.







- Reduces time creating equipment inventories from plans, specifications, and submittals. An accurate equipment inventory can generate a return on investment of 3% in energy savings by identifying all facility components that affect energy usage, require maintenance, and assist in safe operations.
- Reduces risk and uncertainty of performing work orders by identifying building components that are not easily identified.
- Maintains links to equipment histories facilitating equipment condition assessments. An accurate equipment inventory reduces the possibility of catastrophic costs for unforeseen repairs by identifying accurate equipment locations and components.
- Optimizes building performance by comparing actual to predicted energy performance. BIM can provide access to design and commissioning data for reference.

Provides business analytics through integration of BIM, BAS, EMS, and CMMS data, allowing better review and access to building controls, schedules, readings, and inventory. Cost and performance trending can be used to troubleshoot high tenant work order areas and identify customer satisfaction or building performance issues. **For GSA Design and Construction Teams:**

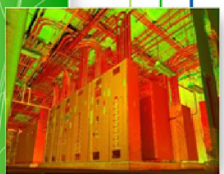
- Reduces costs of re-documenting "as-built" conditions and field surveys for building renovation projects. Savings could occur from reduction in time to verify field conditions, change orders due to unforeseen conditions, reduction in destructive testing and repair costs to confirm existing conditions.
- Meets federally mandated energy targets through greater accuracy in model assumptions and better estimation of energy performance
- Designs higher quality building systems from better equipment selection and specifications based on feedback from building operations
- Better commissioning through understanding impacts of individual HVAC components on overall HVAC system. For example, a VAV box in Room 1 is adjusted for a tenant. All other VAV boxes within the same HVAC system are affected because of the change in air flow. As adjustments are made to each individual box, the overall system performance can be analyzed and adjusted.

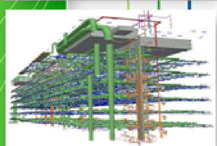
For GSA Spatial Data Managers:

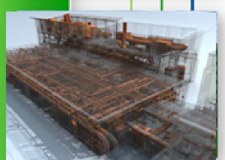
- Increases precision in existing condition information, which is used for accuracy of rent bill management, reduction in costs for audits and re-walks.
- Reduces time to polyline spatial program drawings through automation process using BIM Guide Series 02.

For GSA Building Tenants:

- Increases satisfaction from quicker resolutions to unscheduled work orders.
- Reduces unscheduled work orders and increased communication between tenants and building maintenance workers regarding scheduled work orders.







1.3 The Data Requirements to Support GSA Business Needs

Acknowledging that each GSA project has a unique set of project opportunities and constraints, GSA has identified three tiers of data requirements that are necessary to support GSA Business Needs. Each of these tiers builds on the previous one, allowing GSA project teams to choose the appropriate level of requirements to meet project conditions. These requirements range from:

- Tier 1
  - Spatial Program BIM
  - Accurate As-Built Geometry for equipment
- Tier 2
  - Equipment information - ID, Make, Model, Serial Number, warranty information, maintenance instructions, etc.
- Tier 3
  - As-designed BIM with energy analysis predictions

1.3.1 Accurate As-Built Geometry and Spatial Program BIM (Tier 1)

The value of an accurate 3D geometric model to many downstream users should not be underestimated. The GSA BIM FM Group has discussed the value of being able to calculate accurate areas of floor covering types for maintenance contracts and also the value of being able to identify locations of building systems and equipment concealed in walls or above ceilings without opening those walls or ceilings.

1.3.1.1 Providing Accurate Data for Renovations

Providing accurate as-built data prior to a major renovation or small project reduces the amount of time and resources to field verify existing conditions.

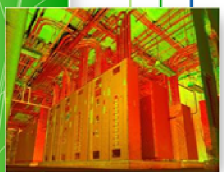
1.3.1.2 Spatial Program Model

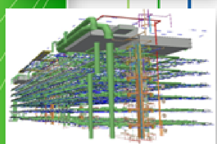
The As-Built BIM shall incorporate the Spatial Program model, updated to correspond with the realities of the facility as-constructed. This requirement is detailed in the BIM Guide Series 02 and incorporated in BIM Guide Series 08 by reference. GSA intends to build on existing BIM requirements to streamline modeling requirements for project teams.

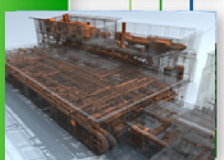
1.3.1.3 BIM Equipment Objects

Each BIM equipment object in the As-Built BIM shall contain geometric data and a minimum set of attributes:

- The BIM object GUID is a machine-interpretable unique identifier that maintains the linkage between the facility management system (including BAS, EMS, CMMS, and others) and the BIM authoring-application. This is detailed further in Section 3.
- The BIM object location primary key is the identifier that provides quick identification of the equipment location.







- The Asset Idenitification Number - A unique, human interpretable naming convention that allows for easy equipment identification by facility management in the 3D model and facility management systems.

1.3.2 Equipment Inventory for O&M Management (Tier 2)

Equipment inventories or facility equipment lists form the basis for many facility management activities. Equipment inventories are used for equipment condition assessments, energy management, emergency response, warranties, man power calculations, and so forth. This is illustrated in Figure 1 below. Operations and maintenance incurs additional time, manpower, and costs with inaccurate or lack of equipment inventories. The failure to properly track equipment inventories reduces the reliability of project scopes and cost estimates, impairs emergency response, and degrades the ability to make executive decisions.

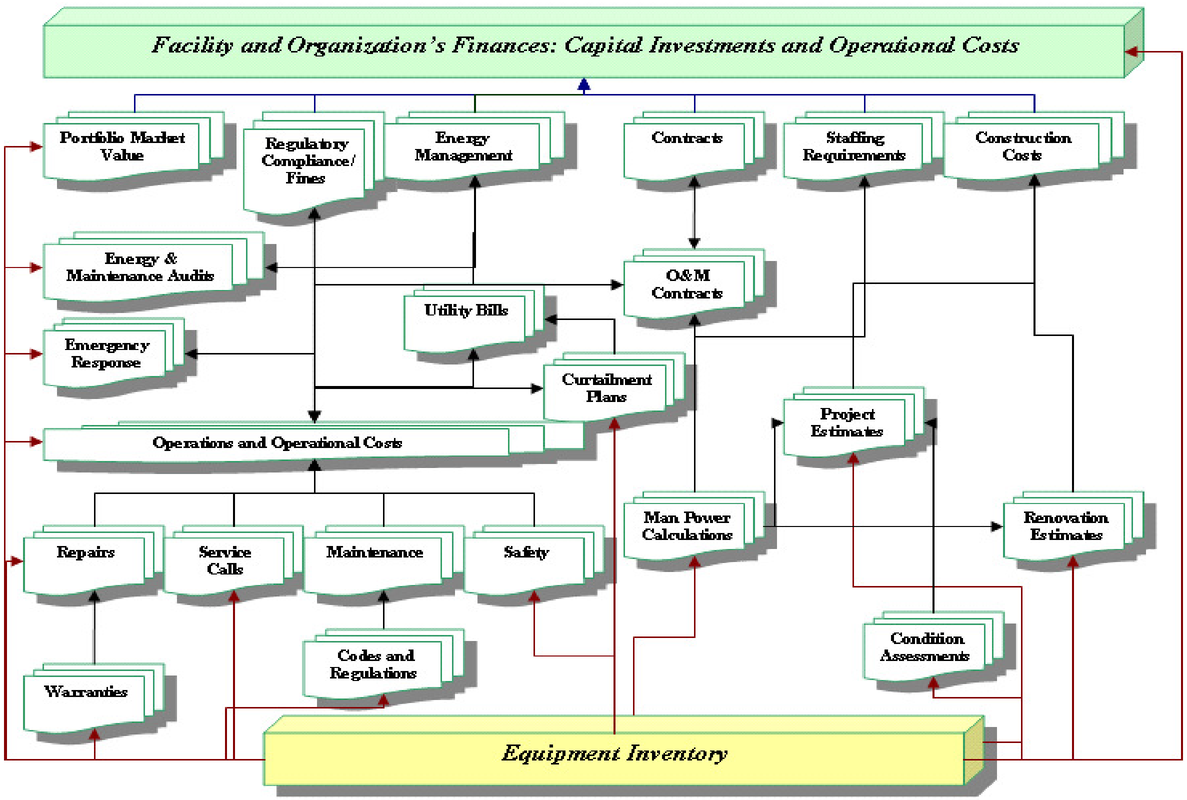
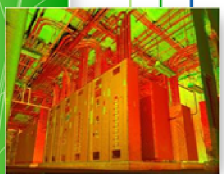
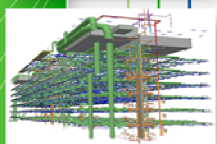
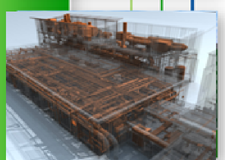


Figure 1: Facility's Equipment Inventory and Finances (Keady 2009)







BIM authoring applications have the ability to populate BIM objects with standard object attributes and add custom object attributes. In addition, COBie allows the creation and management of additional data external to the BIM authoring application. This is discussed further in Section 3.

At project closeout, equipment attribute data can be extracted from the BIMs and COBie files and loaded into a centralized database for access by multiple facility management applications.

1.3.2.1 Negotiate Operations and Maintenance (O&M) Contracting

An accurate equipment inventory can properly define the scope of work for O&M contracting. An accurate equipment inventory creates better alignment of Independent Government Estimates (IGEs) and O&M contractor bids, reduces turnaround times for O&M contractor bids, and produces more accurate and complete O&M contractor bids.

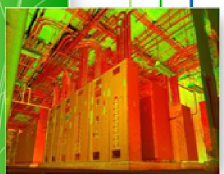
1.3.2.2 Populating BIM Data into CMMS at Project Turnover

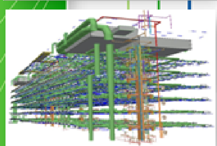
A CMMS is used to manage facility assets, maintenance transactions, and store facility data during the facility's operation and maintenance phase. Specifically, a CMMS manages equipment inventories, work orders, preventive maintenance, predictive maintenance and condition based monitoring programs. Typically, CMMS is populated at project turnover with facility information created during the design, construction, and commissioning phases.
Data required by a CMMS will be created either in the Design and Construction BIMs or in an external format such as COBie. See Section 3 for further discussion on COBie. At project turnover, this data will then be loaded into a CMMS or database used in the Region. The BIM for facility management is to be linked to the CMMS, as well as other systems, for visual coordination of facility assets with operations and maintenance (O&M) data.

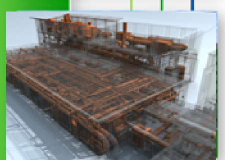
The equipment data in the Equipment Inventory and CMMS shall contain the same equipment attributes identified in Section 1.3.1.3 for the As-Built BIM:

- BIM object GUID,
- BIM object location, and
- Asset Identification Number - Human interpretable naming convention.

This will allow cross-referencing and automated updating of data between systems.







1.3.2.3 Sustainable Facility Management

In the *Sustainability Matters* report published by the GSA, sustainable facility management is identified: "…as a building practice that helps facility managers upgrade and operate their buildings to achieve long term human and ecosystem balance."

Facility management can make informed building operational decisions with access to accurate, current facility data. BIM supports a reliability centered maintenance program in the following ways:

- Equipment Inventory
- Preventative Maintenance – BIM provides accurate equipment inventories and maintenance instructions
- Work orders
- Predictive Maintenance
- Condition based Monitoring
- Access to system monitoring and controls

1.3.3 As-Designed BIM with Energy Analysis (Tier 3)

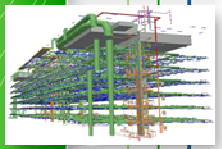
If as-designed BIM with energy analysis is captured, the data can eventually be integrated with a facility BAS, enabling model-based analysis and optimization. Ideally, the BIM energy analysis would enable building operators to understand when and how actual performance differs from predicted performance. This allows a feedback loop of lessons learned and troubleshooting. During operations, it enables building operators to understand how to building was intended to be operated to achieve optimum performance. Feedback regarding the actual operation of the building, as compared to the design assumptions, will then be critical to creating more realistic and accurate energy predictions during design. This work will build on energy analysis requirements and guidance found in the existing BIM Guide Series 05 – Energy Performance.

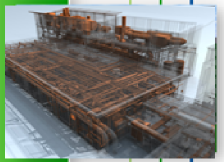
1.3.4 The use of open standards for data transfer

In addition to the specific data required at FM handover, GSA requires data to be delivered with open standards. In order to maintain the greatest flexibility for our project teams, GSA does not mandate a specific BIM-authoring software. Project teams are free to choose whichever BIM-authoring software is suitable for their project workflows, as long as these softwares are able to export the data in open formats, such as IFC. Since GSA currently has multiple CMMS systems, the need for open standards becomes even greater.

1.4 The Vision for BIM and Facility Management

BIM represents both an enhanced technology and a process change for the architecture-engineering-construction-facilities management practices at GSA. Currently GSA has established national processes for New Construction, Major Renovation and Alterations, and Small Projects. While a national process for Operations and Maintenance (O&M) does not exist today, there are





discussions on whether to implement a national CMMS solution and in doing so, develop a standardized O&M process with that implementation.

The business processes were evaluated from a holistic point of view through the lifecycle phases of Planning, Design, Construction, and Post-Construction. How BIM is integrated into the end to end project lifecycle and coordinated throughout the lifecycle plays a significant factor in the quality and comprehensiveness of the BIM-FM information that is achieved at the completion of the project. Furthermore, processes identified can always be improved. As GSA integrates BIM into the project lifecycle, successes and lessons learned should be factored into a continuous cycle of process improvement.

Figure 2 depicts the vision for managing facility lifecycle data through a national standardized business process addressing BIM-FM Integration.

GSA's vision is to streamline how BIM is used in support of BIM-FM integration throughout the facility's lifecycle from Planning through Operations. GSA is responsible for federal real estate and its associated assets, such as drawing sets and equipment information. A Central Facility Repository[1] will be a key component in managing the facility information. The Central Facility Repository plans to integrates and houses 3D object parametric data, MEP system layouts, asset management data, facility management data, building materials and specifications, 2D data, laser scanning data, and real time sensor data and controls. Through the Central Facility Repository, it is envisioned that buildings' BIMs would be managed and maintained for all types of projects including New Construction, Major Renovation / R&A, Small Projects, and O&M. Furthermore, O&M personnel would be able to view the BIMs. Software tools would "sit on top" of the Central Facility Repository to provide security, search and view capabilities, version control, notifications on updates, and analysis and reporting.

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[1] Further details on the mechanics of the Central Facility Repository are described in Section 4: Technology.

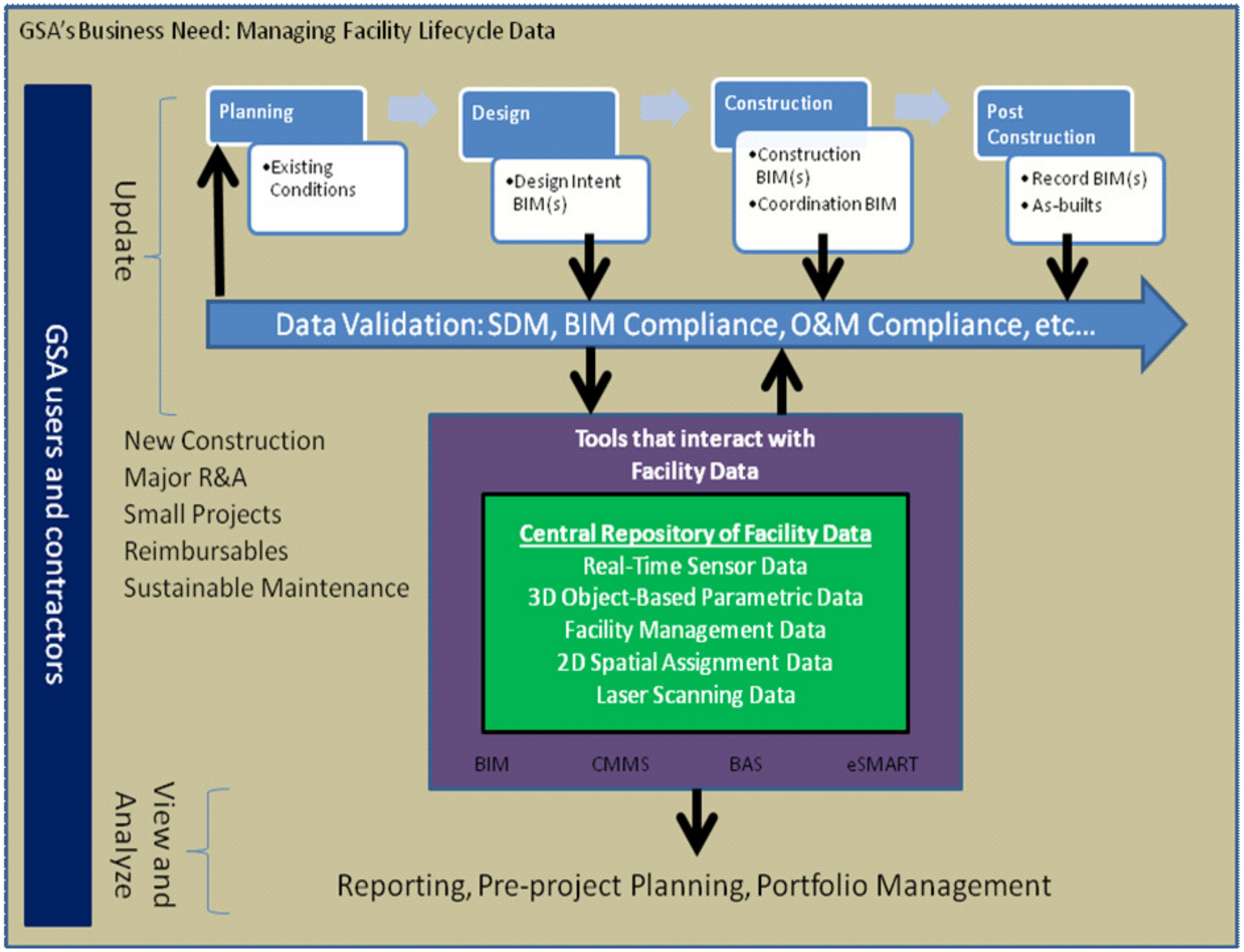
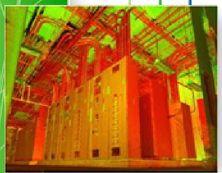
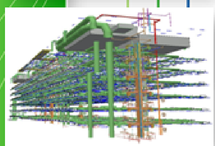


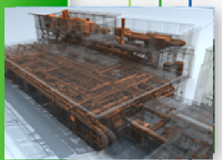
Figure 2: *Vision for BIM for Facility Management Integration*

section 02:

implementation guidance







section 2: Implementation Guidance

This section provides implementation guidance to GSA project teams. Project teams are also encouraged to read the GSA BIM Guide Series 01 – Overview which further provides guidance on implementing 3D-4D-BIM technologies.

