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NASA Headquarters Facilities Engineering and Real Estate Division

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Superseding NASA Building Information Modeling Scope of Services and Requirements for Architects and Engineers Revised 2017-01-10

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

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DOCUMENT HISTORY LOG

Status	Document Revision	Change Number	Approval Date	Description
Baseline			2020-01-03	Initial Release—Converted from NASA Building Information Modeling Scope of Services and Requirements for Architects and Engineers revised 2017-01-10, adapted from Design-Bid-Build Version 1.0 dated 2010-07-09. Key changes were: Reformatted document to meet NASA Technical Standard requirements and clarified requirements and guidance. Added specific Geo-Spatial references.

FOREWORD

This NASA Technical Standard is published by the National Aeronautics and Space Administration (NASA) to provide uniform engineering and technical requirements for processes, procedures, practices, and methods that have been endorsed as standard for NASA programs and projects, including requirements for selection, application, and design criteria of an item.

This NASA Technical Standard is approved for use by NASA Headquarters and NASA Centers and Facilities, and applicable technical requirements may be cited in contract, program, and other Agency documents. It may also apply to the Jet Propulsion Laboratory (a Federally Funded Research and Development Center (FFRDC)), other contractors, recipients of grants and cooperative agreements, and parties to other agreements only to the extent specified or referenced in applicable contracts, grants, or agreements.

This NASA Technical Standard establishes the architects' and engineers' scope of services and requirements for using Building Information Modeling (BIM) on NASA projects delivered using a design-bid-build or a design-build methodology.

Requests for information should be submitted via "Feedback" at https://standards.nasa.gov. Requests for changes to this NASA Technical Standard should be submitted via MSFC Form 4657, Change Request for a NASA Engineering Standard.

Original Signed By — 1/3/2020

Richard Marrs
Acting Director, Facilities and
Real Estate Division (FRED) and
Deputy Associate Administrator for
Strategic Infrastructure

Approval Date

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF APPENDICES

TABLE OF CONTENTS (Continued)

LIST OF TABLES

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

1. SCOPE

1.1 Purpose

The purpose of this NASA Technical Standard is to define the scope of work and deliverables for architects and engineers (A-E) using Building Information Modeling (BIM) on NASA projects delivered in compliance with NPR 8820.2, NASA Facility Project Requirements, and the Facilities Design Policies Guidelines, published by NASA Facilities and Real Estate Division (FRED). BIM may be attached to a Request for Proposals for Architectural Services; the A-E's responses should include the tasks and deliverables in this NASA Technical Standard within their proposals. If BIM is attached to the A-E's contract for services, the tasks and deliverables required by this NASA Technical Standard become an integral part of the A-E's contract for services in compliance with NPR 8820.2 and the Facilities Design Policies Guidelines. BIM, when used effectively, 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 should be structured to achieve the required purposes. This NASA Technical Standard describes NASA's requirements for use of BIM in the design and development of its facilities.

1.2 Applicability

This NASA Technical Standard is applicable to A-E using BIM on NASA projects delivered using either a design-bid-build or a design-build methodology.

This NASA Technical Standard is approved for use by NASA Headquarters and NASA Centers and Facilities, and applicable technical requirements may be cited in contract, program, and other Agency documents. It may also apply to the Jet Propulsion Laboratory (a Federally Funded Research and Development Center (FFRDC)), other contractors, recipients of grants and cooperative agreements, and parties to other agreements only to the extent specified or referenced in applicable contracts, grants, or agreements.

Verifiable requirement statements are designated by the acronym "BIMR" (Building Information Modeling Requirement), numbered, and indicated by the word "shall"; this NASA Technical Standard contains 115 requirements. Explanatory or guidance text is indicated in italics beginning in section 4. To facilitate requirements selection and tailoring by NASA programs and projects, a Requirements Compliance Matrix is provided in Appendix A.

1.3 Tailoring/Waiving of Requirements

See section 8.

2. APPLICABLE DOCUMENTS

2.1 General

The documents listed in this section contain provisions that constitute requirements of this NASA Technical Standard as cited in the text.

2.1.1 The latest issuances of cited documents apply unless specific versions are designated.

2.1.2 Non-use of a specifically designated version is approved by the Director of FRED.

Applicable documents may be accessed at https://standards.nasa.gov or obtained directly from the Standards Developing Body or other document distributors. NPRs are accessible at https://nodis3.gsfc.nasa.gov/. When not available from these sources, information for obtaining the document is provided.

References are provided in Appendix B.

2.2 Government Documents

National Aeronautics and Space Administration (NASA)

	Facilities Design Policies Guidelines
NPR 8800.15	Real Estate Management Program
NPR 8820.2	NASA Facility Project Requirements

2.3 Non-Government Documents

ASTM International

ASTM E-1557	Standard Classification for Building Elements and Related Sitework—UNIFORMAT II (OmniClass Elements Table)

International Code Council (ICC)

	International Building Code (https://www.iccsafe.org/)

OCCS Development Committee

Edition: 1.0, 2006-03-28	OmniClass: A Strategy for Classifying the Built Environment (http://www.omniclass.org/)

The American Institute of Architects

AIA E-202™	Building Information Modeling Protocol Exhibit (https://www.smacna.org/resources/resource/2008/01/04/aia-e202-building-information-modeling-protocol-exhibit)

2.4 Order of Precedence

2.4.1 The requirements and standard practices established in this NASA Technical Standard do not supersede or waive existing requirements and standard practices found in other Agency documentation or in applicable laws and regulations unless a specific exemption has been obtained by the Director of FRED.

2.4.2 Conflicts between this NASA Technical Standard and other requirements documents are resolved by the Chair of the NASA BIM Working Group designated by the Director of FRED.

3. ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

3.1 Acronyms, Abbreviations, and Symbols

%	percent
A-E	architects and engineers
AI	architectural interiors
ASF	assignable areas
BEP	BIM Execution Plan
BGSF	building gross square footage
BIM	Building Information Modeling
BIMR	Building Information Modeling Requirements
BMS	building management system
BOCA	Building Officials Code Administrators International
CD	compact disc
COBie	Construction Operation Building information exchange
CoF	Construction of Facilities
D	dimensional
DBIM	Design Building Information Modeling
DC	District of Columbia
DGSF	department gross square footage
DNSF	department net square footage
DVD	digital versatile disc
FF&E	furniture, furnishings, and equipment
FFRDC	Federally Funded Research and Development Center
FIPS	Federal Information Processing Standards
FRED	Facilities Real Estate Division
GBxml	Green Building XML
GIS	Geographic Information Systems
GSA	General Services Administrations
GSF	gross area (in square feet)
GUID	Globally Unique Identifier

HARN	high accuracy reference network
HVAC	heating, ventilation, and air-conditioning
IBC	International Building Code
ICC	International Code Council
IFC	Industry Foundation Classes
LOA	level of accuracy
LOD	level of development
LOI	level of information
MEPF	mechanical, electrical, plumbing, fire protection
MSFC	Marshall Space Flight Center
MVD	model view definition
NAD	North American Datum
NASA	National Aeronautics and Space Administration
NaSF	non-assignable areas
NAVD	North American Vertical Datum
NGVD	North Geodetic Vertical Datum
NPR	NASA Procedural Requirements
NSF	net square footage
O&M	operations and maintenance
OCCS	OmniClass Construction Classification System
PDF	portable document format
PER	Preliminary Engineering Report
SpecsIntact	Specifications-Kept-Intact
STD	Standard
SW	southwest
URL	uniform resource locator
US	United States
XML	Extensible Markup Language

3.2 Definitions

Bid Set: Procurement documents consisting of general drawings and specifications.

Building Information Modeling (BIM): A parametric, computable representation of a facility's project design and construction details integrated into a single model. This model can be used for design, analysis, estimating, detailing, fabrication, construction, operation, and/or maintenance of the facility project and/or any portion or element of the facility project. (Source: NPR 8820.2)

Building Information Modeling (BIM) at 30%, 60%, 90%, 100% (Final): At the 30% submittal delivery of the project, the BIM model is an LOD 100. At the 60% submittal delivery of the project, the BIM model is an LOD 200. At the 90% submittal, BIM model is an LOD 300. At 100%, the BIM model is LOD 400 with some or all elements at LOD 500.

Building Information Modeling (BIM) Authoring Software: Collaborative software used to manage, analyze, design, and produce construction documents.

Building Information Modeling (BIM) Execution Plan (BEP): Defines a foundational framework to ensure successful deployment of advanced design technologies on your BIM-enabled project. The BEP is about optimizing work and model flow across the project, as contrasted with optimizing siloed interests. The key is good planning of the design-to-engineering-to-construction process to minimize downstream surprises, rework, redundancies, or gaps in the flow of (model-based) information.

Clash Free and Gap Free: All elements in the BIM are geometrically placed and not penetrating or overlapping any other item. All polylines used in the development of the BIM model are enclosed volumes with no breaches in the defined boundary of an object or area.

Closeout Record Model Set: Completed BIM model incorporating all products and their associated attributes and geometry used in the project.

DBIM Functional Requirements: Imbedded attributes within a BIM Object to represent behavioral characteristics.

Design BIM (DBIM): The construction drawings illustrating the physical location of materials and equipment and the details of construction.

Design Review: A collaborative effort during which users and technical experts verify that the design adequately addresses the project scope, objectives, and technical requirements (typically at the 30-percent, 60-percent, and 90-percent design milestones). (Source: NPR 8820.2)

Family: Components used to build models such as walls, windows, stairs, doors, etc. Each family can have multiple types such as different size, materials, parameter, and variables. Any change to a type is updated in every instance throughout the project.

Four-Dimensional (4-D) Modeling: BIM Model is dynamically connected to a scheduling program that provides a time factor.

Level of Development (LOD): Defines the content and reliability of BIM elements at different stages or milestones. Reference NBIMS-US, V3, Section 2.7.

Level of Information (LOI): A broad term that describes the process of creating and managing digital information about a built asset such as building, bridge, roadway, tunnel, and so on. The level of information is used to indicate the level of the information that is linked to the family. A family with an extremely high level of information comprises, for example, manufacturer-specific data sheets and a maintenance instruction. Reference NBIMS-US, V3, Section 2.

Operations and Maintenance (O&M) Manuals: Organized procedural information specifying methods of operating and maintaining building systems, collateral equipment, and support equipment. O&M personnel use the manuals in the performance of day-to-day tasks. Preferably, the manuals are in an electronic format. (Source: NPR 8820.2)

Three-Dimensional (3-D) Point Cloud: A database containing points in three-dimensional coordinate system.

Waiver: A documented authorization releasing a program or project from meeting a requirement after the requirement is put under configuration control at the level the requirement will be implemented. (Source: NPR 7120.5)

4. GENERAL REQUIREMENTS

4.1 BIM Competence and Responsibilities

4.1.1 [BIMR 1] The Design Contractor shall provide a detailed written description of the BIM experience of its key project team members.

4.1.2 [BIMR 2] The Design Contractor shall designate a BIM Manager possessing the following skills and experience, at a minimum, to oversee the technical aspects of developing, managing, and maintaining the BIM models:

a. Bachelor's Degree in Architecture or Engineering.

b. Three to seven years' experience with software modeling in an architectural or engineering environment.

c. Two to three projects completed as a BIM coordinator or specialist.

d. Experienced and proficient in Navisworks® Manage.

e. General knowledge of integrated architectural and engineering practice.

f. Strong supervisory, leadership, and communication skills.

g. Experience with project planning and tracking.

h. Experience with Microsoft® Office® (i.e., Word®, Excel®, Access®, and Outlook®.

