NASA BUILDING INFORMATION MODELING SCOPE OF SERVICES AND REQUIREMENTS FOR ARCHITECTS AND ENGINEERS

Revised January 10, 2017

Adapted from

Design-Bid-Build Version 1.0 – July 9, 2010

NASA BUILDING INFORMATION MODELING SCOPE OF SERVICES AND REQUIREMENTS FOR ARCHITECTS AND ENGINEERS

Table of Contents

1 Introduction

This document defines the A-E's scope of work and deliverables for using Building Information Modeling on NASA projects delivered using a design, bid, build methodology. If attached to a Request for Proposal for Architectural Services, the Architect-Engineer's (A-E's) response should include the below tasks and deliverables within its proposal. If attached to the A-E's contract for services, the tasks and deliverables required by this document become an integral part of the A-E's contract for services. Services and deliverables must comply with NASA Facility Project Requirements NPR 8820 and the *Facilities Design Policies Guidelines* dated 01/06/11 published by the GRC Facilities Division, Facilities Engineering Management Branch.

1.1. Statement of Purpose

If used effectively BIM provides opportunities to improve facility quality while maintaining or reducing facility cost. In addition, BIM creates opportunities for reusing data for multiple purposes, including NASA's operation and maintenance of its facilities. To achieve these ends, the BIM must be structured to achieve the required purposes. This document describes NASA's requirements for use of Building Information Models (BIM) in the design and development of its facilities.

1.2. BIM Competence and Responsibilities

The architects, engineers, designers and technicians involved with providing services under A-E's Agreement, must be trained and experienced in using BIM technology and processes. Unless BIM software is being provided by NASA, A-E must have, or must obtain at its own cost, sufficient software licenses and computer hardware to adequately perform the services required.

A-E will provide NASA with past BIM experience of project team members. The experience will include three BIM projects of each team member.

1.3. Data Ownership and Reuse

Information regarding NASA's facilities is important to NASA's overall facility management program as well as its continued use, modification and reuse of the project being designed under this Agreement. All building information models and supporting information are the property of NASA, which has unrestricted right of reuse. A-E is not responsible for any modifications to the building information models made by NASA subsequent to completion of this Project.

1.4. Relationship of DBIM to Contract Documents**.**

The A-E will use the Design BIM (DBIM) to generate 2d, printed documents and IFC models that will be included in the Contract Documents for contractor bidding and construction. The DBIM will be provided to bidders and the selected contractor as an indication of the A-E's design intent and an aid in interpretation of the Contract Documents. The file formats for A-E deliverables are set forth in Section 5.7.1.

1.5. Additional Uses

The DBIM will be used to check for physical coordination conflicts between the DBIM and Contractor's and Subcontractor's submittals. In addition, the DBIM may be used to develop record drawing information, studies, PERs and a model or models used for operation and maintenance of the Project. A-E will coordinate with NASA and its commissioning agent regarding inclusion of operations and maintenance information into the DBIM data. and in the BIM Execution Plan will describe the inclusion of O&M and facility management information

2. DBIM Functional Requirements

The DBIM must be sufficient to achieve each of the functional uses described below.

2.1. Program Space Validation

The A-E will use the BIM Authoring software or other analysis tools to compare and validate stated program requirements provided by NASA. The space validation will be based on the NASA NPR 8800.15, GLPR 8800.15, and OmniClass Space and Facility Types Table and/or BOCA/IFMA Standards. The comparison and validation will include space allocations, adjacencies, and affinities.

The following will be developed automatically from the building information model.

- Assignable Areas (ASF) and Non-assignable Areas (NaSF) measured to inside face of wall objects and designated boundaries of areas.
- Gross Area (GSF) measured to the outside face of wall objects.

2.2. Design Model

2.2.1. Geometric Model

Using BIM Authoring software applications, the A-E will deliver 3D geometric models of the components listed below. A-E will use 3D geometries to represent building components. The A-E will properly use available intelligent objects to embody information including, but not limited to, material properties, functions, coding (naming conventions, standards, and dimensions. The following sections describe in more detail the specific discipline requirements for 3D geometric modeling.