2.1 Identify Project Opportunities

Section 1-2 identified GSA business needs for BIM and Facility Management. To identify project opportunities, GSA associates are encouraged to gather appropriate team members (e.g., project manager, facility manager, spatial data manager, Regional BIM Champion) to discuss potential opportunities.

2.2 Define an implementation strategy

Implementing BIM for facility management requires:

- Defining information required and how it is to be used. This is covered in Sections 1 and 3.
- Knowing when in the facility life cycle you are starting implementation.
- Understanding of when in the facility life cycle the information is initially created and by whom.
- Assessing how the project delivery approach (Traditional, Design/Build-Bridging, or other alternative project delivery methods) will affect the contractual responsibility for information delivery.
- Developing appropriate contract terms to require the information deliverables.
- Creating a BIM Execution Plan (BEP) to provide a *master information/data management plan and assignment of roles and responsibilities* for model creation and data integration at project initiation. The BEP will reference the Modeling Requirements defined in Section 3.
- Putting technology in place to allow GSA to monitor compliance and validate the quality of the deliverables. This is discussed in Section 4.
- Establishing the responsible GSA party for monitoring compliance with the BEP and validating the completeness and quality of the deliverables.
- Putting the central repository in place at GSA to receive the deliverables. This is discussed in Section 4.
- Establishing responsibility within GSA for ensuring that the information is maintained, secured and updated to reflect existing conditions of the building.

2.2.1 Identify the phase of the facility lifecycle

Implementation approach will need to be adjusted based on when in the facility life cycle you are beginning implementation and what the vehicle for taking the first step will be. For example:

- There may be no BIM or CMMS for the facility, but you need to conduct an Equipment Inventory and would like to use the inventory as an opportunity to move into BIM for facility management. By capturing your equipment data in COBie format, or even in a spreadsheet, adhering to GSA standardized terminology and using the eSmart Space ID as the Space Primary Key, you will be able to submit your equipment inventory to a central facility repository and also visualize the equipment location.

- A Small Project may be affecting just a portion of a facility or a single building system. By creating a BIM for that project and registering that BIM to the 2D floor plan, you can begin to create a 3D model of the facility. If the project involves reconfiguring rooms, require a Spatial Program BIM (see BIM Guide Series 02). In addition, if the project involves equipment, adhere to the COBie format and GSA standardized terminology and use the eSmart Space ID as the Space Primary Key.
- New Construction offers the best opportunity to do a full BIM for facility management implementation, as described below.
- Major Renovations in which a facility is substantially gutted permit an implementation similar to New Construction. If the scope of a Major Renovation is limited, then the implementation will follow the Small Project model.

2.2.2 Identify Impact of Project Delivery Approach on Implementation

Under a Traditional (Design/Bid/Build) project delivery approach, there will be multiple contracts and multiple responsible parties for BIM development and deliverables. Requirements and contract language must be geared to the scope and responsibilities of the respective parties.

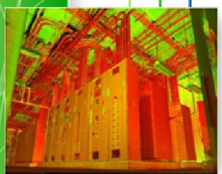
Alternative project delivery approaches, such as Design/Building, Design/Build-Bridging, CMc (CM at risk), and Integrated Project Delivery (IPD) blur the distinctions between the design and construction teams. In the cases of D/B-B, a single entity would be responsible for the delivery of the information required for facility management. In the case of Traditional (Design/Bid/Build) delivery as indicated above, the A/E and the contractor would each have BIM and COBie deliverables defined in their contracts.

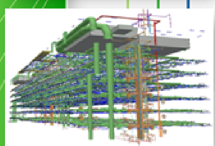
2.2.3 Develop a BIM Execution Plan

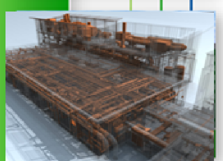
project-based **A project based BIM Execution Plan (BEP)** is developed to provide a *master information/data management plan and assignment of roles and responsibilities* for model creation and data integration at project initiation. The BEP shall align the project acquisition strategy needs and requirements with GSA technical standards, team member skills, construction industry capability, and technology maturity. Through this process, the team members and GSA project management shall jointly agree on how, when, why, to what level, and for which project outcomes BIM will be used. The BEP brings together the modeling and attribute requirements defined in Section 3 with the format requirements (COBie, IFC, etc.), the current extent of BIM implementation for the facility, and the project-specific conditions and work processes to ensure that GSA receives the facility management information it requires dependably, timely, and cost-effectively. The BEP must also address the team members' information exchanges amongst themselves. The project team member(s) holding a contract with GSA should have the responsibility for producing the BEP. For New Construction, Major Renovation, and larger scope and dollar Small Projects, project specific BEPs would be developed. The BEP is considered a living document and shall be continually developed and refined throughout the project development lifecycle and be used as a means to keep the various contractor's use of BIM consistent. Project teams shall produce a BIM Execution Plan based on the BIM Project Execution Planning buildingSMART alliance™ (bSa) Project.

The Building Information Modeling (BIM) Project Execution Plan Content includes the following sections major sections:

- BIM PROJECT EXECUTION PLAN OVERVIEW







- PROJECT INFORMATION
- KEY PROJECT CONTACTS
- PROJECT GOALS / BIM USES
- ORGANIZATIONAL ROLES / STAFFING
- BIM PROCESS DESIGN
- BIM INFORMATION EXCHANGES
- BIM AND FACILITY DATA REQUIREMENTS
- COLLABORATION PROCEDURES
- QUALITY CONTROL
- TECHNOLOGICAL INFRASTRUCTURE NEEDS
- MODEL STRUCTURE
- PROJECT DELIVERABLES
- DELIVERY STRATEGY / CONTRACT

2.2.4 Determine When and By Whom Information Is Created

On new construction, the A/E is responsible for the building configuration, accommodation of the spatial program, sizing of building systems (structure, MEP/FP) and location and specification of major equipment. This information is developed during Design. Details of the building systems and sometimes the enclosure system, as well as specific product details are provided by the trade contractors and fabricators and developed during construction. However, in alternative project delivery approaches, responsibilities may change and some tasks, such as detailing building systems, may be performed earlier in the design/build process. In addition, there is equipment information generated during Commissioning, by the Commissioning contractor.

The COBie specification assigns specific information to be entered by the A/E and the contractor. See Section 3 for COBie deliverables from design, construction, and commissioning.

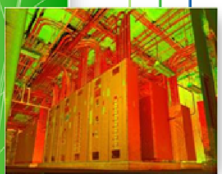
2.2.5 A/E Requirements

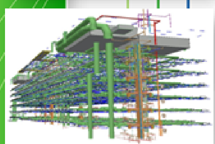
In Traditional (Design/Bid/Build) project delivery, the A/E contract should contain requirements for BIM and COBie deliverables, as well as a requirement that the A/E deliver for GSA approval a project BEP.

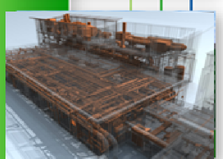
2.2.5.1 BIM deliverables

BIM deliverable requirements include:

- Spatial Program BIM, per BIM Guide Series 02, delivered at Final Concept Design. Project teams are still required to submit 2D drawings per PBS CAD Standards.
- Design Intent BIM: Building information model(s) created by and conformed to the bid addenda by the A/E. Elements are modeled per BIM Guide Series 02 and are accurate in terms of quantity, size, shape, location and orientation. The Design Intent BIM includes the Spatial Program model. Elements also contain unique asset identification numbers that link them to the COBie data. The Design Intent BIM must be submitted in both .ifc and native format.







- MEP/FP BIM, created by and conformed to the bid addenda by the A/E, that includes all GSA-required equipment. MEP/FP BIM must be submitted in both .ifc and native format.
  - All GSA-required equipment shall include the following attributes:
    - Equipment GUID
    - Asset Identification Number
    - Space Primary Key
- Extract all major plans, sections and elevations from the BIM. The design, three-dimensional location, size and relationships of the building elements and equipment required by GSA in the BIMs shall be included in and derived from the BIMs only.
- Transition BIM to Contractor for the Construction phase. The BEP shall outline the transition process including changes in roles and responsibilities to ensure Design BIMs are appropriately used and leveraged during construction.

2.2.5.2 COBie deliverables

A COBie submittal during the design phase is required. See Section 3 for more about COBie requirements.

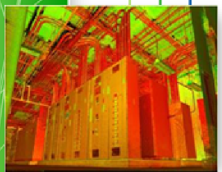
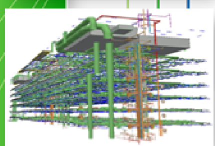
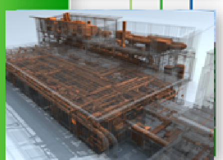
- Include the following COBie worksheets: Contact, Facility, Floor, Space, Zone, Type, Component, System, Document, and Attribute.
- Use the same coordinate system, model origin, and units used in the BIMs.
- Handover COBie submittal to the contractor for the Construction phase.
- Use unique asset identification numbers for COBie and corresponding BIM objects.
- GSA Project Managers shall contact their Regional BIM Champions for specific contract language.

2.2.6 Contractor Requirements

Best practice in construction phase BIM use is for the designer, construction manager or a third party to create the base building BIM (architectural and structural components) and for the trade contractors to create the BIMs for the systems they are fabricating. These are the Construction BIMs, which are merged to form the Coordination BIM. By resolving building system conflicts in the Coordination BIM, the construction team can minimize field problems and improve budget and schedule conformance. In order to perform accurate interference checking, the Construction BIMs are updated throughout construction.

An important point is that the various trades should *build to the model,* to ensure that coordination benefits are achieved. If this is the case, the coordinated Construction BIMs represent an immediate, extremely complete, accurate and useful physical description of the building to inform a broad range of facility management activities.

Again, for Traditional (Design/Bid/Build) delivery, the contractor must provide an updated project BEP, BIM, and COBie deliverables. These requirements can be included in Division 1 specifications.

2.2.7 Monitoring Compliance and Submittals

Quality control checks on BIM Models are performed at key project milestones defined in the BEP and incorporated into the contractor's Quality Service Plan (QSP) and Construction Quality Control (CQC) Plan. The quality control checks occur across the project lifecycle. GSA develops the means and methods to properly enforce contract BIM requirements throughout the project delivery and O&M process. This includes enforcement of standards and guidelines (e.g. attributes, naming conventions) and assurance that the virtual building is being maintained in conjunction with the constructed building at designated project checkpoints. GSA is also developing a VDC scorecard to measure the quality of BIM use and compliance on projects. The scorecards will be evaluated at project milestones defined in the BEP.

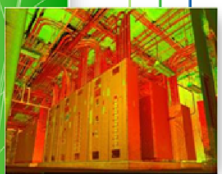
BIM models are validated against the standards established in the BIM Guide Series to ensure accuracy and completeness of the model. The BIM Project Coordinator, identified in the BEP, will lead this effort and leverage other project resources as needed to assist. Automated validation, as is possible for Spatial Program Validation, is the target approach. The output of the validation effort is a list of deficiencies and when they should be corrected, e.g. at current or next project milestone. The latter is important to ensuring that the accuracy of time sensitive information is addressed at the current milestone. An example of time sensitive information is what is needed by SDM to determine impacts to an Occupancy Agreement (OA) and whether the OA needs to be re-signed. If a deficiency is reported in the validation and it may have an effect on the OA, then the model should be updated immediately so that impacts can be determined.

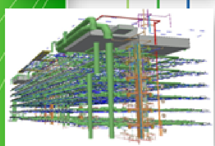
GSA plans to utilize a BIM scorecard to provide on-going evaluation of BIM use and compliance on GSA projects. The scorecard is intended to ensure project objectives and goals outlined in the BEP are being met. The scorecard will also highlight potential areas of improvement during the project. Project teams should contact their Regional BIM Champion and Central Office BIM Program to obtain a copy of the scorecard.

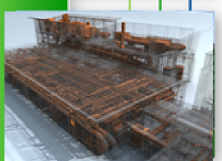
2.3 Standardizing the identification, classification and coding of equipment

One early Lesson Learned from Pilot Projects is the importance of standardizing what information is required, what that information is called (e.g., Asset Identification Number) and the allowable terminology for that information, For example: The Equipment Identification consists of the standard Equipment Acronym and a Sequence Number.

In one Pilot Project, HNTB received an export of 1,018 Maximo records in .xls format for Building 105 in the GSA's Good Fellow Complex in St. Louis, MO. One of the goals of the project was to match the Maximo records to the corresponding equipment in a Revit BIM. Despite comprehensive review of existing building documentation as well as field verification efforts, HNTB was able to match only 176 out of 1,018 Maximo® records (17%) in the BIM. They recommended that the integration of CMMS and BIM required more standardization and structuring of the data within both systems.







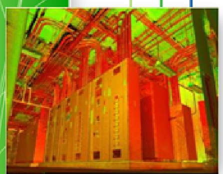
Today CMMS systems are not standardized nor do all Regions use a CMMS. There is value in Integrated Facility Management, having a shared CMMS solution in all Regions will be beneficial. At this time, a national team within GSA is collaborating with regions to develop and implement a National CMMS. –However, standardizing the system without standardizing the data will be ineffective. Accurate inventories are critical for a CMMS, and validation of PBS' equipment inventory is needed before loading to the CMMS.

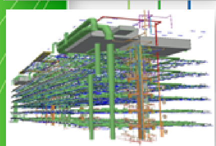
GSA is working towards a comprehensive, standard list of building element and equipment types, and their attributes. A number of GSA internal as well as industry-wide initiatives have partially addressed this issue:

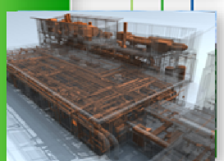
- GSA's National Equipment Standard Team (NEST) has done considerable work to standardize the identification, classification, collection, and coding of equipment within facilities across the regions.
- For the Richard Bolling Federal Office Building BIM Pilot Project, Region 6 provided a list of required equipment types and attributes for loading into their Computer-Aided Facility Management System (CAFM).
- For the Rodino BIM for FM Pilot Project, the GSA Service Center prioritized a long list of equipment types and defined their attributes, based on PBS Operations and Maintenance Standards, Draft 2.1, April 24, 2007.
- As part of the National Building Information Model Standard effort, the Inter-Agency Federal Asset Classification Team (IFACT) is addressing the problem that, without an industry standard, users have been unable to cross-reference equipment and other asset data between organizations, agencies, industry, disciplines, and software solutions. Knowing that this creates inaccuracies and inefficiencies that have a major impact on effective maintenance, operations, and management of assets and facilities, IFACT has contributed to OmniClass Table 23 - Products and the United States National CAD Standard®, and created a cross-reference database to improve equipment asset object identification and tracking, and asset information management. These enhancements will allow a higher degree of data integration for all related software solutions and facility management systems. Participating Agencies include:
  - General Services Administration
  - Department of Veteran Affairs
  - Department of State
  - Department of Homeland Security

  This group has addressed the harmonization of acronyms across multiple industry standards and organizations. See www.wbdg.org/pdfs/bim_fs_ifact.pdf .

- Specifiers' Properties Information Exchange (SPIE) is a NIBS/buildingSMART Alliance project to create an open schema to allow manufacturers to export product data into a format that can be consumed by designers, specifiers, builders, owners, and operators. This initiative aims to turn specifications into property sets that can be applied to the appropriate BIM objects. The focus is on the properties needed for specification, discovery, selection, and verification of products against those specifications. See http://www.buildingsmartalliance.org/index.php/projects/activeprojects/32.





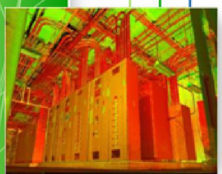


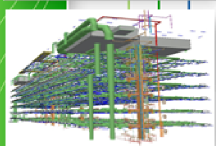
- The International Framework for Dictionaries (IFD) is, in simple terms, a standard for terminology libraries or ontologies, based on internationally-accepted open standards that have been developed by ISO (ISO 12006-3:2007). It is multi-lingual. See www.buildingsmart.com/content/ifd.

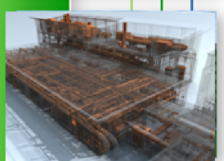
GSA project teams should see their Regional BIM Champion and Central Office BIM Program for guidance.

section 03:
modeling requirements

section 3: Modeling Requirements







While design and construction BIMs are produced throughout the project lifecycle, this section focuses on the modeling requirements for a Record BIM. The Record BIM is submitted at project turnover to document the final as-constructed building and is archived as part of the project record. The As-Built BIM is an editable copy of the Record BIM that is maintained by GSA for updates to the building and systems configuration. Section 3.2 describes which components should be modeled for each building system and the object properties that should be included in the Record BIM.

Equipment attributes required for facility management activities, such as manufacturer, capacities, model number, etc. should be submitted in the current version of the Construction Operations Building Information Exchange (COBie) format. Section 3.3 describes the minimum COBie requirements. It is important to note that this information will be entered by various project team members at various points in the design and construction phases. Project teams should define how COBie requirements will be met in the project BEP.