4.1.3 [BIMR 3] Unless BIM software is being provided by NASA, A-E shall have, or obtain at their own cost, sufficient software licenses and computer hardware to adequately perform the services required.

4.1.4 [BIMR 4] A-E shall provide NASA with project team members' experience from three of their past BIM projects.

4.1.5 BIM/COBie Submittals

4.1.5.1 [BIMR 5] BIM submittals shall be listed in SpecsIntact, "Section 01 78 25, Building Information Modeling (BIM)"; "Section 01 79 00, Construction Operations Building information exchange (COBie)"; and in the BEP.

Refer to Table 1, SpecsIntact BIM Design Example, and Table 2, SpecsIntact BIM Design COBie Example.

Table 1—SpecsIntact BIM Design Example

(Note: Requirements indicated in Table 1 are for example only and are not requirements for compliance with this NASA Technical Standard.)

1.2 Submittals

Failure to provide approved BIM with native content will result in the following withholdings. The withholding will be released following the compliance with the specifications and Government approval of the required BIM model set. These withholdings reflect the cost to the Government to independently recreate the required BIM Data and Document Files.

1.2.1 Design 30% Complete

An additional $20,000 withholding will be held if BIM models are not provided at 30% completion. The 35% BIM model set content shall meet the Modeling Requirements in NASA-STD-10001, NASA Building Information Modeling Scope of Services and Requirements for Architects and Engineers, as applicable.

1.2.2 Design 60% Complete

An additional $20,000 withholding will be held if BIM models are not provided at 60% completion. The 65% BIM model set content shall meet the Modeling Requirements in NASA-STD-10001, NASA Building Information Modeling Scope of Services and Requirements for Architects and Engineers, as applicable.

1.2.3 Design 100% Completion

An additional $25,000 withholding will be held if BIM models are not provided at 100% completion. The 100% BIM model set shall completely meet the Modeling Requirements in NASA-STD-10001, NASA Building Information Modeling Scope of Services and Requirements for Architects and Engineers.

1.2.4 Bid Set

An additional $30,000 withholding will be held if BIM models are not provided at completion of the Bid Set. The BIM model set shall completely meet the Modeling Requirements in NASA-STD-10001, NASA Building Information Modeling Scope of Services and Requirements for Architects and Engineers.

Table 2—SpecsIntact BIM Design COBie Example

(Note: Requirements indicated in Table 2 are for example only and are not requirements for compliance with this NASA Technical Standard.)

1.2 Submittals

Failure to provide approved COBie-Specific Submittals will result in the following withholdings. The withholding will be released following the compliance with the specifications and Government approval of the required COBie data set and verification that it originated from the BIM models. These withholdings reflect the cost to the Government to independently recreate the required COBie data and document files.

1.2.1 Design 30% Complete

An additional $20,000 withholding will be held if COBie data are not provided at 30% completion. The COBie data exported from the BIM models shall be COBie compliant and contain the following information, as a minimum:

COBie Worksheet	Required Content
Contact	One row for the designer's BIM manager.
Facility	One facility per COBie file.
Floor	One row for each vertical level to include foundations, floors, roofs, and site.
Space	One row per functional space, per room. Multiple spaces in a room possible.
Zone	One row for each COBie.Space and COBie.Zone type.
Type	One row for each scheduled product type found on design drawings.
Component	One row for each individually scheduled product found on design drawings.
Document	One row for each associated deliverable document linked to relevant sheet.
	One row listing URL of target product COBie. Type selected.
Attribute	One row for each required COBie. Space Attribute.
	One row for each required COBie. Type Attribute.
	One row for each required COBie. Component Attribute.
System	One row for each system to be defined in the next stage of design.

Table 2—SpecsIntact BIM Design COBie Example (Continued)

(Note: Requirements indicated in Table 2 are for example only and are not requirements for compliance with this NASA Technical Standard.)

4.1.5.2

1.2.2 Design 60% Complete An additional $20,000 withholding will be held if COBie data are not provided at 60% completion. The COBie data exported from the BIM models shall be COBie compliant and include the asset information as specified in the LOI for all assets contained in the models at this submittal. 1.2.3 Design 100% Complete An additional $25,000 withholding will be held if COBie data are not provided at 100% completion. The COBie data exported from the BIM models shall be COBie compliant and include all asset information as specified in the LOI. 1.2.4 Bid Set An additional $30,000 withholding will be held if COBie data are not provided at completion of the bid set. The COBie data exported from the BIM models shall be COBie compliant and include all asset information as specified in the LOI.

[BIMR 6] The design review and closeout deliverable submittals shall be customized to the specific needs of the project.

4.1.5.3 [BIMR 7] Both SpecsIntact sections shall list each submittal and the dollar value withholding amount for each submittal if BIM or COBie deliverables are not provided.

4.2 Data Ownership and Reuse

[BIMR 8] All BIMs and supporting information shall become the property of NASA with unrestricted right of reuse.

[Rationale: 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.]

A-E are not responsible for any modifications to the BIMs by NASA subsequent to completion of the project.

4.3 Relationship of Design BIM (DBIM) to Contract Documents

All content has to be Native BIM and 3-dimensional (3-D) in nature as specified by the LOD.

4.3.1 [BIMR 9] From the set of linked 3-D models, the A-E shall use the DBIM set to generate 2-D, printed documents and Industry Foundation Class (IFC) models as specified in the Request for Proposals contract documents for contractor bidding and construction.

4.3.2 [BIMR 10] The DBIM set shall provide a clash-free and gap-free design solution to bidders and the selected contractor as an indication of the A-E's design intent and an aid in interpretation of the contract.

Refer to section 7.12, Modeling Requirements.

The file formats for the A-E's deliverables are set forth in section 7.12.7.

4.4 Additional Uses for the DBIM

4.4.1 [BIMR 11] A-E shall coordinate with NASA and its commissioning agent regarding inclusion of operations and maintenance (O&M) information into the DBIM data as described in the BEP the inclusion of O&M and facility management information.