2.2.1.1. Architectural

The A-E will provide a 3D BIM created with architectural components that embody proper object information and parametric relationships in accordance with good architectural practice. These components include, but not limited, to slabs/floors, walls, roofs, doors, windows, stairs, elevators, finishes, ceilings, millwork and case goods.

2.2.1.2. Furniture, Furnishings and Equipment (FF&E)

The A-E will provide a 3D BIM created with architectural components that embody proper object information and parametric relationships in accordance with good architectural practice. These components include, but not limited, to furniture, furnishings and equipment. *[Consider requiring the AE to model all equipment that is critical to the mission of the facility, even equipment that is not in contract, existing or future.]*

2.2.1.3. Structural

The A-E will provide a 3D BIM created with structural components that embody proper object information and parametric relationships in accordance with good structural engineering practice. These components include, but not limited to, all substructure and superstructure components. The object information will include member profile and dimension information.

2.2.1.4. Mechanical

The A-E will provide a 3D BIM created with mechanical components that embody proper object information and parametric relationships in accordance with good mechanical engineering practice. These components include, but not limited, to all major mechanical equipment, cooling towers, chillers, air handling units, pumps, terminal boxes, hydrants, HVAC piping and ductwork, hangers, and other HVAC equipment. Piping bends are to be modeled for coordination with other trades. Refer to LOD for minimum sizes for mechanical piping to be modeled.

2.2.1.5. Electrical

The A-E will provide a 3D BIM created with electrical components that embody proper object information and parametric relationships in accordance with good electrical engineering practice. These components include, but not limited to, all major electrical equipment, transformers, switchgear, generators, panel boards, lights, conduit over 2", hangers, cable trays, raceways and other electrical equipment. Conduit bends are to be modeled for coordination with other trades.

2.2.1.6. Plumbing

The A-E will provide a 3D BIM created with plumbing components that embody proper object information and parametric relationships in accordance with good mechanical engineering practice. These components include, but not limited to, all major plumbing equipment, fixtures, boilers, pumps, piping over 2", hangers, and other plumbing equipment. Pipe bends are to be modeled for coordination with other trades.

2.2.1.7. Telecommunications / Information Technology

The A-E will provide a 3D BIM created with telecommunications and information technology components that embody proper object information and parametric relationships in accordance with good engineering practice. These components include, but not limited to, all major equipment, panel boards, conduit over 2", hangers, cable trays, raceways and other equipment. Conduit bends are to be modeled for coordination with other trades.

2.2.1.8. Life Safety and Fire Protection

The A-E will provide 3D BIMs created with life safety and fire protection components that embody proper object information and parametric relationships in accordance with good mechanical and electrical engineering practice. These components include, but not limited to, fire alarm devices, fire alarm panels, the main sprinkler piping risers and related devices with piping 1 ½" or larger in diameter, control valves, fire suppression equipment, pumps, hangers, and other equipment. Pipe bends are to be modeled for coordination with other trades.

2.2.1.9. Underground Utilities (Civil)

The A-E will provide a 3D BIM for underground utilities created with civil components that embody proper object information and parametric relationships in accordance with good civil engineering practice. These components include all underground utilities, vaults, manholes, handholes, location of soil borings with associated data and other civil features.

2.2.1.10. Site / Campus (Civil and Landscape)

The A-E will provide 3D BIMs for site and campus design with both civil and landscape components that embody proper object information and parametric relationships in accordance with good civil engineering and landscape architecture practice. These components include, but not limited to, topographic grading, streetscape, landcape including trees, planting stock (including roof), storm water drainage features, exterior lighting, and other pertinent site and campus features.

Refer to LOD for tight spaces and spaces critical to the mission of the facility to have all proposed components modeling regardless of size.

2.2.2. Design Coherence

2.2.2.1. General

It is the A-E's responsibility to conduct and manage an adequate and thorough Clash Detection process throughout the design process, so that all major interferences between building components will have been detected and resolved before construction. It will be the goal of the A-E to eliminate changes during construction due to major building interferences to zero.