3.1 High-Level Modeling Requirements

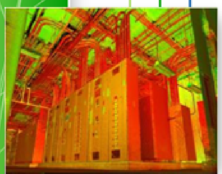
3.1.1 BIM-Authoring Applications

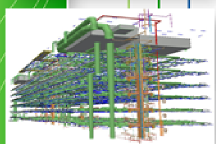
Project teams are required to use BIM-authoring applications which are IFC compliant to meet GSA BIM requirements. The BIM-authoring application, at a minimum, should be able to create IFCs in compliance with the coordination view, spatial program validation view (BIM Guide Series 02), and COBie. BIM-authoring applications, unlike traditional CAD applications, enable project teams to provide object intelligence for building elements. CAD applications that primarily focus on producing printed or plotted drawings, often referred to as 2-D CAD applications, are generally not adequate for a BIM design process and do not satisfy the BIM requirements in this Guide. Further, 3-D functionality in a CAD application does not automatically imply that the system is capable of producing a BIM. Project teams should consult with GSA Central Office to determine if a software application will meet GSA BIM requirements.

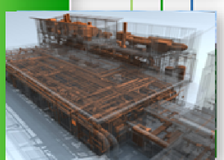
> ***Note****: The ability of BIM-authoring applications to manage components and spaces with complex geometric shapes varies. BIM Modelers should be aware that in some situations, IFC BIM export from a BIM-authoring application may fail to preserve such complex shapes. This could be a limitation in some applications' level of support for the IFC standard. BIM Modelers should work with their BIM-authoring vendor to understand if any such limitations exist in the IFC export to be used for submission to GSA. Limitations that may affect submissions to GSA shall be documented in the BEP.*

3.1.2 Model Containment Hierarchy

The model structure (or containment hierarchy) of BIM is normally generated by the BIM-authoring application. Users have little if any possibility to influence it. In situations where the user can define the model containment hierarchy, it should be structured







as in the IFC data model. Typically, spaces and building elements are contained in a building floor, building floors are contained in buildings, buildings are contained in a site, and a project can contain one or more sites. In the submission to ODC, the site object is optional (in which case the building is contained directly by the project).

This containment hierarchy can be summarized as follows:

- Project
  - Site
    - Spaces
    - Building Elements
    - Buildings (same as below)
  - Buildings
    - Building Floors
      - Spaces
        - Building Elements

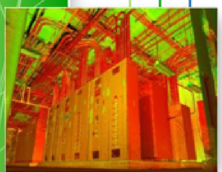
Spaces can also be members of one or more Zones (e.g., daylighting, HVAC, or even an organizational department). See BIM Guide Series 02 for more detail on Spaces and Zones.

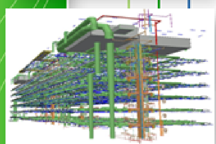
In general, the BIM-authoring application will manage this for the BIM modeler, but it is important to be aware of this containment hierarchy in order to better understand the requirements for developing a BIM. As always, BIM modelers are encouraged to consult with their BIM-authoring application vendor for more information if this topic is unclear.

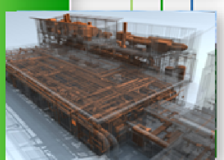
3.1.3 Asset Identification Number

A major feature that differentiates CAD from BIM is the fact that BIM provides a computable description of a building. The lifecycle view of a BIM requires tracking what changes are made, when and by whom, over the life of the facility. To be useful, changes must be tracked at the element or component level, not at the file level. Thus, each object within a BIM needs to have a unique identity that can be referenced as changes occur. Within the software community, this unique identifier is implemented as a Globally Unique Identifier, or GUID. The concept is that a GUID is a totally unique number – one that will never be generated twice by any computer in existence. While each generated GUID is not guaranteed to be unique, the total number of unique keys is so large that the probability of the same number being generated twice is very small.

GUIDs are typically managed by the software and not under control of the user. Some early BIM adopters discovered that certain BIM analysis applications "recreated" the model and assigned all new GUIDs to the BIM objects. In order to ensure that GSA and







its consultants and contractors can manage each BIM object's unique identifier, each equipment object shall have an Asset Identification Number in addition to the GUID.

3.2 Design, Construction, and Record BIMs

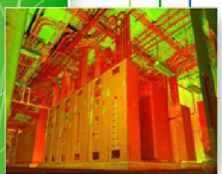
Throughout the project, various types of BIMs are created and modified. Project teams will start with a design intent BIM, move to multiple construction BIMs, and ultimately, create a Record BIM. At the end of construction, there are multiple, building system specific Construction BIMs. Typically, the architectural and the structural models are those produced by the design team with minor modifications. In the case of a steel structure, a fabrication model may be available. The mechanical/electrical/plumbing/fire protection (MEP/FP) models are frequently produced by the trades using very specialized software packages that interface with cost estimating, inventory, and /or fabrication systems. As the BIMs are created for the project, the project team should follow the BEP in demonstrating how the virtual building is being maintained in conjunction with the constructed building at designated project checkpoints.

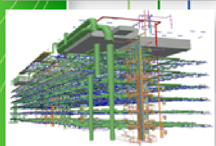
3.2.1 Required BIM Objects and Properties

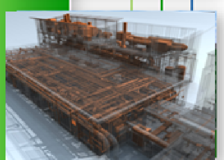
Objects

The following object types are required in the Record BIM submitted to GSA:

- All objects required by BIM Guide Series 02
- Ceilings
- Lighting systems, fixtures and equipment
- Communications systems and equipment
- Irrigation system and equipment
- Furniture manufacturers and specifications
- Electrical systems, equipment, and clearances
- Mechanical systems, equipment, insulation, and clearances
- Plumbing systems, equipment, insulation, and clearances
- Fire protection systems, equipment, and clearances
- Specialty systems, equipment, and clearances







GSA project teams in conjunction with the Service Center should define the minimum list of equipment types required in the BEP. See Section 2.2.4. The BEP should spell out specific, detailed modeling requirements. These will vary depending on building type, building system types, and location. If no attribute information is listed in the BEP, project teams are required to submit accurate geometric representations and object properties (see below) for all objects listed above.

GSA project teams shall contact regional BIM Champions for specific contract language for submitting COBie files. This GSA-specific language is based on a general specification found on the Whole Building Design Guide (http://www.wbdg.org/resources/cobie.php).

Object Properties

The minimum set of properties that should be associated with each required BIM equipment object:

- Equipment GUID,
- Equipment Asset Identification Number, and
- Space Primary Key (i.e., object location)

Space objects must include GSA space properties, as defined GSA BIM Guide Series 02.

3.2.2 National Equipment Standard

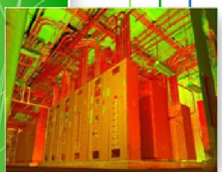
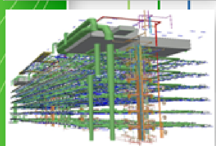
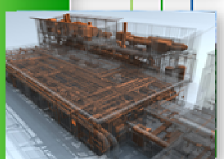
GSA is currently developing a National Equipment Standard to be used on GSA projects. The overall purpose of utilizing national equipment standards is to enable GSA to leverage equipment data through the facility lifecycle. GSA intends to utilize and update this data throughout the facility lifecycle - through new construction, small projects, building operations, and major renovations.

3.2.3 Organization of Record BIMs

To be at all useful, the Record BIMs will need to be partitioned by floor and building system. The structural model should be partitioned to include the slab for the relevant level up through the framing for the level above. The slab at the level above should not be included, to allow visualization of the MEP/FP systems at each level. If the building floor plate is very large, then additional partitioning may be advisable. A composite model can always be assembled from multiple sub-models. Organization of models shall be determine by the project team and documented in the BEP.

3.2.4 Modeling Precision

The system of measure for modeling PBS new construction projects is hard metric (e.g., 250mm). The system of measure for modeling renovation and alteration projects can be soft metric (e.g., designations such as 1 inch or 25.4mm in which metric equivalents are attached to International System of units (SI)). Measurement accuracy shall be in accordance with the *PBS CAD Standard* (June 2010).

3.2.5 Consistent Units and Origin

In order to properly register all building models in 3D space, a common coordinate system and units must be used. Scale will be 1:1 (world scale), units for existing buildings will follow that the current building measure system, or per P100. Imperial inches is the unit standard for models for Spatial Data Management (SDM). Models used to represent a single building will use a common reference point for each model assembly, example 0, 0, 0 for the south west exterior finish of the ground floor with north being the top of a sheet or screen view.

3.2.6 Prior to submittal of Record BIMs

Prior to submittal of Record BIMs the following are required:

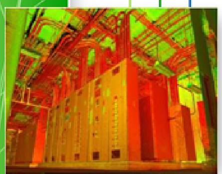
- Verify that all Construction BIMs (building, structure, finishes, and building systems) represent as-built conditions, including Architectural Supplemental Instructions, Change Notices, and field changes and include the minimum attributes required by GSA.
- Create, for each discipline or system, a Record BIM for each floor of the building. Save in native format of authoring application.
- Verify that the Record BIMs for each floor register in X, Y and Z dimensions.
- MEP/FP BIMs: verify that primary keys correspond to those in equipment inventory.
- Create .ifc version of each Record BIM.
- Create a composite model of the Record BIMs in .ifc format.

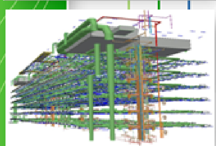
3.2.7 Maintaining and Updating As-Built BIMs

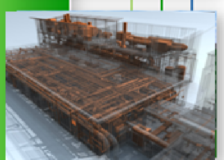
Record BIM serves two purposes: to document the as-constructed building and components for use in future projects and O&M activities, and as the project record archive. The As-Built BIM is maintained by GSA to capture building and component updates throughout the facility lifecycle. GSA has identified several major issues that must be resolved in order to efficiently maintain BIMs during facility operations. Internally, GSA has been identifying potential work processes and the technology requirements to support these new processes, but no future process has been established yet. GSA welcomes any feedback or comments on these major issues.

What needs to be maintained in the BIM versus externally?

For the most part, non-geometric data about a facility will be more easily accessed and updated if maintained in a database external to the parametric model. This will not necessarily be a standard relational database but could be a model based central repository. A common unique identifier for each item of interest must be maintained in the BIM authoring application model and the database to maintain association. Additional attributes may be included in the BIM authoring application model by designers or contractors to meet their own needs, such as generating wall, window and door schedules and extracting quantities for cost estimating.







BIM authoring tools use proprietary methods to manage the parametric relationships among building components and assemblies. This means that "perfect" data transfer between unlike BIM authoring tools via a neutral standard such as IFC is not possible at this time. This needs to be taken into consideration when discussing the maintenance and updating of as-built BIMs. This may change in the future as greater IFC support becomes available across the broad range of BIM authoring applications used by designers and trade contractors. Currently, it is possible to move any AutoCAD-based model to IFC through a multi-step process:

- Convert proxy objects to AutoCAD-native elements
- Load into AutoCAD MEP
- Create IFC file

When loaded into a BIM-viewing application or Model Checker, these files have little property information but do contain GUIDs. These GUIDs could be assigned as primary keys and could be coordinated with the external database or COBie submittals containing the property information.

How should GSA update the As-built BIM to reflect ongoing facility changes?

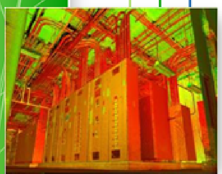
The update process will depend on the type of information that needs to be updated:

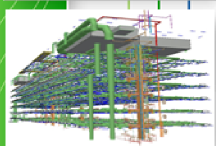
- Update attributes: can be accomplished by updating the external database
- Replace equipment: if a new primary key needs to be assigned, the change must be made in both the BIM and external database. This would probably require a delete/add operation in the BIM authoring tool; if the primary key remains the same, then this operation is the same as above
- Reconfigure space or building systems: this requires use of a BIM authoring tool to add, delete, move building elements: walls, doors, windows, ducts, pipes, light fixtures, etc. For extensive renovations, the IFC file should probably be used as an underlay to create a new model of the portion of the facility being reconfigured. When such a project affects only a portion of the floor, selective updating of the as-built model will be tricky. This is true of CAD as well, but a requirement to maintain primary keys on existing-to-remain building elements will further complicate the issue.

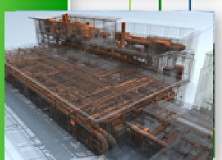
3.3 COBie Submittals

The Construction Operations Building Information Exchange (COBie) is an open standard approach to handing design and construction information over to facility management. The Army Corps of Engineers and NASA have been the primary developers of COBie, with several other agencies (including GSA) adopting this open standard. For the current version of COBie and a more detailed explanation, please visit the Whole Building Design Guide (http://www.wbdg.org/resources/cobie.php).

COBie provides an open standard format for capturing project data, particularly equipment data, when it is generated during the design, construction, and commissioning phases. COBie minimizes information exchange loss and associated costs from the physical handover of project information at the end of a project. COBie maximizes the chances of receiving relevant information







when the information is created. It has been demonstrated through NIBS sponsored “COBie Challenges” that COBie data can be imported into a facility management system such as a CMMS to update and track facility asset data.

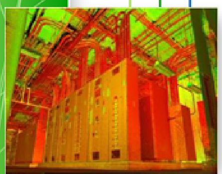
Not all attribute information must be in a BIM, but required information should be transferred via COBie-compliant files. Required COBie space, zone, and equipment data must be linked to the objects in the Record BIMs. A common primary key should be assigned in both COBie and the model to link the BIM objects to their associated attributes. Project teams shall document how they will comply with COBie requirements in their BIM Execution Plan.

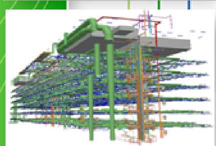
The COBie-compliant Excel fileconsists of 16 separate spreadsheets or worksheets that capture project data from different facility lifecycle phases. The following table identifies each COBie worksheet, the purpose of the worksheet, and the facility lifecycle when the data is captured.

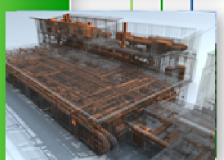
Table 1: Standard COBie Worksheets

GSA Required	COBie Worksheet	Purpose	Lifecycle When Data is Captured
Yes	Contact	Capture data providers and manufacturers contact information.	All
Yes	Facility	Facility description and measurement standards.	Design
Yes	Floor	Identifies floors or levels.	Design
Yes	Space	Identifies rooms or spaces.	Design
Yes	Zones	Identifies zones.	Design
Yes	Type	Identifies equipment, parts, or materials and warranty information.	Design/Construction[1]
Yes	Component	Identifies each equipment, part, or material instance and installation information.	Design/Construction[2]
Yes	Systems	Associates building components with building systems.	Design/Construction
No	Job	Identifies operations and maintenance procedures.	Construction/Commissioning[3]
No	Resource	Special materials, tools or training required to complete a Job Task.	Construction/Commissioning

[2] The worksheet is created in the first facility lifecycle and updated in the second facility lifecycle.
[3] The worksheet can be completed in either facility lifecycle phase.







No	Spare	Identifies spare parts lists.	Construction/Commissioning
Yes	Documents	Indexes submittal documents.	All
No	Issues	Identifies other issues including operational safety issues.	All
No	Coordinates	Applies coordinates to a facility, floor, space or component.	All
Yes	Attributes	COBie2 extensibility alternative for user defined columns in other worksheets.	All
No	Connections	Identifies logical connections between components.	All

3.3.1 Minimum COBie Requirements

For GSA, a COBie deliverable in accordance with Table 1 shall be submitted for all projects that involve space, zone, building systems or equipment changes.

The COBie deliverable should contain attribute data for all BIM objects required by the GSA project team, as outlined in the BIM Execution Plan. The Record BIM and the COBie deliverable should contain the same Equipment Primary Key, Equipment Identification, and Space Primary Key for each BIM equipment object. The Equipment Primary Key and the Equipment Identification link the equipment attribute data in the COBie deliverable to the BIM equipment object in the Record BIM. Electronic copies of product information and shop drawings shall be linked to the model.

3.3.2 Creating COBie Deliverables

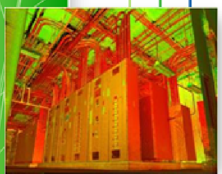
COBie deliverables can be created and updated one of fourways:

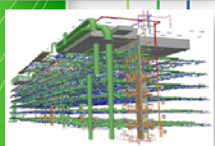
- Manually enter data in the COBie spreadsheet,
- Extract BIM attribute data into a COBie compliant file, and
- Direct use of COBie compliant software.
- Exporting an IFC file with correctly structured property sets.

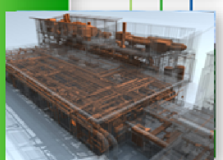
The method selected for creating and updating the COBie deliverable should be defined in the BEP. Project teams should consider the capabilities and resource requirements among the different methods to deliver COBie data when determining which method to use.

Standardized terminology is required. GSA project teams should consult their Regional BIM Champion or Central Office BIM Program for COBie templates and specifications.

section 04:
technology







section 4: technology

This section describes various technologies for BIM for facility management.

4.1 Technology Requirements

4.1.1 Central Repository of Facility Information

Key to using BIM effectively for facility management is the establishment of a centralized repository of facility data. The data may actually be stored in multiple, linked repositories but the data must serve as a centralized resource, available to all appropriate users.

The question of whether there is one repository for all of PBS or each Region has its own repository does not affect the technology requirements. What is important is having the data captured in the same standard format across all regions.

4.1.2 Infrastructure

Software tools and communication links must be responsive if users are expected to access and maintain facility information in a central repository. Necessary technology infrastructure includes:

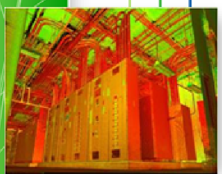
- Adequate, high-speed data storage
- Adequate server capacity
- Adequate desktop computer processing capacity
- Adequate numbers of software licenses
- Adequate network bandwidth
- Responsive license servers

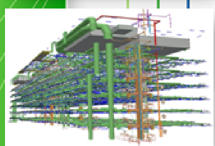
4.1.3 Security

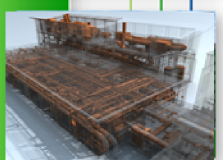
All facility management information and FM BIMs should be maintained inside GSA firewalls. However, external repositories, accessible to GSA, A/Es and construction teams, are needed to allow copies of Design, Construction, Record, and As-Built BIMs to be made available to project teams, to permit the sharing and collaborative updating of the project models, and to support the submission of the As-Built BIMs and other electronic deliverables. These repositories must meet security requirements for sensitive but unclassified (SBU) information.