4.4.2 [BIMR 12] Commissioning data in the BIM models shall be COBie compliant.

The DBIM set of models are to be passed on to the contractor for use in checking for physical coordination conflicts between the trades using the various BIM models to proactively avoid errors and clashes, for 4-D models for scheduling, to facilitate assembly prefabrication, and for other methods of improving construction efficiencies. The Construction Contract has to require the contractor to keep the BIM model up to date through the construction process for each specified construction submittal, including the Closeout Record Model set.

5. DBIM FUNCTIONAL REQUIREMENTS

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

5.1 Program Space Validation

5.1.1 [BIMR 13] The A-E shall use the BIM Authoring software or other analysis tools to compare and validate stated program requirements provided by NASA.

5.1.2 [BIMR 14) The space validation shall be based on the International Building Code (IBC), NPR 8800.15, Real Estate Management Program, and OmniClass Space and Facility Types Table, and include the comparison and validation of space allocations, adjacencies, and affinities.

5.1.3 [BIMR 15] The following shall be developed automatically from the BIM:

a. Assignable areas (ASF) and non-assignable areas (NaSF) measured to inside face of wall objects and designated boundaries of areas.

b. Gross area (GSF) measured to the outside face of wall objects.

5.2 Design Model

Discipline models may be split up if necessary to limit BIM file sizes. For example, an "A" model (General Architecture) can reference an "AI" model (Architectural Interiors), which contains only raised access flooring. Otherwise, the "A" model would be too large and greatly slow the model's performance.

5.2.1 Geometric Model

[BIMR 16] Using BIM Authoring software applications, the A-E shall deliver 3-D geometric models using 3-D geometries to represent building components and properly use available intelligent objects to embody information, including, but not limited to, material properties, functions, coding (naming conventions), standards, and dimensions.

5.2.1.1 Architectural

[BIMR 17] The A-E shall provide 3-D BIM created with architectural components, including, but not limited to, slabs/floors, building envelop, walls, roofs, doors, windows, stairs, elevators, finishes, ceilings, millwork, and case goods, that embody proper object information and parametric relationships in accordance with good architectural practice.

5.2.1.2 Furniture, Furnishings, and Equipment (FF&E)

[BIMR 18] The A-E shall provide 3-D BIM created with architectural components, including, but not limited to, FF&E, that embody proper object information and parametric relationships in accordance with good architectural practice.

Consider requiring the A-E to model all equipment that is critical to the mission of the facility, even equipment that is not in contract, existing or future.

5.2.1.3 Structural

5.2.1.3.1 [BIMR 19] The A-E shall provide 3-D BIM created with structural components, including, but not limited to, all substructure and superstructure components that embody proper object information and parametric relationships in accordance with good structural engineering practice.

5.2.1.3.2 [BIMR 20] The object information shall include member profile and dimension information.

5.2.1.4 Mechanical

5.2.1.4.1 [BIMR 21] The A-E shall provide 3-D BIM created with mechanical components, including, but not limited to, all major mechanical equipment; cooling towers; chillers; air handling units; pumps; terminal boxes; hydrants; heating, ventilation, and air-conditioning (HVAC) piping and ductwork; hangers; and other HVAC equipment, that embody proper object information and parametric relationships in accordance with good mechanical engineering practice.

5.2.1.4.2 [BIMR 22] The A-E shall provide an Energy Simulation at each phase of the project.

Piping bends are to be modeled for coordination with other trades. Refer to level of development (LOD) for how minimum sizes for mechanical piping are to be modeled.

5.2.1.5 Electrical

[BIMR 23] The A-E shall provide 3-D BIM created with electrical components, including, but not limited to, all major electrical equipment, transformers, switchgear, generators, panelboards, lights, duct banks, conduit 1-inch diameter and over, hangers, cable trays, raceways, and other electrical equipment, that embody proper object information and parametric relationships in accordance with good electrical engineering practice.

Conduit bends are to be modeled for coordination with other trades.

5.1.2.6 Plumbing

[BIMR 24] The A-E shall provide 3-D BIM created with plumbing components, including, but not limited to, all major plumbing equipment, fixtures, boilers, pumps, piping 1-inch diameter and over, hangers, and other plumbing equipment, that embody proper object information and parametric relationships in accordance with good mechanical engineering practice.

Pipe bends are to be modeled for coordination with other trades.

5.2.1.7 Telecommunications/Information Technology

[BIMR 25] The A-E shall provide 3-D BIM created with telecommunications and information technology components, including, but not limited to, all major equipment, panelboards, conduit 1-inch diameter and over, hangers, cable trays, raceways, and other equipment, that embody proper object information and parametric relationships in accordance with good engineering practice.

Conduit bends are to be modeled for coordination with other trades.

5.2.1.8 Life Safety and Fire Protection

[BIMR 26] The A-E shall provide 3-D BIM created with life safety and fire protection components, including, but not limited to, fire alarm devices, fire alarm panels, the main sprinkler piping risers and related devices with piping 1-inch diameter and over, control valves, fire suppression equipment, pumps, hangers, and other equipment, that embody proper object information and parametric relationships in accordance with good mechanical and electrical engineering practice.

Pipe bends are to be modeled for coordination with other trades.

5.2.1.9 Underground Utilities (Civil)

[BIMR 27] The A-E shall provide a 3-D BIM for underground utilities created with civil components, including all underground utilities, vaults, manholes, handholes, location of soil borings with associated data, and other

civil features, that embody proper object information and parametric relationships in accordance with good civil engineering practice.

5.2.1.10 Site/Campus (Civil and Landscape)

[BIMR 28] The A-E shall provide 3-D BIM for site and campus design with both civil and landscape components, including, but not limited to, topographic grading, streetscape, landscape including trees, planting stock including roof, storm water drainage features, exterior lighting, and other pertinent site and campus features, that embody proper object information and parametric relationships in accordance with good civil engineering and landscape architecture practice.