The A-E's Information Manager will assemble a composite model from all of the model parts of each design discipline for the purpose of performing a visual check of the building design for spatial and system coordination. Vertical shafts should also be reviewed to ensure that adequate space has been allocated for all of the vertical mechanical systems and that all of the shafts line up floor to floor. The clash detection process should uncover and address hard clashes between modeled elements and soft clashes, such as infringements into code or maintenance required clearances and necessary clearances for fireproofing, insulation or other non-modeled elements. Prior to each scheduled coordination meeting, an updated clash report will be issued by the A-E Information Manager to the technical discipline consultants.

A-E will use coordination software for assembling the various design models to electronically identify, collectively coordinate resolutions, and track and publish interference reports between all disciplines. The A-E will be responsible for updating their models to reflect the coordinated resolution.

The A-E will review the model and the clash reports in coordination meetings throughout the design phases and as required by the BEP, until all spatial and system coordination issues have been resolved.

Internal Clash Resolution – A-E Consultants who are responsible for multiple scopes of work are expected to coordinate the clashes between those scopes prior to providing those models to the A-E Information Manager for spatial and system coordination.

Spatial Coordination Verification: Verification and tracking of resolved conflicts of all discipline coordination issues which could result in change orders or field conflicts will be provided to NASA during project milestone dates, and should be fully resolved before bidding.

For ease of identification during the 3D clash detection/coordination process, it is recommended that the following trades be represented in these assigned colors:

Trade colors for Clash Detection

Trade Name	**Color Name**	**RGB Number**
Architecture	White	255,255,255
Structural Steel	Maroon	176,48,96
Concrete	Grey75	191,191,191
HVAC Equipment:	Gold	255,215,0
HVAC Supply Duct/Diffuser	Sky Blue	50,153,204
HVAC Return Duct/Diffuser	Magenta	255,0,255
HVAC Pipe	Gold	255,215,0
Electrical Equipment	Dark Yellow	205,205,0
Electrical Conduits	Light Yellow	255,255,224
Communication Conduit	Light Blue	205,127,50
Electrical Cable Tray	Dark Orange	255,140,0
Electrical Lighting	Yellow	255,255,0
Plumbing Water	Cyan	209,238,238
Plumbing Sewer	Magenta	255,0,255

Plumbing Storm Drain	Green	0,255,0
Fire Protection	Red	255,0,0
Pneumatic Tube	Dark Green	47,79,47
Equipment	Light Green	152,251,152
Gas	Light Green	152,251,152
Security Systems	Orange	255,165,0
Fire Alarm	Fuchsia	255,0,255

2.2.2.2. Minimum Requirements for Spatial Coordination and Clash Detection

Architecture + Structural:
Below-grade spaces, proposed floor plates with major penetrations, floor-to-floor heights, beam clearances, heavy utilities locations, floor loads, core, and vertical shafts, beam depths and required clearances, slab thickness, columns, column caps, and structural bracing including seismic. Provide adequate space for construction and maintenance access to structural elements, building equipment, and distribution systems.

Clearance reservations shall be provided for all equipment that moves during use. Including overhead and bay doors, overhead cranes and moving platforms.

Architecture + MEPF
Structural and space elements, flow and isolation requirements, proposed functional area configurations, floor-to-floor heights, fire containment, vertical and horizontal transportation. Possible future expansions will be considered and will be clash-free.

MEPF/HVAC + Architecture, Structure, and Telecommunications
Main distribution and collection systems, configurations and sizes for piping, duct, conduit, power wiring, blowers; diffusers; intakes, large compressors, hangers. Clearance reservations for equipment maintenance filter removal, and equipment removal and replacement will be modeled with the equipment, and sign-off on the adequacy of the space reservations will be obtained from NASA.

Architecture + Life Safety Fire Protection
Safe zone and fire suppression pipe and hanger location, egress paths and exit distance requirements, equipment, and pipe penetrations.

Architecture/HVAC + Interiors
Merges will include ductwork and piping + ceilings and FF&E + HVAC.

Space Validation
There will be no space gaps. Bounding boxes used to represent room and zone spaces will match with architectural requirements and data values, and all

will be coordinated with values given in the program and engineering requirements as defined in the PER.