4.1.4 Functionality

From the project process through the update and maintenance of facility information throughout the lifecycle, there are a number of different technology requirements:







- During project execution, the design and construction teams need the ability to collaborate on the development of the facility model. Multiple groups within GSA, including Design & Construction and Spatial Data Management, also need to be able to monitor progress and compliance to GSA requirements throughout this process.
- At project closeout, the facility information must be handed over and uploaded into the central facility repository inside the GSA firewall.
- During Operations and Maintenance phase, tools are needed to update the As-Built BIMs and synchronize those updates with activity in the CMMS and Equipment Inventory Database, as well as with eSmart (GSA's 2D drawing repository).

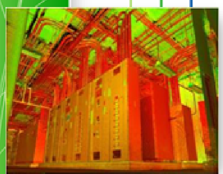
4.2 The Vision: Technology Overview

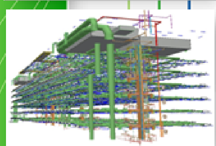
The diagram, Overview of Central Facility Repository, in Appendix A details the ultimate vision for the contents and functioning of a central repository system. Its components are described below.

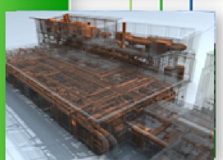
4.2.1 PBS Central Facility Repository

The diagram envisions a single repository that contains many data packages in a range of formats. It defines specific applications that "own" each data package - that is, applications that can change the data. For most data packages there are two "owner" applications:

- BIM and CMMS:
  - Equipment
  - Warranty
  - O&M Manuals
  - Materials and Finishes
  - Commissioning
  - Energy
- BIM and eSMART
  - Spatial data related to Design, Construction, and As Builts
- CMMS and SBS
  - Performance Data
- BIM only
  - Cost Estimate







4.2.1.1 Repository of Files

The Central Facility Repository manages a range of file types, including:

- BIM models
- COBie compliant files
- 2D drawing files
- Project documents
- Equipment lists
- Preventive maintenance schedules
- Warranty documents
- O&M manuals
- Laser scanning files

4.2.1.2 Versioning of Files

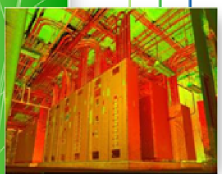
The Central Facility Repository manages multiple versions of all files and assigns the following statuses:

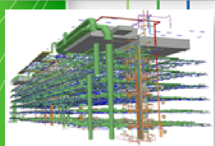
- Pending – represents changes to the building as a result of a project which has not reached substantial completion yet
- Current – represents existing conditions of the building inclusive of cumulative set of changes on all projects that have reached substantial completion
- Archived – past history of drawings, objects, and equipment related to the building

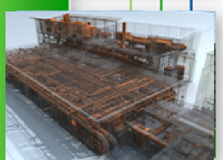
4.2.1.3 Functionality

The key functionalities provided directly by the Central Facility Repository are:

- Data Security: security requirements for compliance with federal government security
- Search and View: easy and intuitive searching and viewing of data
- Version Control: versioning of files and data; maintenance of multiple versions
- Audit trail: tracking each version's creation date and author, as well as other metadata, to maintain history of changes
- User Notifications Upon Update: stakeholder notification when data or files change - sent to those users who have checked out that data or file and to those users who registered to receive notifications such as O&M and SDM personnel.
- Analysis and Reporting: tools to support analysis and reporting of the data such as identifying equipment down time, failure history, repair/restoration cost history, operation/maintenance man-hours, efficiency, and energy consumption (if metered).
- System Review and Control: access to various facility management systems
- File and Data Naming Standards: communication of standards and conversion to those standards where applicable
- GUID Generation / Maintenance: ensures uniqueness of GUIDs in a building, across buildings, and across Regions







4.2.1.4 Middleware Layer

All data entering the Central Facility Repository passes through an automated data conversion and standards compliance checking layer.

4.2.1.5 Synchronization

The Central Facility Repository should support two-way synchronization with GSA internal systems such as:

- Smart Building Systems (SBS)
- Building Automations System (BAS)
- Energy Management System (EMS)
- Computerized Maintenance Management Systems (CMMS)
- eSMART
- ePM
- RExUS (maybe 1-way only)
- Business Intelligence (1 way only - for analysis)

4.2.1.6 Primary Data Sources

Primary data sources are projects: New Construction, Major Renovations and Small Projects. This data may be submitted by either external consultants or contractors or internal GSA staff.

4.2.1.7 Check-Out/Check-In

The Central Facility Repository envisions a Check-Out/Check-In process, but not the one that is commonly understood from traditional electronic document management systems.

4.2.1.7.1 Check-Out

Checking out does not lock the data. Rather, multiple check-outs of the same package are supported. The Check-out process determines if the info package has already been checked out. If it has, the process notifies all users who have it checked out. If any changes occur in the package after check-out, all users are notified.

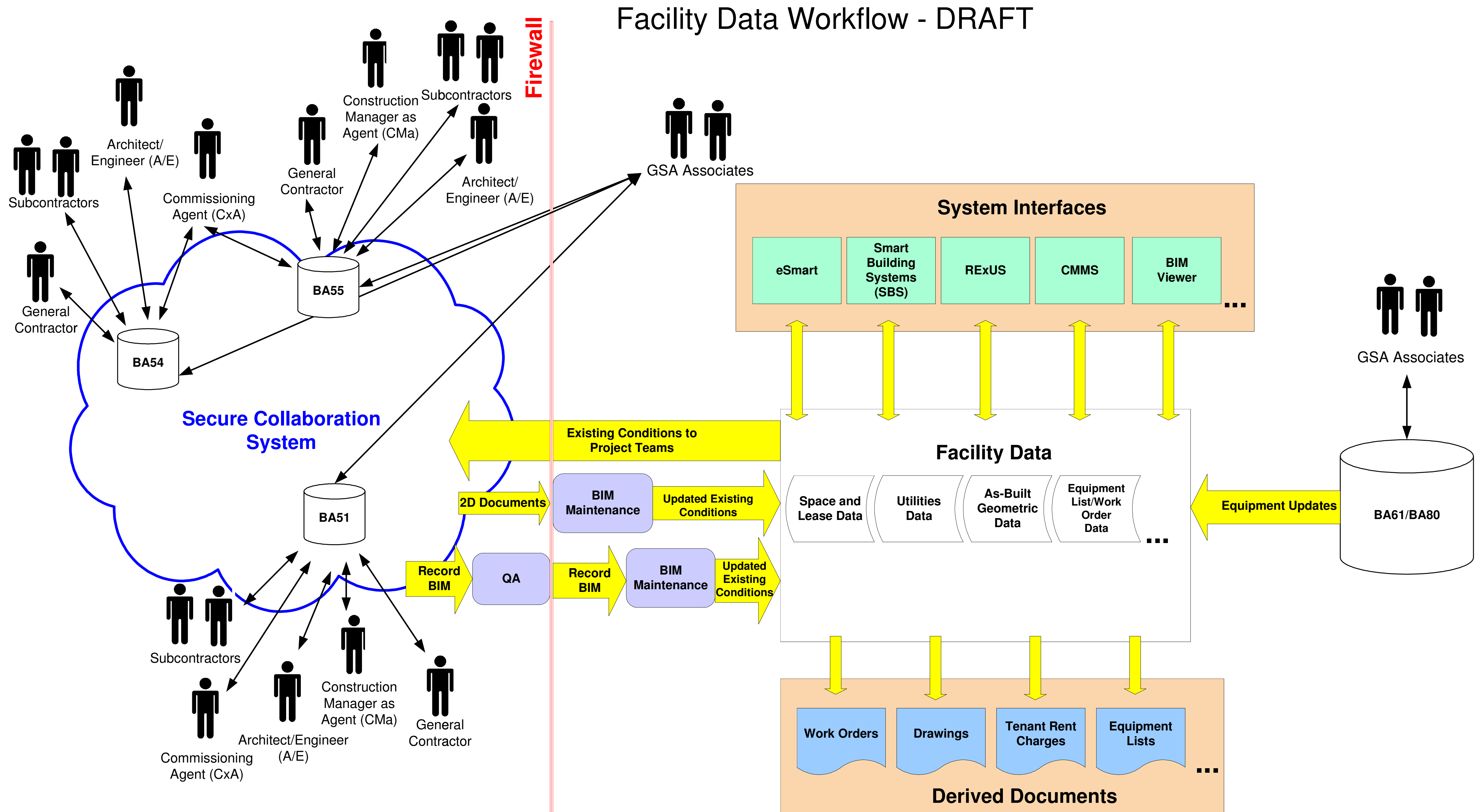
4.2.1.7.2 Check-In

Checking in involves the following steps:

- Notify QC review/approval process
- Determine if the data package has changed since check-out
- Create an historical record of the information package
- Update the information package based on the change
- Notify stakeholder(s) of change

4.3 Current Technology Challenges/Recommendations for Immediate Implementation

Despite the fact that BIM is a relatively young technology, it has developed to the point where it can be effectively deployed for facility management. Figure 3 revises the Central Facility Repository vision for current BIM deployment.

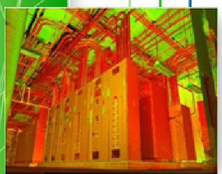


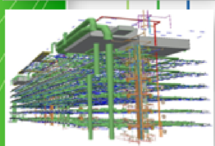
Firewall

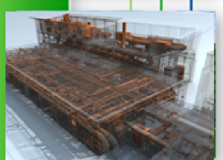
Notes:
1. BA51 is the GSA acronym for New Construction.
2. BA54 is the GSA acronym for Small Projects.
3. BA55 is the GSA acronym for Major Renovations & Alterations.
4. BA61 is the GSA acronym for Operations and Maintenance.
5. BA80 is the GSA acronym for Reimbursable Work.

Last Updated: December 22, 2010

Figure 3: Facility Data Workflow for Current BIM Deployment







The following discusses current technology challenges and provides recommendations for immediate implementation.

4.3.1 Multi-User Update

New construction projects will provide the initial facility information. That information will be updated in multiple ways:

1) Exchanging data with other GSA systems
2) Capturing changes resulting from both small projects and major renovations

Within any facility, multiple change activities will overlap. Therefore the multi-user access requirements are quite complex. The type of Check-Out/Check-In system envisioned in 4.2.1.7 does not exist today and would be extremely cumbersome to manage. If multiple users have modified the same data, whose changes take precedence? The last check-in? What if that is old data whose check-in was delayed, rather than data that represents the latest building modification? It is for this reason that Check-out typically locks the data and permits Check-in of changes to that data by only one user.

Increasingly, BIM software products support access to and updating of building information at the component level. However, only one user has update access at any one time. There are a few products that support Web services for updates. This scenario would permit something like database record locking, with the lock released the moment the change transaction is completed. This appears to be the direction in which the industry is moving.

4.3.2 Management of Updates

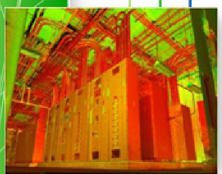
Today, most BIM data, particularly the geometric information, is managed at best at the level of a checked out and locked set of components. Managing updates of the As-Built BIM in the environment of many GSA facilities where there are multiple, overlapping major renovations, small projects and maintenance activities underway simultaneously is challenging.

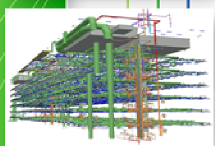
Projects pose additional challenges:

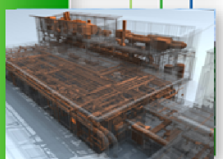
- When should the project data replace the official existing conditions information?
- How can a project model for a specific area of a building be inserted into the overall model?
- How can such an update be accomplished while accurately managing the primary keys of GSA-required COBie objects so that primary keys of:
  - Items that remain are unchanged
  - Items that are removed during the project are removed from other systems (e.g., CMMS)
  - New items are identified and transferred to other systems

Recommendations are:

- Project work should not be incorporated into the As-Built BIM for the overall facility or CMMS until such time as the construction is complete and the project's As-Built BIMs have been checked and accepted.







- The A/E should produce a report indicating the primary keys of COBie objects that will remain and those that will be removed as a result of the project.
- Contractor should ensure that primary keys on items remaining are **not** changed in the As-Built BIMs. This will be a difficult requirement to get across, but it will be possible to validate that primary keys are unchanged based on the A/E's report.
- The incorporation of the project As-Built BIM into the overall facility AS-Built BIM cannot be completely automated at this time, unless the renovation is so extensive that an entire As-Built BIM file can be replaced. In other circumstances, an experienced and knowledgeable BIM user will need to knit the modifications into the existing fabric of the building. This is currently the case with FM CAD as well.

4.3.3 Multi-User Access and Viewing

Access to facility information can be facilitated through 3D visualization. However, BIM authoring tools are not the correct application to provide this access to users who need view-only access. Easy-to-navigate, low-cost or free viewers are preferred.

Similarly, capturing and extracting needed facility data (attributes) using a BIM authoring tool becomes cumbersome and difficult to manage. The BIM file size becomes very large and slow to manipulate with all the required facility data. Every user requires high-powered hardware and access to and training in expensive BIM authoring tools.

4.3.4 Vendor Neutral Options

GSA is committed to the interoperability of data as a strategic management issue to ensure GSA's access to building information over the life of the capital asset. This implies,

There are vendor neutral options. The GSA National Equipment Standard Team has suggested that capturing design and construction data in an open, ODBC-compliant database format supports GSA's policy on vendor neutral software. This format provides for easy interoperability with similar database-structured facility management systems.

COBie (Construction to Operations Building Information Exchange) provides a vendor neutral format to capture design, construction, and commissioning data. The COBie format data can be used to populate CMMS or other database structured facility management systems. COBie data can be entered manually and/or extracted from BIMs into COBie compliant format. BIMs can be linked to the COBie file. In National Institute of Building Sciences (NIBS)-sponsored COBie Challenges, BIMs in both native and IFC format have been demonstrated to transfer data to COBie.

Recommendations are:

- Use the COBie file to synchronize As-Built project data with CMMS and other facility management systems.
- Use Equipment Primary Key to link BIM equipment objects with external equipment data that is created by multiple project and O&M activities.
- Use the current version of the COBie file.

4.3.5 Multiple Paths for Data Transfers

With current technology, there are some limitations as noted above, but also many opportunities for harvesting useful BIMs and linked data for facility management (Figure 4).

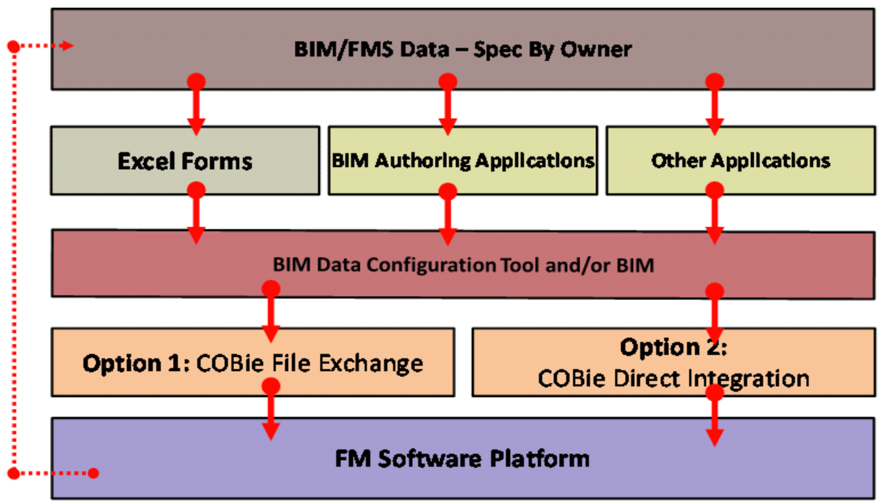
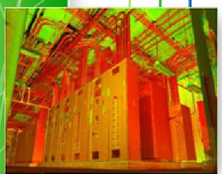
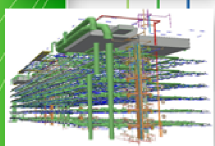
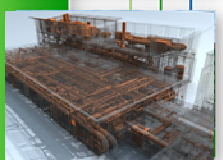


Figure 4: *Multiple Paths for Data Transfer (Image courtesy of Onuma, Inc. with edits)*



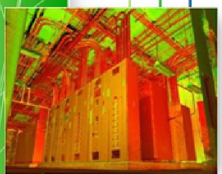


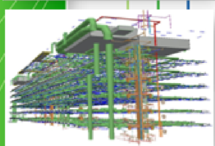


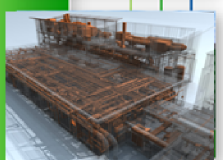
4.4 Emerging Technology: Model Servers

There is an emerging class of BIM software product referred to as "model servers."". Model Servers provide the type functionality envisioned for the Central Facility Repository shown in Appendix A, discussed in Section 4.2 above. A number of GSA Pilot Projects are examining this category of technology. A preliminary list of model server requirements includes:

- Manages models in IFC format
- Manages related files in multiple formats
- Manages associated object properties in ifcXML format
- Assigns an object's GUID as an explicit property
- Provides viewers for all formats managed
- Allows volumes and/or components of a model to be associated with a particular project
  - Project properties include start/end date range
  - Supports queries such as:
    - Find all projects that have affected this part (volume) of the building in the last <number> years
    - Find any projects scheduled to affect this part of the building between <date range>
    - Find any maintenance projects currently underway in this part of the building
    - Find all changes that have been made to this branch of the HVAC system since the building was constructed
- Allows model elements associated with a project to be copied to a "working model"
  - Can notify other users who have copies of any of the same model elements
- Can use Web Services to permit the model to be updated in real time on a component-by-component basis
- Has the ability to update the primary model by "Checking In" project models:
  - Can route Check-In data through validation and compliance checks
  - Can compare the incoming model to the current version and identify changes
    - Changes to geometry
    - Changes to properties, including primary keys
  - Can replace each (and only) changed components with a new version
  - Can maintain an audit trail for each version of each component
  - Can apply a status to each model checked in, at a minimum:
    - Pending
    - Current
    - Archive







  - Can notify other users who have copies of any of the changed components or properties
- Has ability to perform real time and batch updates of models and component properties based on data transfers from other systems
  - Provides integration tools for automating such updates
- May incorporate tools for direct model update
- Has the ability to perform coordinate transformations (translation and rotation) so that a project with a local coordinate system can be accurately registered to a building, campus, city, and so forth.
- Is FISMA compliant, based on GSA security category mappings.

section 05:
pilot projects

section 5: pilot projects

GSA has initiated pilot projects to investigate the implementation of BIM for facility management. The pilot projects illustrate the different software tools and project work flows for implementing BIM for facility management.