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

5.2.2 Design Coherence

5.2.2.1 General

5.2.2.1.1 [BIMR 29] The A-E's Information Manager shall 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.

5.2.2.1.2 [BIMR 30] Prior to each scheduled coordination meeting, an updated clash report shall be issued by the A-E Information Manager to the technical discipline consultants.

See section 5.2.2.1.5.

5.2.2.1.3 [BIMR 31] A-E shall use coordination software for assembling the various design models to electronically identify clashes, collectively coordinate resolutions, and track and publish interference reports among all disciplines and update their models to reflect the coordinated resolutions.

5.2.2.1.4 [BIMR 32] The A-E shall review the model and the clash reports in coordination meetings throughout the design phases and as required by the BIM Execution Plan (BEP) until all spatial and system coordination issues have been resolved.

5.2.2.1.5 [BIMR 33] The A-E BIM Manager shall present the composite model, all the current clashes and other problems, and discuss outstanding issues to resolve or note action that is being taken at face-to-face coordination meetings held in a room with a large screen to display the model and Webinar resources for those not present in the meeting space.

[Rationale: 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 is the goal of the A-E to eliminate changes to zero during construction due to major building interferences.]

5.2.2.1.6 [BIMR 34] Vertical shafts shall 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.

For 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.

5.2.2.1.7 [BIMR 35] For spatial coordination verification, verification and tracking of resolved conflicts of all discipline coordination issues that could result in change orders or field conflicts shall be provided to NASA during project milestone dates and be fully resolved before bidding.

For ease of identification during the 3-D clash detection/coordination process, it is recommended that the trades from Table 3, System Colors for Clash Detection, be represented in these assigned colors:

Table 3—System Colors for Clash Detection

System Name	Color Name	RGB Number
Air	Blue	0,0, 255
Ammonia	Orange	255, 128, 0
Architecture	White	255, 255, 255
Bollards	Yellow	255, 255, 0
Carbon Monoxide	Blue	0, 0, 153
Carbon Dioxide	Blue	102, 102, 255
Chemical Storage Tanks	Gray	160, 160, 160
Communication Conduit	Light Blue	205, 127, 50
Concrete	Grey75	191, 191, 191
Electrical Equipment	Dark Yellow	205, 205, 0
Electrical Conduits	Light Yellow	255, 255, 224
Electrical Panels	Yellow	255,255, 0
Communication Conduit	Light Blue	205, 127, 50
Electrical Cable Tray	Dark Orange	255, 140, 0
Electrical Lighting	Yellow	255, 255, 0
Engine or Test Article	Gray	156, 156, 161
Equipment	Light Green	152, 251, 152
Fire Alarm	Fuchsia	255, 0, 255
Fire Protection	Red	255, 0, 0
Gaseous Hydrogen	Yellow	243, 243, 14
HVAC Equipment:	Gold	255, 215, 0
HVAC Pipe	Gold	255, 215, 0
HVAC Return Duct/Diffuser	Magenta	255, 0, 255
HVAC Supply Duct/Diffuser	Sky Blue	50, 153, 204
Hydraulic Fluid	Black	35, 38, 61
Hydrogen Peroxide	Orange	234, 119, 40
Isopropyl Alcohol	Yellow	211, 208, 14
Liquid Hydrogen	Yellow	239, 237, 98
Liquid Nitrogen	Gray	180, 180, 163
Liquid Oxygen	Gray	211, 211, 206
Lubricant	Black	51, 50, 47

Natural Gas	Yellow	244, 238, 66
Plumbing Water	Cyan	209, 238, 238
Plumbing Sewer	Magenta	255, 0, 255
Plumbing Storm Drain	Green	0, 255, 0
Pneumatic Tube	Dark Green	47, 79, 47
Polymer Dry Air	Blue	66, 244, 226
Propane	Yellow	241, 244, 66
Gas	Light Green	152, 251, 152
Gaseous Methane	Yellow	244, 188, 66
Gaseous Oxygen	Blue	66, 203, 244
Rocket Propellant	Brown	113, 76, 1
Roof Drain	Gray	170, 169, 166
Security Systems	Orange	255, 165, 0
Steam	Aluminum	189, 193, 198
Storm Drain	Gray	138, 140, 141
Structural Steel	Maroon	176, 48, 96
Tank Drain	Gray	180, 182, 184
Vacuum	Blue	28,129, 219
Vent	Gray	113,132,149

5.2.2.2 Minimum Requirements for Spatial Coordination and Clash Detection

5.2.2.2.1 Architecture + Structural

a. [BIMR 36] Clearance reservations shall be provided for all equipment that moves during use, including overhead and bay doors, overhead cranes, and moving platforms.

b. [BIMR 37] Adequate space shall be provided for construction and maintenance access to structural elements, building equipment, and distribution systems.

Architecture + Structural includes 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.

5.2.2.2.2 Architecture + Mechanical, Electrical, Plumbing, and Fire Protection (MEPF)

[BIMR 38] Possible future expansions shall be considered and clash-free.

Architecture + MEPF includes structural and space elements, flow and isolation requirements, proposed functional area configurations, floor-to-floor heights, fire containment, and vertical and horizontal transportation.

5.2.2.2.3 MEPF/HVAC + Architecture, Structure, and Telecommunications

a. [BIMR 39] Clearance reservations for equipment maintenance filter removal and equipment removal and replacement shall be modeled with the equipment.

b. [BIMR 40] Sign-off on the adequacy of the space reservations shall be obtained from NASA after specific coordination review meeting(s) with A-E BIM Manager navigating live through the 3-D BIM model.

MEPF/HVAC + Architecture, Structure, and Telecommunications include main distribution and collection systems, configurations and sizes for piping, duct, conduit, power wiring, blowers; diffusers; intakes; large compressors; and hangers.