General Model Quality Checking
All walls will be properly joined to prevent “space leaks” in areas defined by enclosing walls. Bounding boxes will not conflict.

Security
Security setbacks + structure + site. Include line of site coherence check.

Accessibility Compliance
Wheelchair pathways and clearances + structure + MEPF components. These componants will include plumbing fixtures. (If using Solibri Model Checker or other rules-based model checking software, accessibility compliance can be checked automatically.

2.2.3. Code Review

The A-E will use the BIM Authoring software or other analysis tools to validate the design is in compliance with stated building code requirements.

2.2.4. NASA Building Requirements

The A-E will use the BIM Authoring software or other analysis tools to validate the design is in compliance with stated NASA building requirements.

2.2.5. Analysis and Optimization

2.2.5.1. Lighting and Daylighting

Lighting and Daylighting simulation and calculations will be based on information within or extracted directly from BIM and validated by lighting and daylighting modeling. The model elements will be created to a level of completeness and quality as required to perform a lighting and daylighting analysis appropriate for the phase and decision requirements of the project.

2.2.5.2. Energy

Energy simulation and life-cycle cost calculations will be based on information within or extracted directly from BIM and validated by energy modeling. The model elements will be created to a level of completeness and quality as required to perform an energy analysis appropriate for the phase and decision requirements of the project.

2.2.5.3. Carbon

Carbon output calculations will be based on information within or extracted directly from BIM and validated by energy modeling. The model elements will be created to a level of completeness and quality as required to perform an energy analysis appropriate for the phase and decision requirements of the project.

2.2.5.4. Wind

Wind simulation and calculations will be based on information within or extracted directly from BIM. The model elements will be created to a level of completeness and quality as required to perform an analysis appropriate for the phase and decision requirements of the project.

2.2.5.5. Water

Water use calculations will be based on information within or extracted directly from BIM. The model elements will be created to a level of completeness and quality as required to perform a water usage analysis appropriate for the phase and decision requirements of the project.

2.2.5.6. Indoor Air Quality

Indoor Air Quality analysis will be based on information within or extracted directly from BIM. The model elements, such as HVAC filters and finish surface materials, will be created to a level of completeness and quality as required to perform an air quality analysis appropriate for the phase and decision requirements of the project.

2.2.5.7. Acoustics

Acoustic simulation and calculations will be based on information within or extracted directly from BIM. The model elements will be created to a level of completeness and quality as required to perform an analysis appropriate for the phase and decision requirements of the project.

2.2.5.8. Functional Analysis per Building Type

Utilize the BIM to analyze and forecast interior and exterior pedestrian circulation and activity patterns within the project parameters. Life safety egress, accessibility requirements for Federal properties and wayfinding will be included in the analysis.

Utilize the BIM to analyze and forecast vehicular circulation and activity patterns within the project parameters. Parking, fire department vehicles access, and accessibility will be included in the analysis.

Utilize the BIM to analyze access for moving facility furniture, fixtures, and equipment throughout the project parameters.

Utilize the BIM to analyze access to facility furniture, fixtures, and equipment throughout the project parameters.

2.2.6. Construction Document Drawings

A-E will produce construction document drawings utilizing IFC compliant BIM Authoring software. All drawing information, including 2D plans, elevations, sections, schedules and details, needed to describe the design intent for construction bidding will be graphically or alphanumerically included in and derived from models created in the BIM Authoring software. All 2D drawings must comply with the graphic standards as referenced in NASA Facility Project Requirements, NPR 8820.

3. BIM Execution Plan (BEP)

Within 30 days after execution of the Agreement, A-E will prepare a BIM Execution Plan (BEP) confirming the intended uses of the BIM, describing the communication paths, the model structure, the Level of Detail of the modeled elements at each contractual milestone or deliverable, and the BIM process design. The BEP will be provided to NASA for its review and approval. Once approved, the BEP can not be modified without NASA's written approval.

The BEP will, at a minimum, contain the following elements.