- Integration of BIM and CMMS via direct, proprietary implementation
- Integration of BIM and CMMS via open standards such as COBie

Figure 5 illustrates the multiple paths for data transfer for BIM for facility management. These pilots also range in their phase of implementation, from early design through construction.

5.1 Integrating BIM with CMMS

5.1.1 Goodfellow Complex, St. Louis, MO, Region 6

GSA engaged HNTB to develop a Proof of Concept to demonstrate the seamless integration of the BIM with the data stored and managed in CMMS for Building 105 in the GSA's Good Fellow Complex in St. Louis, MO.

The goal of the HNTB effort was to enable:
- identifying equipment listed in the CMMS database in the BIM,
- locating each asset spatially,
- tracking the attributes of the asset in both systems, and
- updating those attributes in both BIM and CMMS throughout the life cycle of the building.

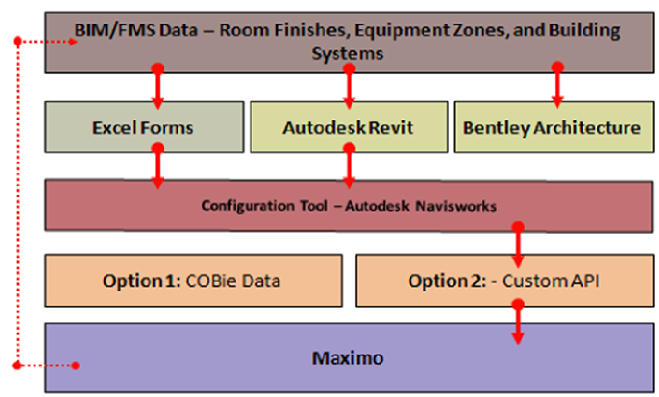


Figure 5: Data Transfer Path for Goodfellow Complex

Background

No BIMs existed for the existing facility. There were 2D CAD architectural, mechanical, electrical and plumbing drawings for the first, second, and penthouse floors reflecting as-built conditions. GSA used Maximo to manage facility management activities and assets.



Technology
For this limited proof of concept, the BIM authoring applications consisted of Autodesk® Revit® Architecture and Autodesk® Revit® MEP for BIM, and Maximo® Asset Management software for the CMMS. HNTB received an export of Maximo data in .xls format for Building 105 in the GSA's Good Fellow Complex in St. Louis, MO.

Workflow
HNTB created Revit® architectural and MEP models from 2D CAD architectural, mechanical, electrical, and plumbing drawings provided by GSA. HNTB conducted an onsite survey to identify missing data including measurements for the Revit® models.

Results
1018 Records with 30 data fields were extracted from Maximo. The only fields that were populated for all records were:
- EQNUM – equipment number
- LOCATION
- COLTYPE

In addition, 1016 records had the Failure Code field populated and 1015 had a Description. Only 691 records contained a Serial Number.

In reviewing the Maximo data provided, HNTB concluded that only the Description and Location fields were useful in identifying and locating equipment in the BIM model, due to inconsistent equipment naming conventions, within both the Maximo data and the BIM.

Although the Maximo Location indications were not entirely consistent, they were able to parse those fields and extract:
- Building Number
- Floor
- Zone
- Room number

Despite comprehensive review of existing building documentation as well as field verification efforts, HNTB was able to match only 176 out of 1,018 Maximo® records (17%) in the Revit® models. The majority of the matched records were mechanical system equipment. Due to the limited availability of information for the electrical, plumbing and fire protection equipment, both in the Maximo data and in the Revit MEP model, it was not possible to identify and locate equipment for these systems in the BIM. Inconsistent equipment location information and non-unique equipment identifiers were the primary reasons for the low number of equipment matched between Revit® and Maximo®.

HNTB recommended that the integration of the two systems required more standardization and structuring of the data within Revit® and Maximo® and identified the following as best practices:
- Creating consistent Revit® families and types. Equipment variations can be captured as a type within a single Revit® family.
- Ensuring standardized naming conventions are utilized for the families, type, and subsystems in Revit®.

- Using consistent naming conventions in Maximo®. The Maximo® naming conventions should match the Revit® naming conventions for easy equipment identification and location.
- Populating information in all the data fields in MAXIMO DB and also populating information in all the Revit parameter fields

HNTB also provided detailed guidance for implementing the BIM-related best practices within Revit.

HNTB also described key characteristics of a standard development framework for BIM/CMMS integration as follows:

- Open Database Compliance (ODBC) – ODBC compliance makes it possible to access any data from any application, regardless of which database management system (DBMS) is handling the data.
- Open Data Structures – Having open access to data is not enough; system developers also need to have open access to the structure of the data. Extensible Markup Language (XML) provides systems the ability to self-describe data for easier data sharing.
- Open Reporting – Open reporting tools give the system developers the flexibility to either tightly integrate reporting capabilities within information systems or generate reports outside of any information system.
- Open Spatial Data – Storing the coordinates of feature locations in an open data structure allows geographic features to be seamlessly shared between information systems.
- Interoperability – Interoperability refers to the ability of systems to operate and communicate with each other. Applying an open approach to system design and implementation ensures true interoperability.

5.1.2 Data Center Campus, the Heartland Region 6

HNTB was engaged by the GSA and DoE to create a Data Center Campus located in Kansas City, MO. The new campus is comprised of 5 buildings and sits on a 185 acre site. Currently, the campus is under construction utilizing a Developer led Design-build procurement method, and as such, is the largest facility of its kind for the GSA in the United States. Nearly 2,500 employees will work at this facility that includes office space, research labs, and manufacturing areas.

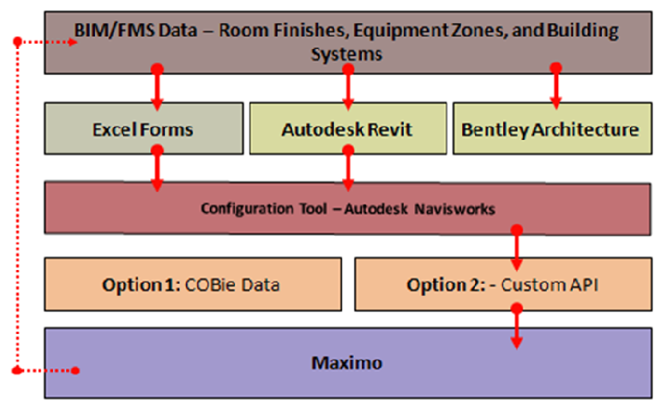


Figure 6: Data Transfer Path for Data Center Campus

Beyond construction of the facility, one of the requirements for the contract award was working with the building users to create a facility management solution for the manufacturing equipment. The facility holds 8,513 mostly unique pieces of manufacturing equipment many of which are custom created for its own production. The equipment contains over 150 design requirements that include vibration control, specialized utility connections and special foundations – all of which impact the overall building design. All of the equipment conditions were supplied in a Microsoft access database the building occupants currently use to manage



and maintain the manufacturing equipment.

Approach

The design team held a workshop with all of the project stake holders to figure out a way to make sure the design requirements were met, the schedule was maintained, and the contractor would have the information they needed to build it right the first time. The outcome of this workshop was the decision to push all of the design requirements into BIM and use an informationally complete BIM model as a lifecycle tool. The design and construction team committed to modeling the entire facility, including the occupant's equipment to help visualize the design criteria. This ultimately created a collection of 69 BIM models that are all inter-linked to complete the campus. Architects, mechanical consultants, structural engineers, the general contractor, and building owner all contributed model data to the create the complete set.

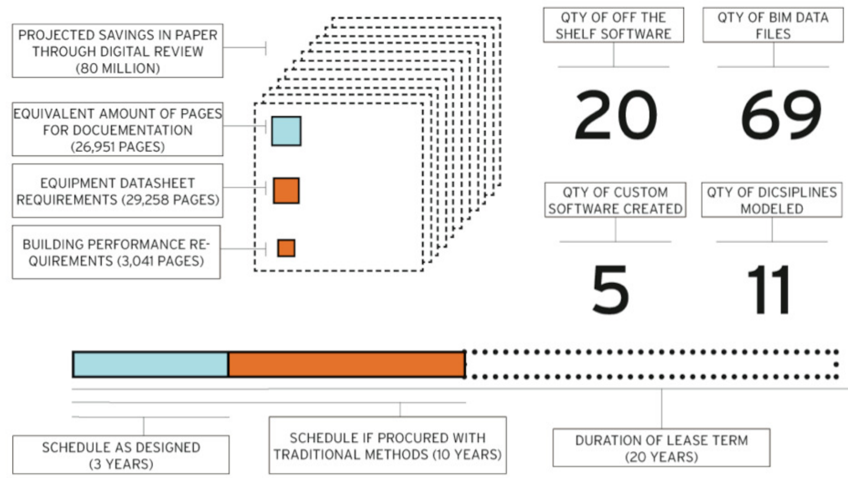


Figure 7: *Data Center Campus - Quantitative Metrics*

Building Occupant shared their confidential equipment database which contained over 1.2M fields. This database contained the design criteria for the 8,513 pieces of manufacturing equipment installed in the building. Examples of that data are:

Special power needs
Vibration isolation
Argon gas
Nitrogen
Compressed air
Special foundations

Venting
Drains
Exhaust requirements
CO2
Steam
Vacuum

Grounding
Nitrogen
Chilled water
Heating hot water
Helium

Since none of the design team were familiar with using databases or running database queries out of MS Access, the building occupant placed a technician in the architect's offices to help understand the database structure. They also performed 'walk-downs' for each piece of process equipment being installed in the new facility taking into account equipment geometry as well as utility needs and any special conditions. These walk-downs were field verifications of equipment size and design requirements.

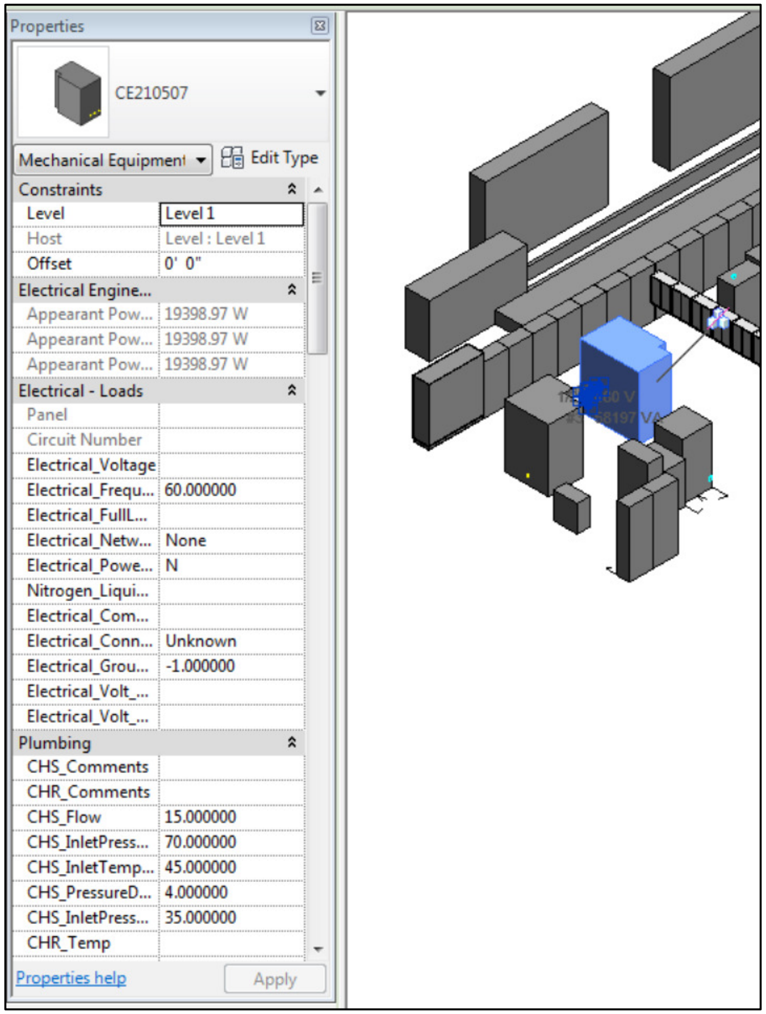


Figure 8: *Data Center Campus FM BIM*

Workflow

The project team established a workflow that would allow BIM metadata (non-geometric information in the model) and the occupant's MS Access database to be merged on a regular basis. This merger was accomplished by the architect modeling the 8500 pieces of process equipment based on the occupant's walk-down information or field verification. These elements were roughly geometrically accurate (length, width, height) and represented all the process equipment that would be housed on the campus when it was complete. Once the elements were modeled, the required data fields were added to the BIM model as empty fields. The database merge filled the fields with design criteria. A piece of equipment after the data merge is shown below. Note that not all of the fields have information in them - not every field is represented by each piece of equipment.

The architects worked directly with the building occupant's on-site representative to verify equipment locations and functionality. During the modeling process and continuing through design, the building occupant had a representative co-located with the design team. This allowed the building occupant to double-check the BIM modeling and data migration process, and was also available to answer questions about errant issues within the database. As an example, the owner has a numbering scheme for each piece of equipment which consists of three letters followed by a string of numbers. Some elements had spaces between the numbers and letters while others didn't which caused synchronization issues with the model. This process not only allowed the design team better access to equipment but gave the owner a tool to validate their own database.

In addition to creating this equipment geometrically, the occupant / architect team then created metadata containers for each piece of equipment – essentially establishing a set of empty parameters within the BIM model. These containers accommodated the necessary design requirements for the process equipment and the owner's database was then merged with the BIM model. Examples of these fields are: utility connections, special gases (argon, helium, etc), special foundation needs, vibration isolation, power supply, venting, etc. This allowed the entire team to visually query design criteria in BIM, run calculations for loads or utility supplies and it supplied the building occupant with a resource to track equipment.

The database / BIM merge was accomplished by:

- Populating a model with roughly geometrically accurate equipment and adding over 150 design parameters per piece of equipment in blank BIM parameters. Equipment was given an alpha-numeric code that was to act as the primary key. This key became the family name in Revit and was also the primary key in the occupant's database. A key example would be FAC101012 which would link to only one piece of equipment. Once the equipment is retired, the number is retired as well.
- Once created, the BIM model was exported to MS Access using Autodesk's Revit dbLink tool. This supplied an access database complete with all of the modeled components in a format that was native to the BIM model.
- This exported data was then merged with the building occupant's information from their access database tying to the equipment ID as a primary key. Since this was part of the model elements in the BIM, it supplied a way to connect the two databases consistently.
- Once the data was merged, the updated building model database was then imported back into BIM populating the blank fields with design criteria.
- Future updates to both the model and the equipment database were handled by re-preforming the export / import / export sequence.

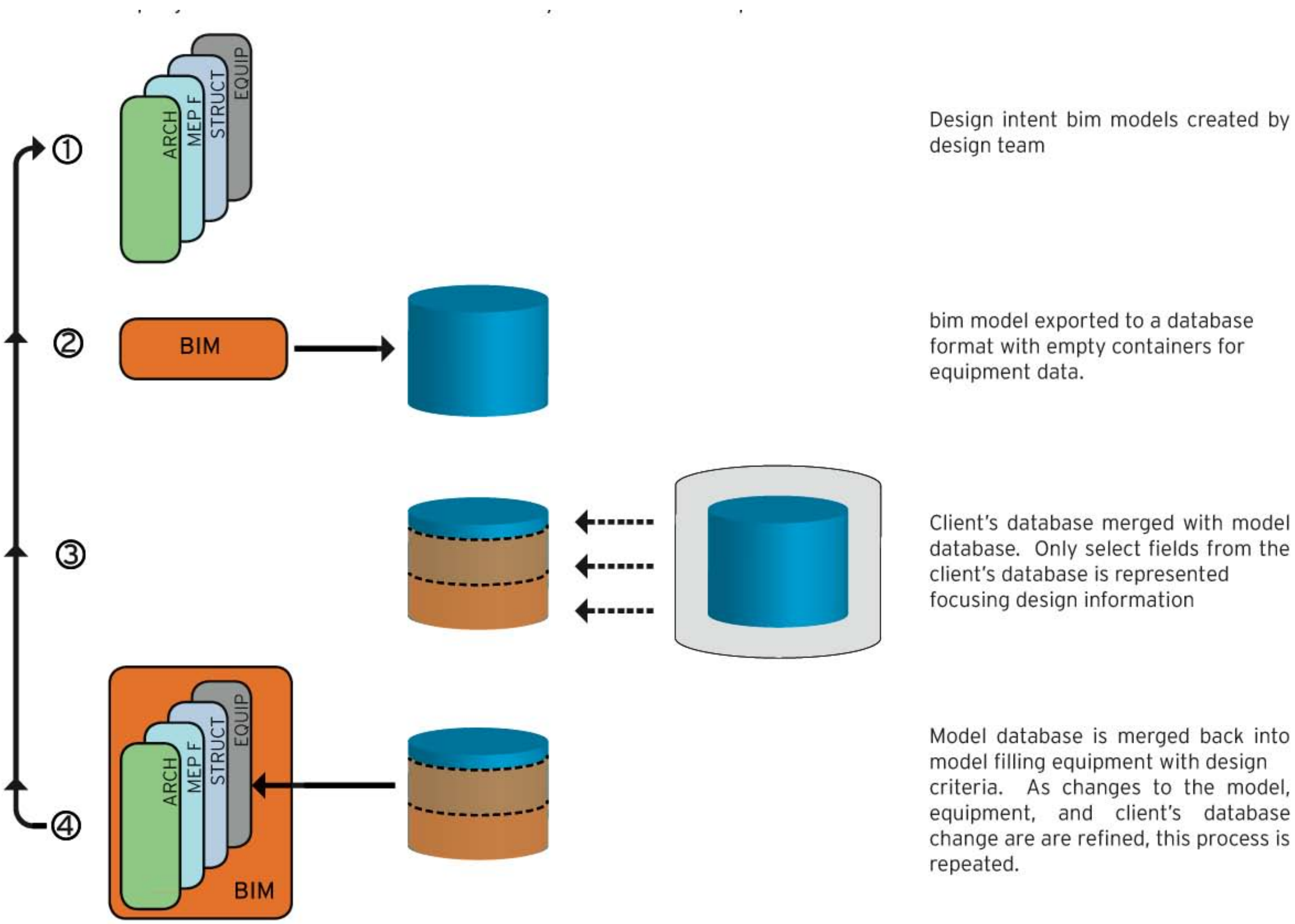


Figure 9: *Data Center Campus Equipment Workflow*

Results

This has been an on-going workflow for the entire construction documentation phase of the project with both positive results and some on-going challenges.