5.2.2.2.4 Architecture + Life Safety Fire Protection

[BIMR 41] Safe zone and fire suppression pipe and hanger location, egress paths, and exit distance requirements, equipment, and pipe penetrations shall be in compliance with the IBC.

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

5.2.2.2.5 Space Validation

There will be no space gaps.

[BIMR 42] Bounding boxes used to represent room and zone spaces shall match with architectural requirements and data values, and all coordinated with values given in the program and engineering requirements as defined in the Preliminary Engineering Report (PER).

5.2.2.2.6 General Model Quality Checking

[BIMR 43] All walls shall be properly joined to prevent “space leaks” in areas defined by enclosing walls with no conflicting bounding boxes.

5.2.2.2.7 Security

[BIMR 44] Security setbacks + structure + site shall include line-of-site coherence check.

5.2.2.2.8 Accessibility Compliance

[BIMR 45] Wheelchair pathways and clearances + structure + MEPF components shall include plumbing fixtures.

(If using Solibri® Model Checker or other rules-based model checking software, accessibility compliance can be checked automatically.)

5.2.2.3 Code Review

[BIMR 46] The A-E shall use the BIM Authoring software or other analysis tools to validate that the design is in compliance with stated building code requirements.

5.2.2.4 NASA Building Requirements

[BIMR 47] The A-E shall use the BIM Authoring software or other analysis tools to validate that the design is in compliance with stated NASA building requirements.

5.2.2.5 Analysis and Optimization

5.2.2.5.1 Lighting and Daylighting

a. [BIMR 48] Lighting and daylighting simulation and calculations shall be based on information within or extracted directly from BIM and validated by lighting and daylighting modeling.

b. [BIMR 49] The model elements shall 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.

5.2.2.5.2 Energy

a. [BIMR 50] Energy simulation and life-cycle cost calculations shall be based on information within or extracted directly from BIM and validated by energy modeling.

b. [BIMR 51] The model elements shall 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.

5.2.2.6 Carbon

5.2.2.6.1 [BIMR 52] Carbon output calculations shall be based on information within or extracted directly from BIM and validated by energy modeling.

5.2.2.6.2 [BIMR 53] The model elements shall 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.

5.2.2.7 Wind

5.2.2.7.1 [BIMR 54] Wind simulation and calculations shall be based on information within or extracted directly from BIM.

5.2.2.7.2 [BIMR 55] The model elements shall 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.

5.2.2.8 Water

5.2.2.8.1 [BIMR 56] Water use calculations shall be based on information within or extracted directly from BIM.

5.2.2.8.2 [BIMR 57] The model elements shall 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.

5.2.2.9 Indoor Air Quality

5.2.2.9.1 [BIMR 58] Indoor air quality analysis shall be based on information within or extracted directly from BIM.

5.2.2.9.2 [BIMR 59] The model elements such as HVAC filters and finish surface materials shall 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.

5.2.2.10 Acoustics

5.2.2.10.1 [BIMR 60] Acoustic simulation and calculations shall be based on information within or extracted directly from BIM.

5.2.2.10.2 [BIMR 61] The model elements shall 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.

5.2.2.11 Functional Analysis per Building Type

[BIMR 62] The BIM shall be utilized to:

a. Analyze and forecast interior and exterior pedestrian circulation and activity patterns, including life safety egress, accessibility requirements for Federal properties, and wayfinding, within the project parameters.

b. Analyze and forecast vehicular circulation and activity patterns, including parking, fire department vehicle access, and accessibility, within the project parameters.

c. Analyze access for moving (removal and replacement routes) facility furniture, fixtures, and equipment throughout the project parameters.

d. Analyze access to facility furniture, fixtures, and equipment throughout the project parameters.

6. CONSTRUCTION DOCUMENT DRAWINGS

6.1 [BIMR 63] A-E shall produce construction document drawings utilizing IFC-compliant BIM Authoring software.

All drawing information, including 2-D 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.

6.2 [BIMR 64] All 2-D drawings shall comply with the graphic standards as referenced in NPR 8820.2.

7. BIM EXECUTION PLAN (BEP)

7.1 [BIMR 65] Within 30 days after execution of the Agreement, A-E shall customize the prescriptive NASA BEP confirming the intended uses of the BIM, describing the communication paths, the model structure, and the LOD of the modeled elements at each contractual milestone or deliverable, and the BIM process design.

7.2 [BIMR 66] The BEP shall be provided to NASA for its review and approval.

Once approved, the BEP cannot be modified without NASA's written approval.

7.3 [BIMR 67] The BEP shall, at a minimum, contain the following elements:

a. Instructions and Reference Information

This section identifies the source of the template and what areas are to be completed/customized. It also refers back to SpecsIntact, Section "01 78 25 Building Information Modeling."

b. Table of Contents

This section lists Section A through Section M with Hyperlinks to each section in the document.

c. Section A: Project Information

(1) This section begins with instructions followed by the project site photo.
(2) Next, the basic project information is listed as follows:
   A. Facility owner.
   B. Project name.
   C. Project location.
   D. Contract type.
   E. Facility type.
   F. Brief project description.
   G. Additional project information regarding COBie implementation.
   H. Agent.
   I. Project numbers include:
      i. Agent contract number.
      ii. Task order number.
      iii. Agent project number.
      iv. Contractor project numbers as applicable.

d. Section B: Key Project Contacts
(1) This section begins with instructions.
(2) The project contract matrix columns include the following:
   A. Role.
   B. Organization.
   C. Name.
   D. Email.
   E. Time zone.
   F. Phone.
(3) Example role rows include, but are not limited to:
   A. Administrative Contracting Officer.
   B. NASA (owner) Project Manager.
   C. Procurement Project Manager.
   D. BIM/COBie Technical Lead Manager.
   E. BIM.