3.1. BIM Staffing Plan

A-E will identify for itself and each of its consultants, the persons that within their organizations responsible for managing the BIM, or portion of the BIM. Where an organization is responsible for multiple disciplines, or where the project is divided into sections or phases, the BIM Staffing Plan should include the persons responsible for the discipline, section or phase. For each person identified, the BIM Staffing Plan should include the person's:

- Name
- Title
- Contact Information (location, primary phone number, mobile phone number, and email address)
- Description of the duration and extent of the person’s experience with the BIM software the A-E proposes to use
- Identification and description of prior projects where the person used BIM software and the extent it was used on that project
- Role (i.e, BIM structural design lead; BIM mechanical design leader, etc.)
- Anticipated time devoted to the project in hours per week. If the level of activity will vary throughout the project, the staffing plan should be delivered as a schedule. This may be depicted on a monthly schedule basis where the level of activity will vary during the project.

3.2. Model Progression Matrix

The BEP must contain a model progression matrix substantially similar to the Model Progression Specification spreadsheet published by American Institute of Architects, California Council or the Model Element Table, Section 4.2 of American Institute of Architect's Document AIA E-202. The model progression matrix must be executed by each party that is assigned responsibility as a model component author in the matrix. The phasing columns of the matrix should be modified to match the phasing of project deliverables in the A-E contract and the Level of Detail (LOD) must comply with Uniformat II, Level 3 model components and should include user level sub-categorization, (Uniformat Levels 4 & 5) if necessary to provide appropriately defined LOD and model component author responsibility. The model progression matrix must show the LOD that must be accomplished on or before the completion of each phase, or the date of each contract deliverable, as identified in A-E's agreement with NASA.

3.3. BIM Process Design

A-E will lead a workshop that includes all design level participants, including A-E's staff, A-E's consultants, and NASA staff. The purpose of the workshop is to develop process diagrams documenting BIM information exchange and BIM workflow. At a minimum, the process mapping should include a process map of the overall BIM processes and individual detailed maps documenting the information and workflow applicable to specific BIM uses. At the conclusion of the workshop, the A-E will prepare the process overview and detailed BIM process maps and distribute them to the workshop participants. Examples of the BIM process design maps and supporting worksheets are contained in the BIM Project Execution Planning Guide, published by the Penn State Computer Integrated Construction Research Program.

3.4. Schedule

A-E will prepare a schedule for BIM design deliverables tied to the Model Progression Matrix. The schedule must include all BIM tasks of A-E's consultants, tasks of other NASA retained consultants who are contributing to the design, the schedule of clash detection and resolution meetings, and appropriate review time by NASA or other governmental agencies that will comment or render decisions regarding the project design. The schedule will be submitted to NASA for review as directed by the contract documents.

3.5. Model Structure

3.5.1. File Naming Structure

The following is specific for Autodesk Revit with its single model concept.

File names for models should be formatted as discipline-project number-building number.file extension. (Example: ARCH-1111-BL001.rvt) File name prefixes by discipine are listed in the table below.

Architectural Model	ARCH-
Civil Model	CIVIL-
Mechanical Model	MECH-
Plumbing Model	PLUMB-
Electrical Model	ELEC-
Structural Model	STRUCT-
Energy Model	ENERGY-
Coordination Model	COORD-
Construction Model	CONST-
Other Model Types as Required	

3.5.2. Model Structure and Division of Modeled Information

In most instances, the BIM will consist of a series of related models that depict information relevant to specific disciplines or uses. Moreover, a specific discipline model or use model may be organized into separate floors, sections, divisions or files. The BEP must describe the organization of the model files, explaining how each file and model is separated, the file naming conventions that will be used for each file type, the relationship of files to each other, and the process that A-E will use to ensure that all of the models remain current and consistent.

3.5.3. Measurement and Coordinate Systems

The measurement and coordinate systems are to be confirmed and documented in the BEP for this project. The A-E will provide the following

- All measurements will be in metric units unless a waiver is provided by the Contracting Officer or is contained in standards applicable to a specific NASA center.
- Site plans and building models will be geo-referenced to HARN/OHIO STATE PLANES, NORTH ZONE, US SURVEY FOOT.