This process allowed the design consultants to leverage layered model and database merged into BIM to such an extent that they more than doubled the original amount of data that was being merged between database and model. The process lead to the ultimate creation of several custom tools to help verify data integrity between the regular database merges, find and locate key pieces of equipment, and perform many operations on 8500+ pieces of equipment that done manually would be time consuming and fraught with opportunity for error.

The building occupant, less familiar with the design process, but very familiar with database technologies, began asking for the design models to be exported to a database format. The occupants found 'viewing' the design in a database format more practical and informative when paired with the design drawings rather than just the drawings alone. They were able to query spatial elements and quantities directly from the database version of the model and compare those to their design goals for areas and quantities.

Some of the challenges faced with this workflow were systemic. Due to the large amount of data being transferred between model and client database a Windows 32 bit operating system was not able to supply enough resources for a workstation to complete a data push. The team ultimately had to build a 64 bit workstation utilizing MS Access 2010 (due to it's 64-bit drivers) in order for the OS to have enough system resources to complete a data transfer. Also due to the size of the data, we were required to break the model into pieces to make them small enough to be manageable with all the metadata.

"There is no question that BIM makes our team better. It gave us an edge to win the Project. It helps us make better decisions by organizing massive amounts of information through design and construction. And its value as a way to efficiently operate and manage the facility is becoming more and more evident the closer we get to completion."

- Building Owner / Lessor

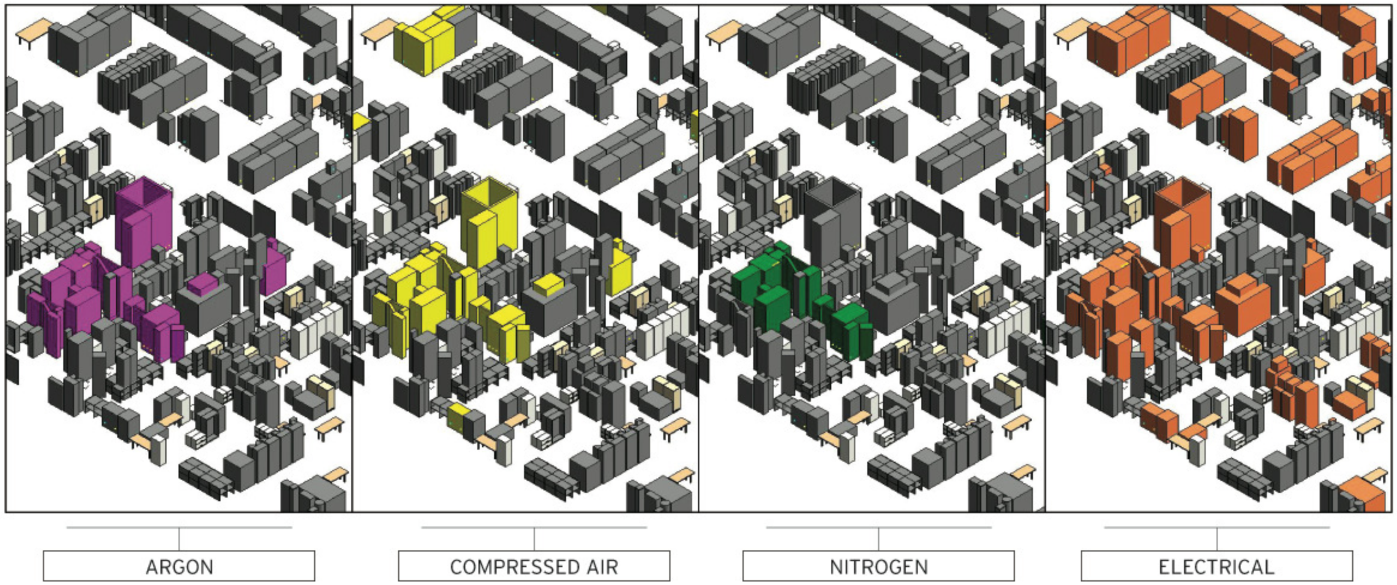


Figure 10: *National Security Center Sample Equipment Visualization Queries*

Future

As the project continues to progress, the building occupant and design team are exploring ways to integrate the final BIM model and Access data into IBM's Maximo for future facility management.

Technology

For this workflow, HTNB utilized the BIM authoring application Autodesk® Revit® Architecture and used Autodesk's dbLink tool (a Revit add on). The database tools were MS Access 2010 and Microsoft's 2010 ODBC drivers. A 64-bit operating system was required for access to more than 3 GB of RAM so Windows 7 was utilized.

5.2 Integrating BIM with COBie Producing and Consuming Software

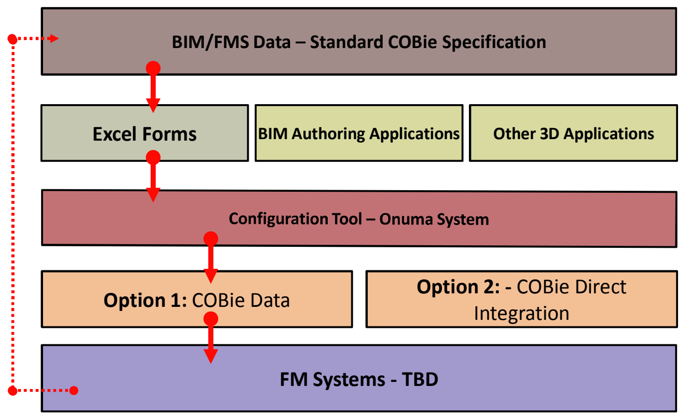


Figure 11: *Data Path Transfers for Region 2 Pilot Projects*

5.2.1 Three Pilot Projects in Newark, New Jersey and San Juan, Puerto Rico, Region 2

GSA is conducting a series of similar pilot projects on BIM for facility management for the Rodino Modernization, Degetau Modernization, and the New San Juan FBI Building in the Northeast and Caribbean Region. The pilot projects have the same goals: to link design and construction data to facility management activities, and educate GSA associates in different BIM uses.

For all three pilot projects, the pilot project teams include the GSA Regional BIM Champion, the GSA Building Manager, the GSA Project Manager, the GSA Contracting Officer, and the BIM Consultant. In addition, the Rodino Modernization includes the Design/Build Construction contractor, the Degetau Modernization includes the Design/Build Construction contractor, and the New San Juan FBI Building includes the Architect/Engineer (A/E).

Background

The pilot projects were selected for the various project scopes. The pilot projects include a partial building modernization, a limited scope heating, ventilating, and air conditioning (HVAC) modernization, and new construction.

The pilot projects are implementing BIM for two different project delivery approaches. The Rodino Modernization and the Degetau Modernization used Design-/Build-Bridging (Design/Build) and the New San Juan FBI Building used the traditional (Design-Bid-Build) project delivery approach. BIMs were created during the design phase for the pilot projects.

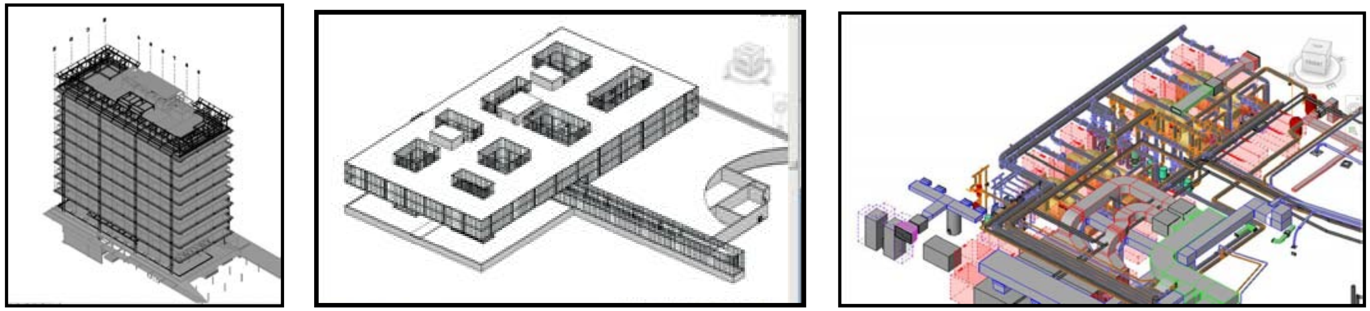


Figure 12: BIMs from Rodino, San Juan, and Degetau Projects

Technology

Tentatively, the pilot projects have not decided on the software applications to interact with the BIMs.
The pilot project teams specify the COBie format for facility data requirements for BIM for facility management. The pilot project teams are using Proliance® electronic project management system (ePM) as the collaboration site.

The teams will use COBie data format to transfer facility data, as the facility management systems and file formats have not been identified, and the Onuma System to validate the COBie deliverables.

Workflow

For the Rodino Modernization, the A/E of Record is creating four Design Intent BIMs. The Design Intent BIMs are split by discipline: interior architectural, exterior architectural, structural and MEP/FP.
For the New San Juan FBI Building, the A/E of Record is creating a spatial concept BIM.

Early Results

The pilot projects have not reported any results from the initial project implementation.

5.2.2. Three Pilot Projects in Southeast Region 4

The Southeast Region (Region 4) three pilot projects on BIM for facility management for the McCoy FB, the Martin Luther King FB, and the Godbold FB (Tuttle Annex). The three pilot projects have the same goal: to create a web based dashboard that queries facility data such as Spatial Data Management (SDM) and energy data from multiple facility management systems and As-Built BIMs. In addition to having the same goals, the pilot projects have the same type of team members. Pilot project members include GSA's Property Management Service Center, GSA Facilities Management and Services Program (FMSP), BIM Consultant, and the Construction contractor.

The pilot projects are only able to report early results from the initial BIM for facility management implementation.

Figure 13: *Data Path Transfers for Region 4 Pilot Projects*

Background

The pilot projects are implementing BIM for facility management for major renovations of existing facilities with different project delivery approaches. McCoy FB and Martin Luther King FB used the traditional (Design/Bid/Build) approach and the Godbold FB used Design-Build Bridging (Design/Build) for the major renovations project delivery approaches. BIMs were created early in the facility life cycle for the pilot projects. McCoy FB and Godbold FB used BIMs during the design and construction phases and Martin Luther King FB used BIM during the construction phase. However, the BIMs were not created with the intent to use them for facility management. For all three pilot projects, the teams started to update the BIMs for facility management near construction completion.

Through a detail involving the region's Service Center division, Region 4 hopes to expand efforts and features of the region's BIM for facility management research. The detail has involved expanding viewable and accessible fields by Building Management, O&M Contractors, and Regional Associates; as well as working with middleware software mapping for a more user friendly environment. Additional partnering on concept development and CMMS review has been conducted through the detail with both regional and national FMSP. The team has hopes of applying the concept, to one of the identified facilities, for a live BIM for facility management environment.

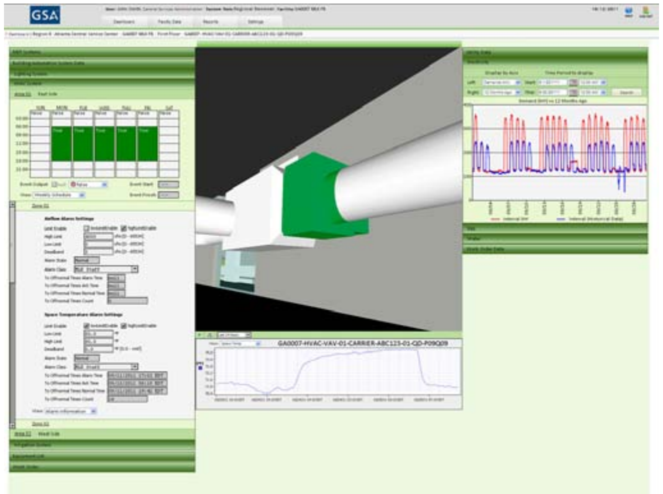


***Figure 14**:Screen Shoot for HVAC VAV Accessible information*

Technology

All three pilot projects identify similar technology approaches for implementing BIMs for facility managementBIMs. The As-Built architectural and structural BIM(s) are entirely Autodesk Revit. The As-Built MEP BIM(s) are Revit MEP in some cases and Autocad MEP in others.

The pilot project teams identify the following facility data requirements for BIM for facility management:

- As-Built data
- Equipment data
- Design specifications

Tentatively, the pilot projects will use the same software applications to interact with the BIMs. The pilot project teams have decided to use Autodesk Revit and Navisworks as model viewers. EcoDomus serves as the middleware viewer that integrates the As-Built BIMs with the facility management data. Also, the teams will use EcoDomus for querying, transferring, coordinating, synchronizing, and viewing facility management data and As-Built BIMs. The teams may use a software application programming interface (API) to assist in transferring facility data.

The teams will use multiple data formats, including IFC and COBie to transfer facility data. Automated transfers between native applications and EcoDomus allow users to track data within EcoDomus. The pilot project team plans to automate and track changes in the native software applications. The portal is also integrated with Google Maps, providing map-based navigation within Region 4.

Workflow

The pilot projects use different workflows for creating and updating the BIMs.

For McCoy FB, the A/E created the BIMs and the BIM Consultant is updating the BIMs during Construction. For Martin Luther King FB Tuttle, the Construction Contractor and subcontractors created and started the initial update of the BIMs through Construction. For Godbold FB, the A/E created a design BIM then the Construction contractor and subcontractors (design build) created construction BIMs and updated them throughout construction. For all three pilot projects, GSA will maintain updates to the BIMs after the pilot projects are complete.

Early Results

The pilot projects have reported early results from the initial project implementation.

- So far, developing standards and prioritizing requirements are major obstacles to accomplishing their primary goal
- It is more beneficial to identify the facility management data requirements at the beginning of the facility life cycle instead near construction completion

5.2.3 Region 3 NASA Langley Pilot

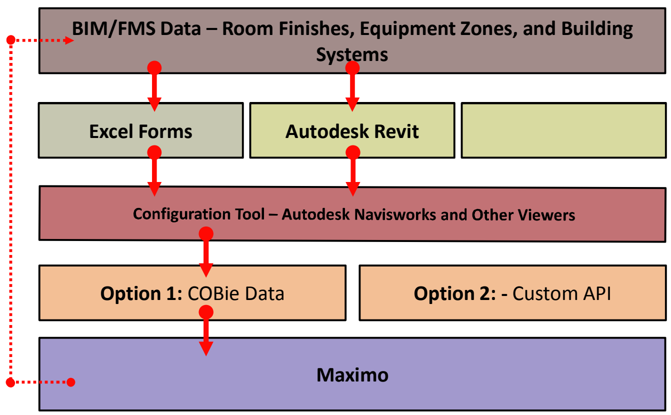


***Figure 15:** Data Path Transfers for Region 3 NASA Pilot*

Background

The National Aeronautics and Space Administration (NASA) has embarked upon a 15-year facility modernization program at its Langley Research Center (LaRC) in Hampton, Virginia. The General Services Administration (GSA) and NASA are jointly managing the implementation of this endeavor, known as New Town, which has a total estimated cost of construction at award (ECCA) of just under $200 million. The program scope includes the design and construction of six new buildings and renovation of two existing buildings. Concurrently, NASA is managing a demolition program that will clear space for the new buildings and also eliminate many older, less efficient facilities. The new buildings will each be delivered in approximately 2-year cycles with a total of 6 phases.

In Phase 1, the Design-Builder's Scope Of Work for Administrative Office Building 1 includes a requirement to provide all as-built product data, warranty information, maintenance schedules and operations data for the building equipment inventory within the BIM Model deliverables. Current software tools have proven that equipment data can be automatically imported and exported to and from Computerized Maintenance Management Systems. The cost and time savings for a highly coordinated and efficient transfer of building data through the construction phase and into the building operations phase is substantial for NASA. Further, the cost and time savings of keeping Record BIM Models current using automated tools throughout building operations is also of significant value for NASA.

GSA awarded a task order to View By View / Ecodomus to integrate BIM and Facility Management data. The objective of this task order is to prove that an integration between the AOB1 Revit Models and NASA's LaRC IBM Maximo CMMS is possible and valuable. The contractor is tasked with providing a feasibility study, an implementation plan, and performing the implementation according to plan. Further integration between the AOB1 Revit Models and BAS System, LaRC CMMS and GIS will be optional.

Technology

The project team is using Revit to create BIMs viewing these models in both Navisworks and EcoDomus. EcoDomus is used to query data, transmit and synchronize data between BIM and CMMS.