7.4 BIM Staffing Plan

[BIMR 68] A-E shall, in the BIM Staffing Plan, identify for itself and each of its consultants the persons within their organizations responsible for managing the BIM, or portion of the BIM, by providing the following information:

a. Name.

b. Title.

c. Contact information (location, primary phone number, mobile phone number, and email address).

d. Description of the duration and extent of the person's experience with the BIM software the A-E proposes to use.

e. Identification and description of prior projects where the person used BIM software and the extent it was used on that project.

f. Role (i.e., BIM structural design lead, BIM mechanical design leader, etc.).

g. 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.

When an organization is responsible for multiple disciplines or the project is divided into sections or phases, the BIM Staffing Plan should include the persons responsible for the discipline, section, or phase.

7.5 Model Progression Matrix

7.5.1 [BIMR 69] The BEP shall 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, Building Information Modeling Protocol Exhibit.

7.5.2 [BIMR 70] The model progression matrix shall be executed by each party that is assigned responsibility as a model component author in the matrix.

7.5.3 [BIMR 71] The LOD shall comply with ASTM E-1557, Standard Classification for Building Elements and Related Sitework—UNIFORMAT II, Level 3 model components.

The phasing columns of the matrix should be modified to match the phasing of project deliverables in the A-E contract. The LOD should include user level sub-categorization (UNIFORMAT Levels 4 and 5) if necessary to provide appropriately defined LOD and model component author responsibility.

7.5.4 [BIMR 72] The model progression matrix shall show the LOD to 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.

7.6 BIM Process Design

7.6.1 [BIMR 73] A-E shall lead a workshop for Construction of Facilities (CoF) level projects 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.

7.6.2 [BIMR 74] At the conclusion of the workshop, the A-E shall 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 Pennsylvania State University Computer Integrated Construction Research Program.

7.7 Schedule

[BIMR 75] A-E shall prepare a schedule for BIM design deliverables tied to the model progression matrix that includes 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.

7.8 Model Structure

7.8.1 File Naming Structure

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

[BIMR 76] File names for models shall be formatted as discipline-project number-building number.file extension.

(Example: ARCH-1111-BL001.rvt) File name prefixes by discipine are listed in Table 4.

Table 4—File Name Prefixes by Discipine

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	

7.8.2 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.

[BIMR 77] The BEP shall 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 to be used by A-E to ensure that all of the models remain current and consistent.

7.8.3 Measurement and Coordinate Systems

[BIMR 78] The A-E shall confirm and document the measurement and coordinate systems in the BEP for this project and provide the following:

a. All measurements in metric units unless a waiver is provided by the Contracting Officer or is contained in standards applicable to a specific NASA Center.

b. Site plans and building models geo-referenced in accordance with Table 5, GEO-References.

Table 5—GEO-References

CENTER	GEO-REFERENCE
Ames Research Center	California State Plane Coordinate System Zone III as defined by NAD 1983 US Feet
Armstrong Flight Research Center	NAD 27 (US Feet) California Zone V
Glenn Research Center	Harn/Ohio State Planes, North Zone, US Survey Foot
Goddard Space Flight Center	Maryland State Plane Grid NAD83 NGVD88
IV and V Facility	NAD 83 State Plane West Virginia North FIPS 4701.
Jet Propulsion Laboratory	NAD 83 (US Feet) California Zone V
Johnson Space Center	NAD_1983_HARN_StatePlane_Texas_South_Central_FIPS_4204_Feet
Kennedy Space Center	Horizontal: Florida State Plane Coordinate System, East Zone, North American Datum 1983/1990 adjustment based on Second Order Class II horizontal control monument. Vertical: North American Vertical Datum (NAVD) 1988
Langley Research Center	NAD 83 HARN (1993) US State Plane Coordinate System Virginia South Zone, in meters. All vertical coordinates shall be reported in NAVD88, as orthometric height derived from GEOID03 in meters.
Marshall Space Flight Center	NAD 1983 State Plane, Alabama, East (FIPS 0101) Feet Vertical Datum: NAVD88, feet
Michoud Assembly Facility	NAD 1983 State Plane Louisiana South FIPS 1702 Feet
NASA Headquarters	Maryland State Plane coordinate system of the American Datum of 1983 (NAD83), as updated in 1991. For vertical coordinates, the standard is the North American Vertical Datum of 1988 (NAVD88). Coordinates are stored in meters.
NASA Safety Center	Harn/Ohio State Planes, North Zone, US Survey Foot
Plum Brook Station	Harn/Ohio State Planes, North Zone, US Survey Foot
Stennis Space Center	Mississippi East State Plane NAD 27, US Survey Foot
Wallops Flight Facility	NAD 83 HARN (1993), Virginia State Plane Grid, South Zone, US Survey Feet
White Sands Test Facility	New Mexico State Plane Central Zone NAD 83, in feet

The measurement and coordinate systems are to be confirmed and documented in the BEP for the project.

7.8.4 Software and Operating Systems

7.8.4.1 [BIMR 79] The BEP shall 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 (32 bit/64 bit).

7.8.4.2 [BIMR 80] Listed software and listed operating systems shall not be changed or upgraded 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 and requires NASA's written approval.

7.8.5 Electronic Communication Procedures

7.8.5.1 File Access and Archiving

[BIMR 81] The BEP shall specify:

a. The physical and logical locations of BIM files and related electronic information;

b. The protocols for archiving and disaster recovery;

c. The protocols for user access and file permissions;

d. The directory/subdirectory/file structure used to organize the BIM files and related electronic information; and

e. 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.

7.8.5.2 Electronic File Formats and Use

[BIMR 82] The BEP shall specify:

a. The types of digital information that will be transmitted between project participants;

b. The acceptable methods of transmission;

c. The acceptable file format(s) to be used for the type of digital information.

7.8.5.3 A-E Information Manager(s)

[BIMR 83] The BEP shall identify the persons responsible for managing and executing the responsibilities of this section.