3.6. Software and Operating Systems

The BEP must list the BIM software and computer operating system or systems to be used by A-E and its consultants for this project. The software and operating systems should be identified by vendor, product name, version identifier, build identifier, patch number, and data architecture (32bit/64bit). Listed software, and listed operating systems, can not be changed or upgraded without NASA's written approval, which will not be granted unless A-E demonstrates that the change or upgrade will not affect the ability to use existing BIM information or to reliably and accurately exchange BIM information with other listed software.

3.7. Electronic Communication Procedures

3.7.1. File Access and Archiving

The BEP will specifiy:

- The physical and logical locations of BIM files and related electronic information;
- The protocols for archiving and disaster recovery;
- The protocols for user access and file permissions;
- The directory/subdirector/file structure used to organize the BIM files and related electronic information; and
- The internet address and directory structure for a secure web site, internet accessible project manager, or web portal used to store and access BIM files.

3.7.2. Electronic file formats and use.

The BEP will specify:

- The types of digital information that will be transmitted between project participants;
- The acceptable methods of transmission;
- The acceptable file format(s) to be used for the type of digital information.

3.7.3. A-E Information Manager(s)

The BEP will identify the persons responsible for managing and executing the responsibilities of this section.

3.8. Pre-Design Site Survey Modeling

If the A-E scope of services includes surveying the existing project site and preparing a pre-design model of the existing facilities, the BEP will include the following:

- Description of tasks and schedule for developing the pre-design model;
- Description of recommended methodology for developing the existing site information, such as:
  - Development of model based on as-built documents for facility;
  - Optical surveying facility to develop a new model or validate the accuracy of existing information used to create a model;
  - Laser scanning all or a portion of the facility to develop new model or validate the accuracy of existing information used to create a model; or
  - Combination of tasks or approaches to accomplish the goals.

If laser scanning is required or will be used by the A-E, the BEP should identify:

- Primary and secondary objectives of laser scanning;
- Areas of Interest;
- Resolution requirements and measurement units;
- Type of deliverable;
- Control network or other dimensional control; and
- Quality control procedures.

A-E should use the GSA BIM Guide for 3D Imaging in developing this portion of the BEP.

4. Interoperability

A-E is responsible for selecting BIM software that is adequate for A-E's tasks. Moreover, A-E must demonstrate that the software used by it and its consultants can exchange BIM information reliably and accurately and can read and export BIM information into open source file formats to the extent required in Section 4.2. NASA's listing of BIM software is not a recommendation that any specific product or products be used, nor is it a representation or warranty as to the adequacy of the software product or of its ability to exchange BIM information reliably and accurately.

4.1. BIM Software

BIM software for NASA projects must support intelligent objects and parametric relationships. The software must comply with current industry interoperability standards and be usable in a collaborative environment. All software platforms used for NASA projects will be compliant with:

- The most current version of Industry Foundation Classes (IFC) file format
- Commercially available collaboration software that provides interoperability between the different software applications (see below).

TYPE (These are general categories. Listed software can be used for more than one "Type.")	**SOFTWARE** (no order of preference)
Planning/Preliminary Cost Estimates	Onuma Planning System (OPS), DProfiler, Tokmo, CodeBook
Authoring – Design (Architecture, Structural)	Revit Architecture, Revit Structure, Bentley AECOsim Building Designer, ArchiCAD, Tekla, Vectorworks
Authoring – MEPF (Engineering & Construction)	ArchiCAD MEP, Revit MEP, Bentley AECOsim Building Designer, CAD-Duct, CAD- Pipe, AutoSprink, PipeDesigner 3D
Authoring – Civil	Bentley Inroads and Geopak, Autodesk Civil 3D
Coordination (clash detection)	NavisWorks Manage, Bentley Navigator, Solibri Model Checker, Horizontal Glue, EPM Model Server, BIMServer
4D Scheduling	Synchro, Vico, NavisWorks Simulate, Primavera, MS Project, Bentley Navigator
5D Cost Estimating	Innovaya, Vico, Tokmo
Specifications (Management software for linking data between BIM and specification editing software utilizing uniformat codes)	Speclink-e, E-Specs
Model Checking Validation, IFC File Optimizer	Solibri
Construction Operations Building Information Exchange (COBIE)	Tokmo COBIE
Energy Analysis	EcoDesigner, Ecotect, eQuest, Green Building Studio, EnergyPlus, Trane/Trace, DOE2, Bentley AECOsim Energy Simulator