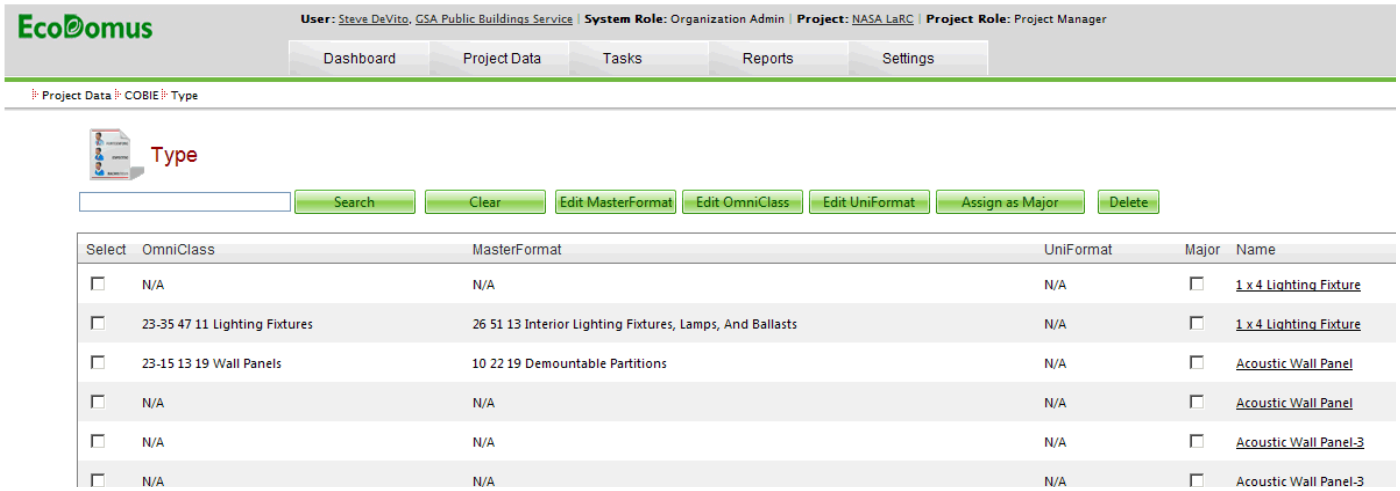


Figure 16: *Selection of 'Major' BIM Object Types which will determine which BIM Objects will be integrated with CMMS*

Results

Although the pilot is only in the first phase of implement, there were several lessons learned regarding project set up and the implementation plan. Facility management buy-in and leadership is crucial to the success of the pilot. This can only occur when all parties understand how BIM for FM can benefit each party involved. Without this, the emerging technology such as this stands no chance against entrenched standard practices and ways of doing business. Moving forward, it would have been better to demonstrate real life workflow and use case scenarios that would benefit real life owners such as PMs, Building Operator technicians and directors etc. Create a narrative from the perspective of the people whose lives it would improve and show in this narrative how it would make them feel better every day. Make this as real as possible. The thing people understand most is 'what does this have to do with me?'

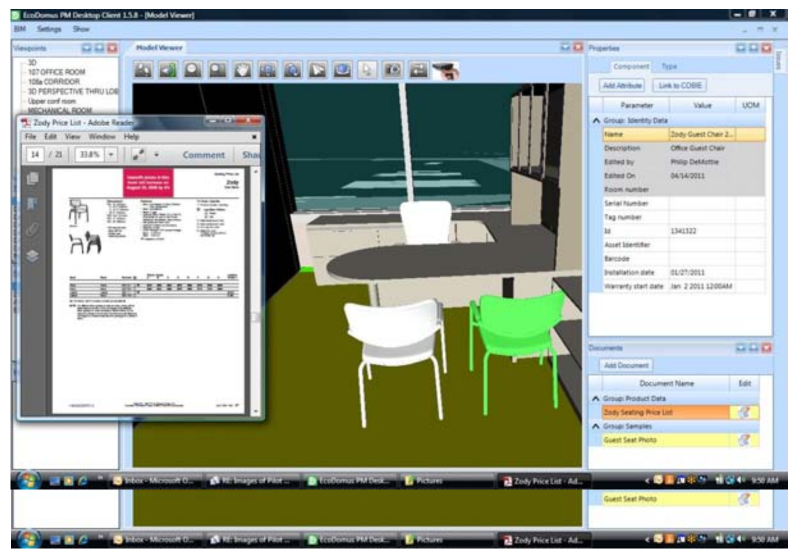


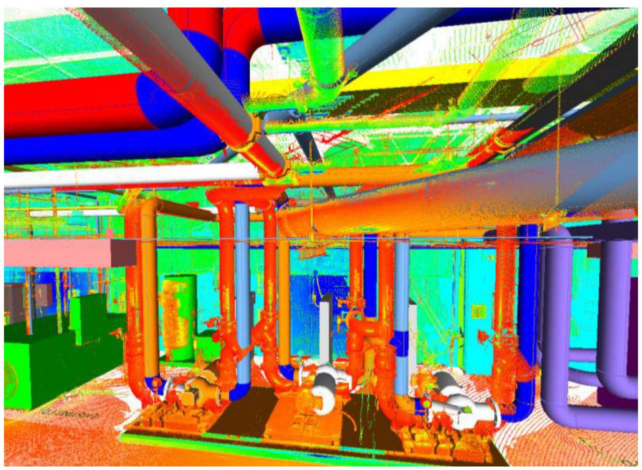
Figure 17: *Access documents by clicking on BIM Object*

In addition, strict security guidelines did not allow GSA to integrate directly with NASA's CMMS system. Instead, the BIM/COBie to Maximo CMMS integration was demonstrated on the test servers outside of NASA's firewall. Direct integration may be possible in the future phases.

Use of standard equipment classifications could help to automatically assign equipment within CMMS to the appropriate category or type. Since the facility had a custom classification system, there was increased subjectivity and additional costs for manual entry of the data.

Project as-built BIMs should be updated throughout construction and synced with the design BIMs to ensure consistency in the data integrated with the CMMS.

5.2.4 GreatThe Greak Lakes Region 5



1 FM Pilot Project

The Great Lakes Region 5 is conducting two pilot projects on BIM for facility management for the 10 W.Jackson (10WJ) building in Chicago (IL) and the Whipple Federal Building in Fort Snelling (MN). The goals are: to link As-Built BIM data to facility management systems; and provide the critical data for BAS/CMMS; and provide electronic version of the As-Built data linked with 3D elements in BIM model; and identify design systems and zones in BIM model to improve facility management and operations.

BIM models were initially created by the A/E team during the design stage. However, BIM models were developed to be As-Built BIM model by incorporating changes made in construction for both graphics and data. Utilizing the BIM integration sessions, all team members put the collaborative efforts to reflect the As-Built conditions and to ensure the accuracy. Managing the changes such as routing ASI has been established during BIM integration sessions in construction.

Background

The pilot projects were carefully selected because of the project scope, full modernization of MEP for both buildings. The entire 10WJ building was renovated and equipped with new mechanical equipments. The contractor provided necessary information including COBie data for equipment as part of the As-Built BIM deliverable requirements. Under the similar scope, the Whipple Federal Building received new equipments for most of the building mechanical systems including the geothermal energy system. The data of mechanical systems were input into BIM model for the future integration with BAS/CMMS. The electronic copy of the As-Built documents including shop drawings, product information, owner's manual were provided by contractor, and linked with proper elements in BIM model. Also both BIM models identify the design systems so that facility managers will be able to verify the systems and connections.

Technology

For both projects, GSA Region 5 BIM Standards were complied to ensure the consistency in BIM models. Two models were required, Design model and As-Built Model, in three formats; 1. BIM authoring tool (in this case, Revit); 2. Navisworks and; 3.IFC. The Level of Detail and BIM Execution Plan were required in order to comply with BIM Standards. Additionally, the Region 5's Revit templates were provided to each A/E to make the deliverables consistent for level of detail, information format, file naming convention, browser structure, etc. The GSA templates included Spatial Data Management and COBie modules to assist the A/Es to deliver information for facility management. 10WJ model is fully developed to be FM BIM and ready to integrate with the current CMMS application, "Angus Anywhere." The attempt for integration is currently in progress.

Workflow

Region 5 exercised a soft version of Integrated Project Delivery (IPD) methods by having a regularly scheduled BIM integrated sessions throughout the design and construction phases. At a minimum, architects, engineers, BIM technicians, contractors and GSA Regional BIM Champion were required to attend the session. Most of the major issues were discussed and decisions were made collaboratively by the team. The main topics for discussion include defining of member's roles and duties, change order management, design changes, model updating and sharing, degree of detailed information in BIM, etc. After changes were completed, the team also verified and approved the changes made in BIM models to ensure the accuracy in the final As-Built BIM models. (Check and Balance)

Early Results

The pilot projects have reported early results from the initial project implementation.

- Region 5 BIM Standards has ensured the consistency in the BIM deliverables.
- COBie is critical to FM application and it has been included in the GSA Region 5 templates. It has been implemented to provide necessary data for facility management.
- File structure for shop drawings, product information and owner's manual have been developed and organized as part of the As-Built documentation deliverable. Easy access from 3D elements to the documents has been established in BIM models.

5.2.5 Region 3 Camden Annex Lifecycle BIM Project

Background

The Camden BIM for FM and Energy Management Pilot objective is to provide previously unavailable tools to Facilities Managers and Building Engineers by integrating currently disparate BIM, CMMS, and BAS building information systems into a single application. For Facilities Managers reports will include but not be limited to Planned vs. Actual energy performance of the building, building floors, building zones, building rooms, and building equipment. These reports will also provide location of the equipment, service history of the equipment and warranty information about the equipment. For Building Engineers, a tablet device will be utilized in the field to instantaneously access location, performance, service, and warranty information and access to operations and maintenance documents of equipment. This information can be shown geometrically in a BIM model allowing the Building Engineers to better understand the relationships between and locations of building floors, zones, rooms, tenants, systems, system components and energy sensors.

Figure 19: *Camden Annex Lifecycle BIM Workflow*

conclusion

There is a great opportunity for the use of BIM for Facility Management. This BIM Guide Series establishes GSA's business need for BIM and Facility Management, highlighting efficiency and quality gains for multiple GSA stakeholders. This Guide also provides implementation guidance for project teams, based on our lessons learned from current pilot projects, including the development of a BIM Execution Plan to communicate how FM BIMs will be created and transferred to GSA. This Guide discussed the minimum modeling and technology requirements establishing the need for industry and open standards using a GSA National Equipment Standard, IFCs and COBie. It also outlines the technology requirements for a future BIM Server. Finally, this Guide discusses various implementation approaches from our current pilot projects.

While this Guide has documented GSA's journey of implementing BIM and Facility Management, there are still many more issues and questions to be answered. GSA plans to continue to establish best practices and lessons learned in this area, including:

- Establish the business value of BIM and FM through quantitative and qualitative metrics from on-going GSA pilot projects
- Identifying additional business needs for BIM and Facility Management
- Promote the use of open standards for data transfer to Facility Management
- Gather lessons learned from pilot projects to develop best practices for implementing BIM for FM
- Identify and narrow the technology gap required to update and maintain BIMs during FM
- Identify the data requirements to integrate other building information technologies, such as GIS and Smart Building technologies with BIM

GSA welcomes any constructive feedback or comments on this Guide.

section 6: bibliography

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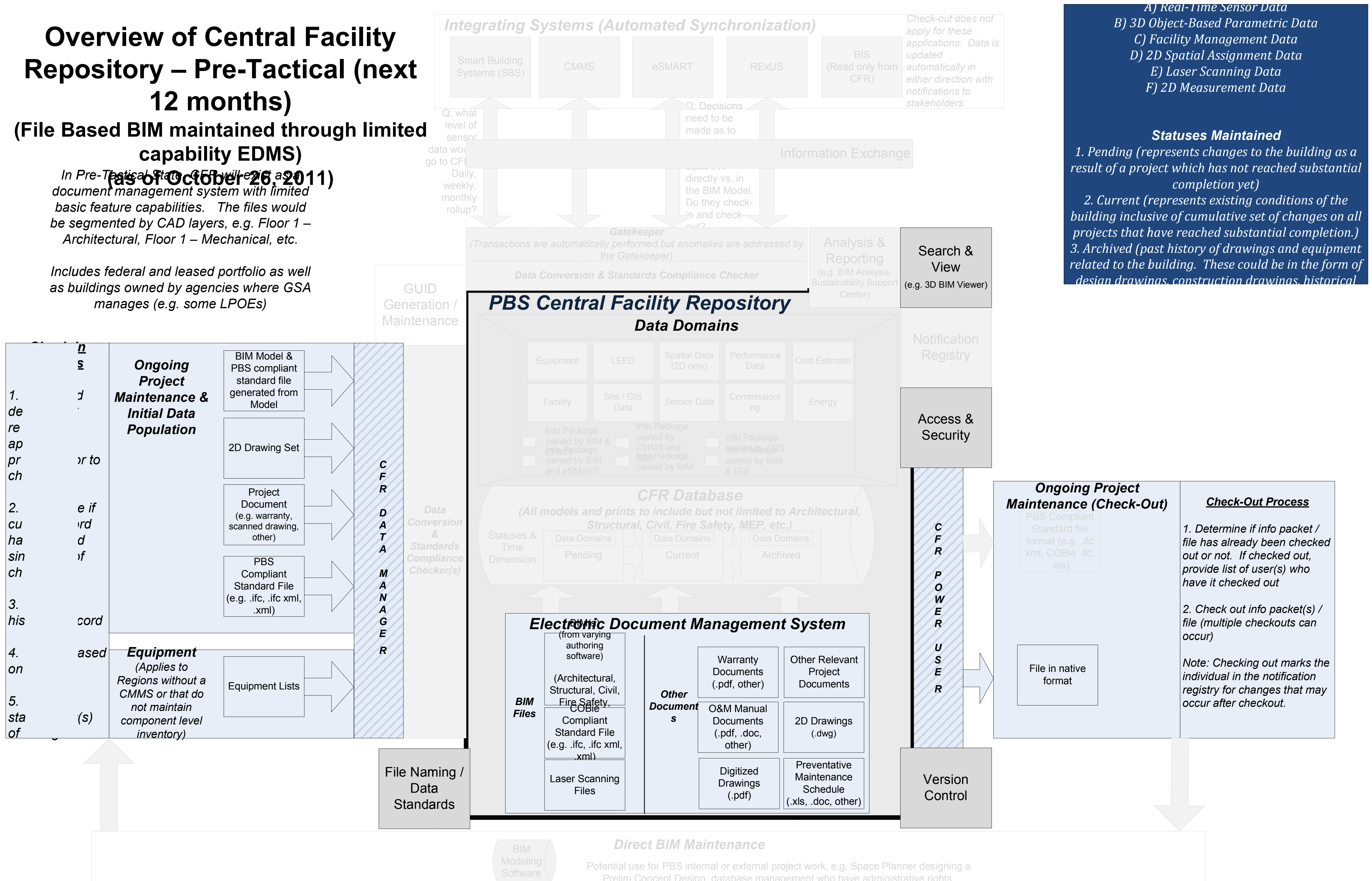
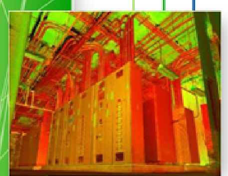
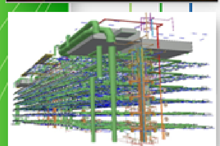
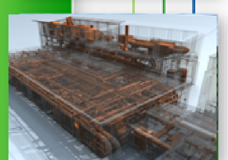
appendices