4.2. Open Source File Formats/Open Standards

4.2.1. Statement of Principal

To ensure the life-cycle use of NASA building information, NASA requires that information supporting common industry deliverables be provided in existing open standards, where available. For those contract deliverables whose open standard formats have not yet been finalized, the deliverable will be provided in a mutually agreed upon format that allows the re-use of building information outside the context of the proprietary BIM software. The formats used will be specified in the BIM Execution Plan and will include, at a minimum, the following standards:

4.2.1.1. Current version IFC Model View Definition (MVD) formats:

Coordination---This format will be required for all deliverables needed to demonstrate the coordination of design disciplines prior to construction. In addition to the Coordination View file(s), where required, the A-E will provide a report highlighting automatically detected (hard and soft) collisions and identifying those collisions that require further work by the A-E.

4.2.1.2. Portable Document Format:

Non-modeled information authored directly by the A-E will be transformed to PDF to allow selection of text within the document. Documents authored by others, but used by the A-E such as manufacturer product data sheets, will be provided the format made available by the manufacturer or scanned as image-based PDF documents.

4.2.1.3. GBxml

At a minimum, Architectural, Mechanical and Electrical BIM software must support accurate and reliable data export to GBxml for environmental analysis, optimization, and sustainability classifications, such as LEED, Green Globes and EnergyStar.

4.2.1.4. COBIE

BIM authoring software must be COBIE compliant.

5. Modeling Requirements

5.1. General

BIM will be used for all building systems design, development, and analysis, including but not limited to architectural, structural, mechanical, electrical, plumbing, fire suppression, civil and landscape.

During the defined design phases, BIM technology will be used to develop and establish building performance and the basis of design in accordance with NASA Standards. The model will be interoperable with analytic tools including but not limited to building envelope, orientation, daylighting, energy consumption, building management system (BMS), renewable energy strategies, life cycle cost analysis, and spatial requirements.

Use BIM authoring software element libraries when creating model objects. Model objects will contain parts and components as opposed to simple 3D geometry (e.g., walls, doors, windows, railings, stairs, and furniture, etc.).

Model objects will contain IFC parameters and associated data applicable to building system requirements. These elements will support the analytic process include size, material, location, mounting heights, and system information where applicable. As an example, a light fixture may contain several parameters such as energy output requirements, user illumination levels, make, model, manufacturer, and bulb life.

Elements, objects and equipment will be tagged with unique identifiers (GUIDs).

5.2. Types of Model Elements

Model elements will be derived from the following sources:

Manufacturer's Model Elements - elements created by and acquired from manufacturers often have more information than is prudent to keep in the BIM model; the appropriate level of detail should be retained for the design element but should not exceed the proposed LOD of the model. However, embedded performance data must remain for analysis and specification purposes.

Custom Created Model Elements – custom model elements that are created must utilize appropriate BIM Authoring tool templates to create custom elements. Custom models components need to be assigned as a part and part of a family or group. LOD of the custom created model elements should match the proposed LOD of the building model.

5.3. Model Geographical Location

The spatial coordination (coordinates) of the master BIM file will be set at the beginning of the project. Once established, spatial coordinates will only be changed by mutual consent of the A-E and the NASA project manager, with the matter recorded in the meeting minutes and the BIM Execution Plan. Once the design coordinate system is agreed upon, any model(s) of existing buildings relevant to the project will be converted into the coordinate system used for each designed building.

As is standard practice, NASA requires that a building within a BIM file include a geo-reference to accurately locate that building within the site and to give it a physical location context at larger scales. The A-E Information Manager will geo-reference site plans and building models for site layout surveying and future GIS use in accordance with the State Plane Coordinate system where the project is located. The BIM file point will be located at the SW corner of the structural grid.

5.4. Points of Reference

The A-E Information Manager will provide a 3D grid for incorporation into the spatial coordination model. This will provide the viewer with a quick point of reference when navigating through the model. Room information will also be incorporated.

5.5. Requirements for Modeling Space

Space information imported from the NASA Project Program Requirements will be the source for space creation in BIM.

Areas of four square feet or greater will be tracked and identified by name, even if those spaces are not listed in the program narrative.

Spatial data will be generated and associated with bounding elements (walls, doors, windows, floors, columns, ceilings).

The Assignable Areas Square Footage (ASF), Non-Assignable Areas Square Footgage (NaSF), and Gross Square Footage (GSF) will be modeled for each functional space, using the appropriate space/object BIM tool to capture and carry the information. Spaces will be represented and broken down into functional spaces even though they may be parts of a larger physical space. A physical space may contain several areas that are treated individually in the spatial program. If two areas have different functional space classifications, even though they are within the same physical space, they will be modeled as two separate spaces.

Space/area schedules and diagrams must be dynamically updated from the model geometry.

Spatial Requirements must be validated through reports generated from the BIM.

5.6. Space Naming and Coding

Each space will include the following attributes and be maintained throughout the Design BIM models:

a. Building
b. Floor (and/or Level)
c. Department
d. Sub-department
e. Space Name – English Name & Abbreviation
f. Room Number – NASA Wayfinding Room Number
g. Room Number – Construction Document Number (used on large complex projects for builder use)
h. Space Code – NASA Room Code
i. Unique Space Number – GUID
j. Space Type - OmniClass
k. Space Type - Uniformat
l. Space Measurement - Net Square Footage (NSF), Department Net Square Footage (DNSF), Department Gross Square Footage (DGSF), and Building Gross Square Footage (BGSF)

5.7. Final A-E BIM Deliverables

5.7.1. 3D Geometric Deliverables – Design Model

The A-E will ensure that the design models remain current throughout design and construction documents phases of the project. It is NOT expected that product specific information will be added to these models. The A-E will be responsible for providing a fully coordinated and assembled BIM as well as separate copies of each technical discipline models in the original software authoring tool, model information and the required instructions on file/folder setup:

1. Native file format(s) of Design Model (version as agreed in BIM Execution Plan)
2. IFC file format (version as agreed in BIM Execution Plan)

3. Collaboration software format (Navisworks or equal or (version as agreed in BIM Execution Plan) for fully coordinated and assembled BIM

5.7.2. Data Deliverables

A-E will provide room/space data in COBIE format.

5.7.3. 2D Deliverables

A-E will produce printed sets of final documents generated from the Design Model

a. In PDF format with fully bookmarked pages.
b. DWG format meeting NASA requirements

5.7.4. Digital Deliverables

All digital deliverables are to be submitted on DVD/CD or provided electronically through a secure website or other electronic portal with the data clearly organized and software version(s) labeled.

6. Waivers of Specific Requirements

If a requirement contained in this document can not be achieved, or can not be achieved at a cost commensurate with the value of the requirement, A-E may request, in writing, that the requirement be withdrawn or modified. The request must certify that A-E has diligently attempted to meet the requirement, that the requirement can not reasonably be met, and that alternative approaches meet the intent of the requirement. The request must be supported by evidence of A-E's research and documentation that the alternative approach meets the function and interoperability requirements of this document. NASA, in its sole discretion, may waive requirements found to be currently unachievable or not commercially practicable.

7. Abbreviations List

A-E	Architect-Engineer
ADA	Americans with Disabilities Act
BEP	BIM Execution Plan
BIM	Building Information Model (also Modeling or Management)
COBIE	Construction Operation Building Information Exchange
DBIM	Design Building Information Model
FF&E	Furniture, Furnishings, & Equipment
GBxml	Green Building XML
GSA	General Services Administrations
GUID	Globally Unique Identifier
HVAC	Heating, Ventilation, and Air-Conditioning
IFC	Industry Foundation Classes

LOD	Level of Detail
MEPF	Mechanical, Electrical, Plumbing, Fire Protection
NASA	National Aeronautics and Space Administration
PER	Preliminary Engineering Report

8. Useful References

National Institute of Bulding Sciences, National Building Information Model Standard-US, V3. Washington DC, 2015.

National Institute of Building Sciences, National BIM Guide for Owners, Washington, DC, January, 2017.