Appendix A: Central Facility Repository



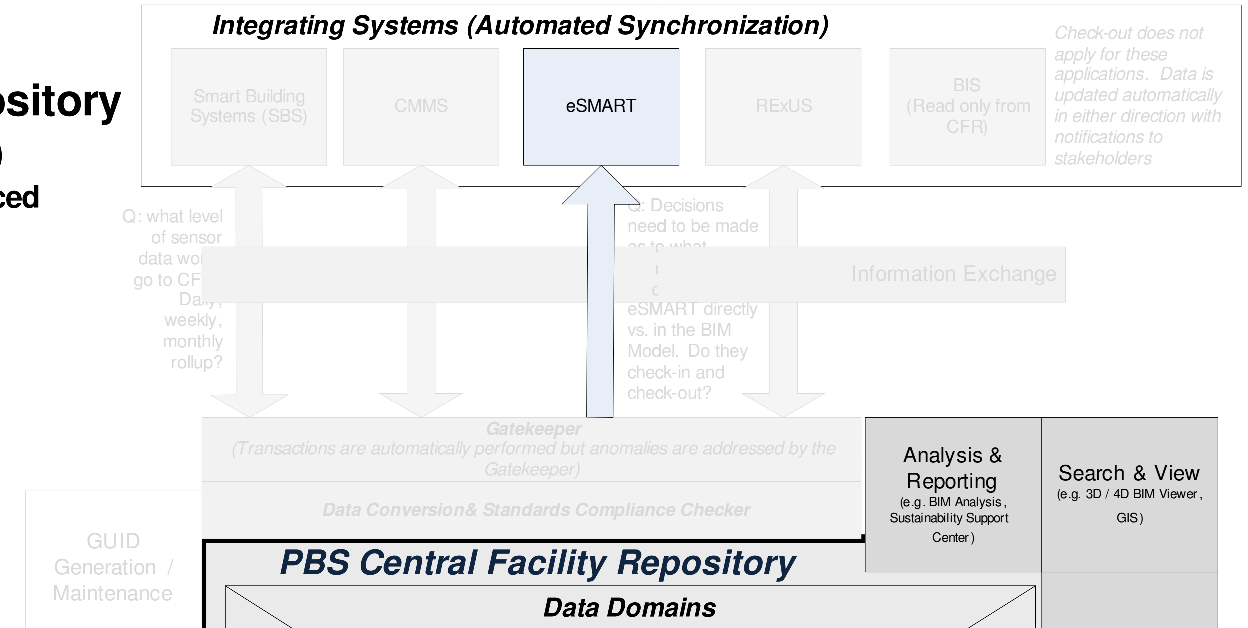




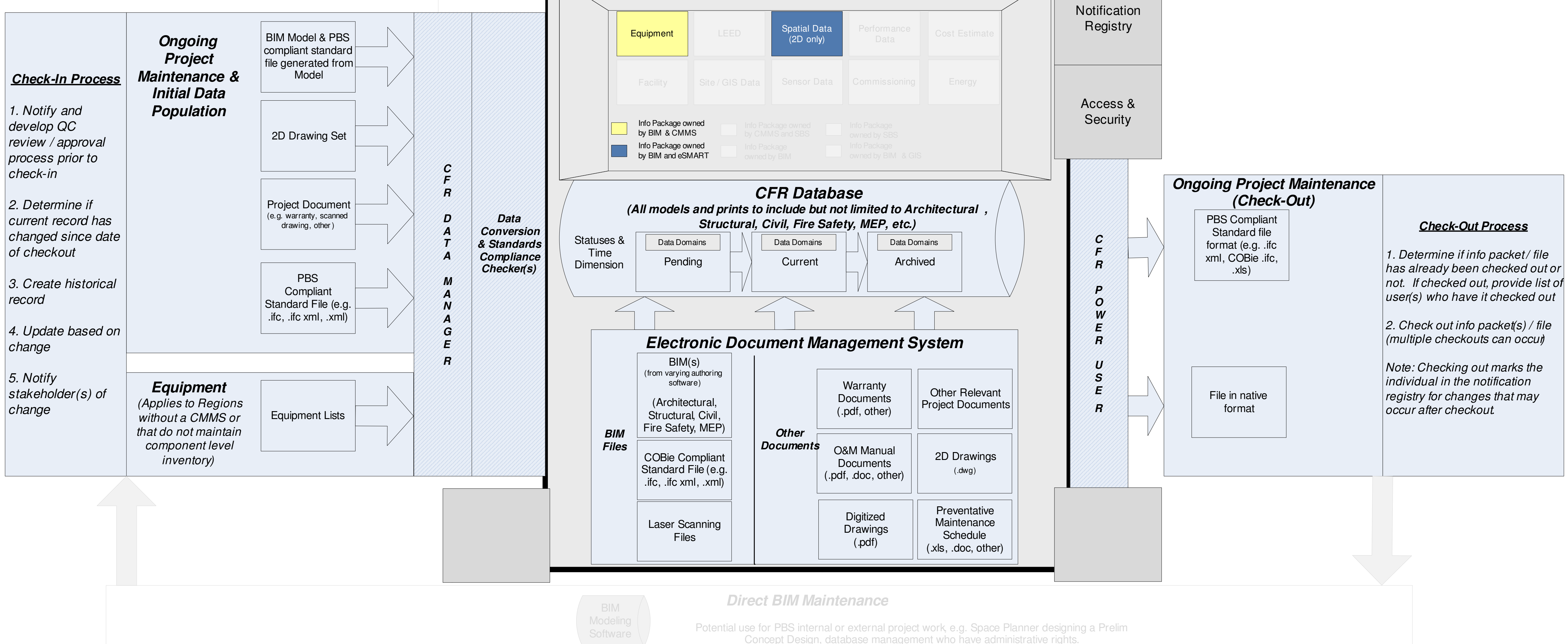
Overview of Central Facility Repository – Tactical (next 24 months)

(File Based BIM maintained through enhanced capability EDMS)
(as of October 26, 2011)

In Tactical State, CFR will exist as a document management system with enhanced feature capabilities. The files would be segmented by CAD layers, e.g. Floor 1 – Architectural, Floor 1 – Mechanical, etc.

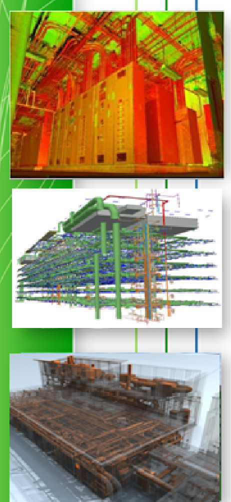
Includes federal and leased portfolio as well as buildings owned by agencies where GSA manages (e.g. some LPOEs)





Information available in the Repository
A) Real-Time Sensor Data
B) 3D Object-Based Parametric Data
C) Facility Management Data
D) 2D Spatial Assignment Data
E) Laser Scanning Data
F) 2D Measurement Data

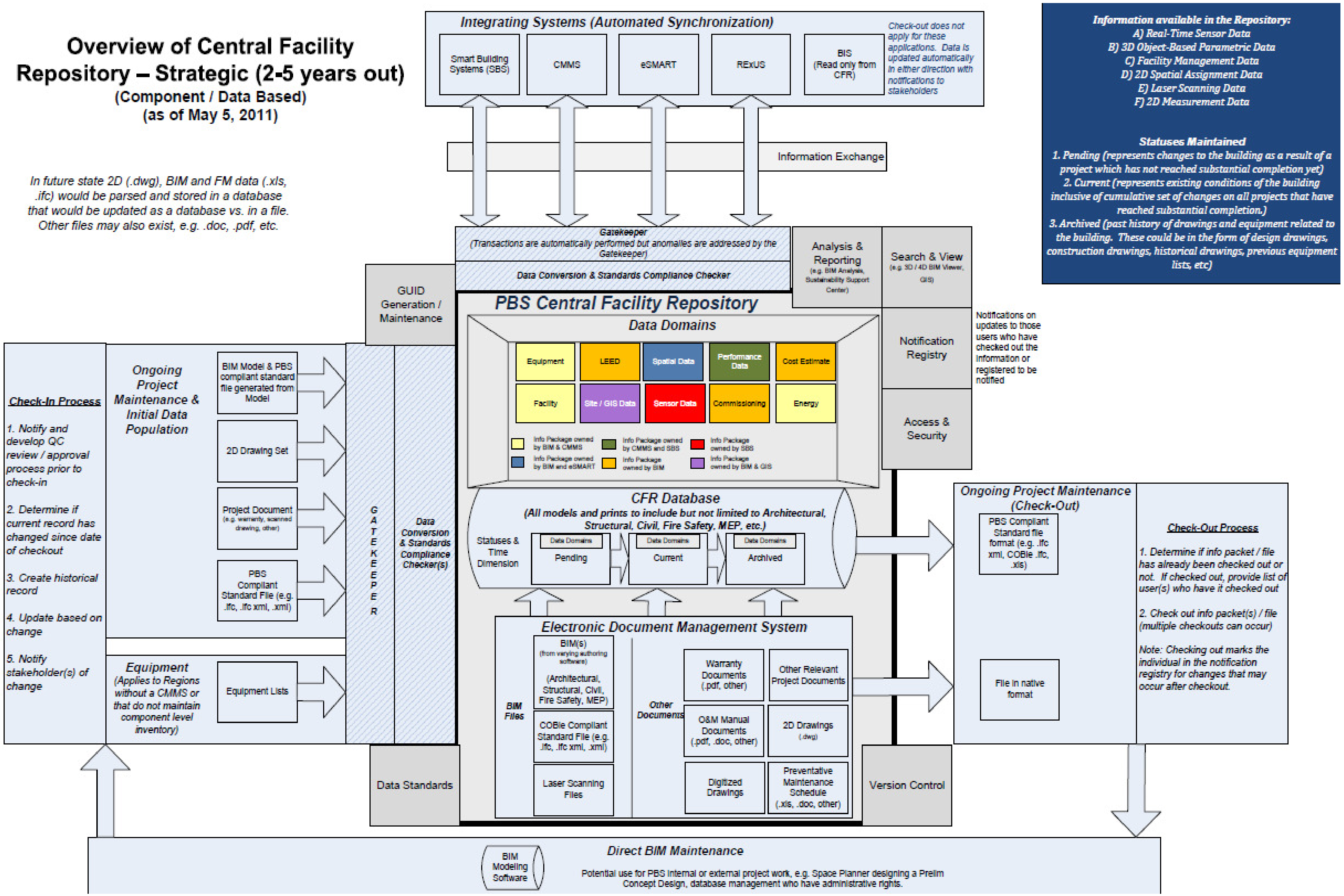
Statuses Maintained
1. Pending (represents changes to the building as a resu project which has not reached substantial completion
2. Current (represents existing conditions of the build inclusive of cumulative set of changes on all projects tha reached substantial completion)
3. Archived (past history of drawings and equipment rela the building. These could be in the form of design draw construction drawings historical drawings previous equi lists, etc)

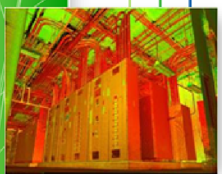


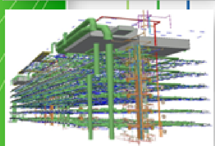
Overview of Central Facility Repository – Strategic (2-5 years out)

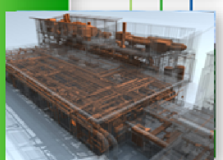
(Component / Data Based)
(as of May 5, 2011)

In future state 2D (.dwg), BIM and FM data (.xls, .ifc) would be parsed and stored in a database that would be updated as a database vs. in a file. Other files may also exist, e.g. .doc, .pdf, etc.









Appendix B: Glossary

2D – two dimensional

3D – three dimensional

4D – four dimensional

A/E – Architect and Engineer

APIs - Application Programming Interfaces

As-Built BIM - Editable copy of the Record BIM that is constantly updated to represent the current building and systems configuration.

BIM – Building Information Model

CAD – Computer-Aided Design

CAFM – Computer Aided Facility Management

CMa - Construction Manager as Agent

CMc – Construction Manager as Contractor

CMMS - Computerized Maintenance Management System: a type of management software that performs functions in support of operations and maintenance (O&M) programs. The software automates most of the logistical functions performed by O&M staff.[4]

COBie - Construction Operations Building Information Exchange (COBie): an information standard that captures facility data generated during the facility's design, construction and commissioning phases.

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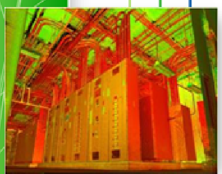
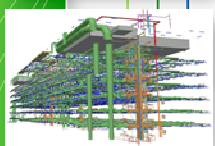
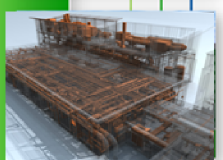
[4] U.S. Department of Energy, Federal Energy Management Program. Accessed December 02, 2010. http://www1.eere.energy.gov/femp/program/om_cmms.html







Construction BIM - Building information model typically representing a single building system created for purposes of planning, scheduling, coordinating, fabricating components and executing construction. Model elements are accurate in terms of size, shape, location, quantity and orientation and may include fabrication, assembly, detailing and non-geometric information. MEP/FP systems models include primary keys that link them to the COBie data. Construction BIMs are maintained in the native format of the authoring software.

Coordination BIM - Composite model that includes multiple Design or Construction BIMs, registered spatially, used for the purposes of interference checking (clash detection), visualization and 4D applications during construction. Coordination BIMs are maintained in the native format of the coordination software.

CxA – Commissioning Agent

Design Intent BIM - Building information model(s) created by and conformed to the bid addenda by the A/E. Elements are modeled per BIM Guide Series 02 and are accurate in terms of quantity, size, shape, location and orientation. The Design Intent BIM includes the Spatial Program model. Elements also contain primary keys that link them to the COBie data. The Design Intent BIM must be submitted in both .ifc and native format.

ERP - Enterprise Resource Planning

FMSP - Facilities Management and Services Program

FP – Fire Protection

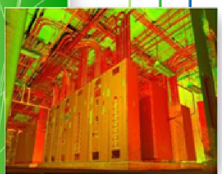
GC – General Contractor

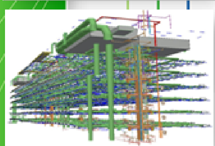
GUID – Globally Unique Identifier

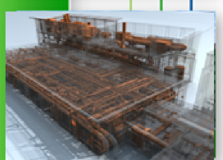
HVAC – Heating, Ventilating, and Air-Conditioning

IDIQ - Indefinite Delivery, Indefinite Quantity

IFC - Industry Foundation Classes: an object oriented neutral file format with a data model developed by buildingSMART (International Alliance for Interoperability, IAI) to describe, exchange and share information typically used within the building and facility management industry sector (AEC/FM). IFC is currently in the process of becoming the official International Standard ISO 16739.







MEP/FP – Mechanical, Electrical, Plumbing, and Fire Protection

NEST – GSA's National Equipment Standard Team: develops equipment standards for the identification, classification, collection, and coding of equipment within facilities to ensure that this data and information complies with industry standards and is consistent throughout GSA.[5]

NIBS – National Institute of Building Sciences

O&M – Operations & Maintenance

ODBC - Open DataBase Connectivity

Record BIM - Multiple Construction BIMs, organized by building system and floor and registered spatially, that represent the final as-constructed building and components configuration, including Architectural Supplemental Instructions, Change Notices, and field changes. Base building model conforms to BIM Guide Series 02 specification. MEP/FP systems models include primary keys that link them to the COBie data. Record BIMs must be submitted in both .ifc and native format. The Record BIMs will be archived as part of the project record and also copied to the Central Facility Repository as the As-Built Building Information Model (BIM).

SBS – Smart Building Systems integrate major open building systems on a common network. Smart Building Systems share information and functionality to improve energy efficiency, operational effectiveness, and occupant satisfaction.[6]

SDM – Spatial Data Management – GSA's national effort to create, update, and maintain its spatial data and associated Computer Aided Design (CAD) floor plans to accurately reflect the national federally owned inventory.[7]

SOW – Statement of Work

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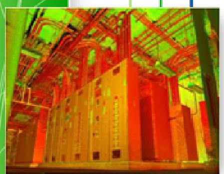
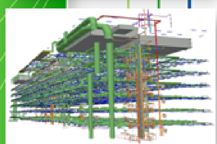
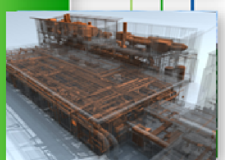
[5] Keady, Robert. *GSA National Equipment Standard Team*. Washington, D.C.: U.S. General Services Administration.
[6] U.S. General Services Administration. Public Buildings Service. The Office of Facilities Management and Services Programs. 2010. *Integration of Smart Buildings Technology in GSA PBS*. http://www.gsa.gov/graphics/fas/Smart_Buildings.pdf
[7] U.S. General Services Administration. *Spatial Data Management Overview*. http://www.gsa.gov/portal/content/104479







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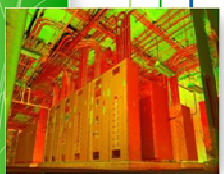
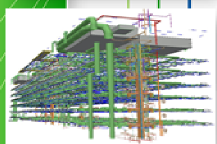
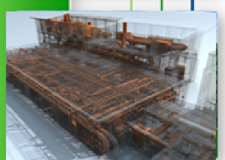

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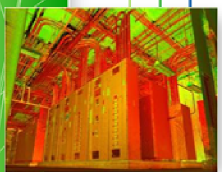

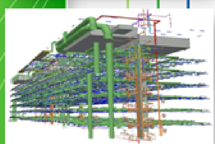

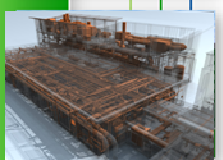

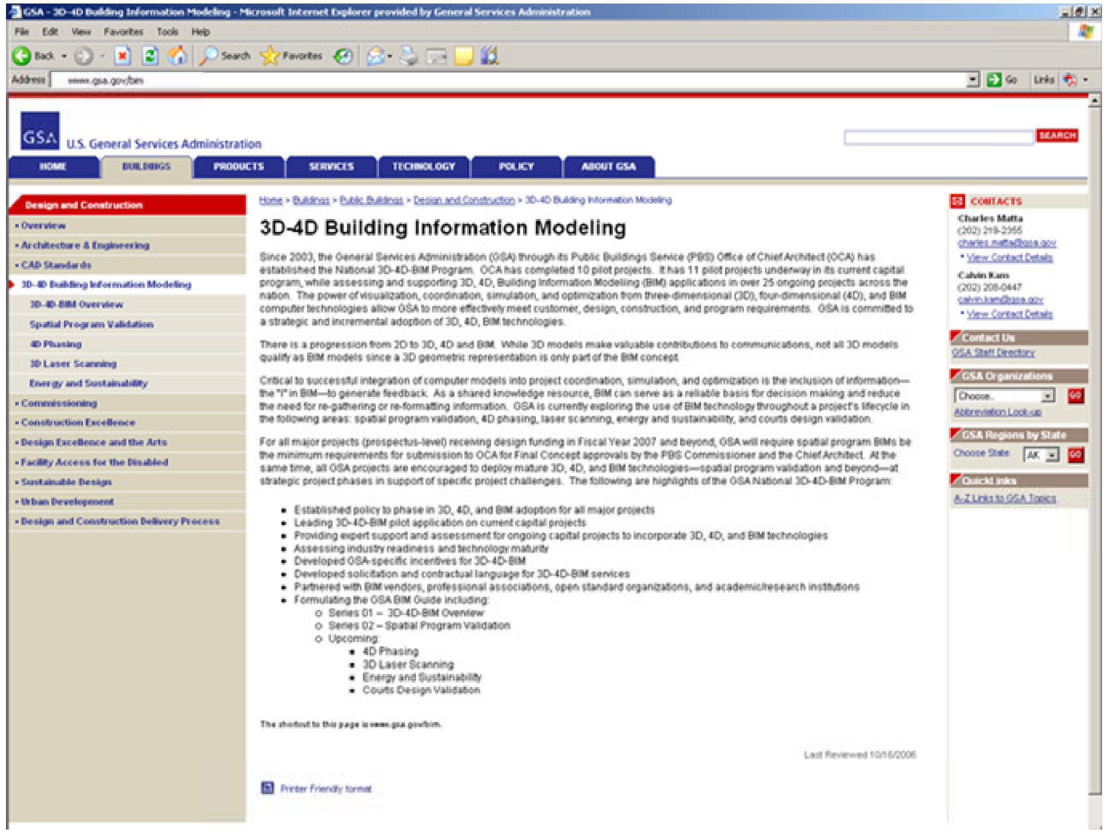

For further information about this GSA BIM Guide Series: 08 – BIM Guide for Facility Management or to submit comments or questions, please visit the National 3D-4D-BIM webpage at http://www.gsa.gov/bim or contact:

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