7.8.5.4 Pre-Design Site Survey Modeling

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

7.8.5.4.1 [BIMR 84] 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 shall include the following:

a. Description of tasks and schedule for developing the pre-design model;

b. Description of recommended methodology for developing the existing site information, such as:

(1) Development of model based on as-built documents for facility;
(2) Optical surveying facility to develop a new model or validate the accuracy of existing information used to create a model:
   A. 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
   B. Combination of tasks or approaches to accomplish the goals.

7.8.5.4.2 [BIMR 85] If laser scanning is required or will be used by the A-E, the BEP shall identify:

a. Primary and secondary objectives of laser scanning;
b. Areas of interest;
c. Resolution requirements and measurement units;
d. Type of deliverable;
e. Control network or other dimensional control; and
f. Quality control procedures.

7.9 Interoperability

A-E is responsible for selecting BIM software that is adequate for A-E's tasks.

[BIMR 86] A-E shall demonstrate that the software used by them and their 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.

7.10 BIM Software

7.10.1 [BIMR 87] BIM software for NASA projects shall support intelligent objects and parametric relationships.

7.10.2 [BIMR 88] The software shall comply with current industry interoperability standards and be usable in a collaborative environment.

7.10.3 [BIMR 89] All software platforms used for NASA projects shall be compliant with:

a. The most current version of Industry Foundation Classes (IFC) file format.

b. Commercially available collaboration software that provides interoperability between the different software applications as specified in Table 6.

Table 6—Commercially Available Collaboration Software Providing Interoperability between Different Software Applications

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 and Construction)	ArchiCAD® MEP Modeler™, Revit® MEP, Bentley® AECOsim Building Designer, CAD-Duct, CADPIPE, 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™
4-D Scheduling	Synchro, Vico, NavisWorks® Simulate, Primavera, MS® Project®, Bentley® Navigator
5-D 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

7.11 Open Source File Formats/Open Standards

7.11.1 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.

[BIMR 90] The formats used shall be specified in the BEP and include, at a minimum, the following current version IFC Model View Definition (MVD) formats:

a. **Coordination View Files**—Required for all deliverables needed to demonstrate the coordination of design disciplines prior to construction and a report provided by the A-E highlighting automatically detected (hard and soft) collisions, identifying those collisions requiring further work by the A-E.

b. **Portable Document Format (PDF)—**Transform non-modeled information authored directly by the A-E to PDF to allow selection of text within the document.

c. **GBxml—**Support accurate and reliable data export to GBxml for environmental analysis, optimization, and sustainability classifications such as LEED, Green Globes, and EnergyStar by the Architectural, Mechanical, and Electrical BIM software, at a minimum.

d. **COBie—**COBie-compliant BIM authoring software.

e. **Documents Authored by Others but Used by the A-E**—Provide documents such as manufacturer product data sheets in the format made available by the manufacturer or scanned as image-based PDF documents.

7.12 Modeling Requirements

7.12.1 General

7.12.1.1 [BIMR 91] BIM shall 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.

7.12.1.2 [BIMR 92] During the defined design phases, BIM technology shall be used to develop and establish building performance and the basis of design in accordance with the project requirements.

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.

7.12.1.3 [BIMR 93] BIM authoring software element libraries shall be used when creating model objects.

7.12.1.4 [BIMR 94] Model objects shall contain parts and components as opposed to simple 3-D geometry (e.g., walls, doors, windows, railings, stairs, furniture, etc.) and 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.

7.12.1.5 [BIMR 95] Elements, objects, and equipment shall be tagged with unique identifiers (GUIDs) and provide the following:

a. OmniClass number.
b. IBM® Maximo® asset number assigned by the NASA Center maintenance program manager when required.

7.12.2 Types of Model Elements

[BIMR 96] Manufacturer's model elements shall be derived from the following sources:

a. Embedded performance data for analysis and specification purposes.

Manufacturer's Model Elements are elements created by and acquired from manufacturers and often have more information than is prudent to keep in the BIM model; the appropriate LOD should be retained for the design element but should not exceed the proposed LOD of the model.

b. Custom-created model elements using appropriate BIM Authoring tool templates.

Custom model 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.

7.12.3 Model Geographical Location

7.12.3.1 [BIMR 97] The spatial coordination (coordinates) of the master BIM file shall be set at the beginning of the project and 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.

7.12.3.2 [BIMR 98] The A-E Information Manager shall geo-reference site plans and building models for site layout surveying and future geographic information systems (GIS) use in accordance with the State Plane Coordinate system where the project is located.

[Rationale: As 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 BIM file point will be located at the southwest (SW) corner of the structural grid.

7.12.4 Points of Reference

[BIMR 99] The A-E Information Manager shall provide a 3-D 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.

7.12.5 Requirements for Modeling Space

[BIMR 100] Modeling space shall comply with the following requirements:

a. The source for space creation in BIM is the space information imported from the NASA Project Program Requirements.

b. Track and identify by name areas of 4 square feet or greater, even if those spaces are not listed in the program narrative.

c. Generate spatial data and associate it with bounding elements (walls, doors, windows, floors, columns, ceilings).

d. Model the Assignable Areas Square Footage (ASF), Non-Assignable Areas Square Footage (NaSF), and Gross Square Footage (GSF) for each functional space, using the appropriate space/object BIM tool to capture and carry the information.

e. Represent and break down spaces 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.

f. Update dynamically space/area schedules and diagrams from the model geometry.

g. Validate spatial requirements through reports generated from the BIM.

7.12.6 Space Naming and Coding

[BIMR 101] Each space shall include the following attributes and be maintained throughout the DBIM models:

a. Building.
b. Floor (and/or Level).
c. Department.
d. Sub-department.
e. Space Name – English Name and 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).

7.12.7 BIM Deliverables

7.12.7.1 BIM Demonstration

7.12.7.1.1 [BIMR 102] To ensure that the Design Contractor is capable of executing the planned use of BIM for the project, the Design Contractor shall demonstrate the planned BIM uses, information exchanges, workflows, and processes as described in the Government-approved BEP.

7.12.7.1.2 [BIMR 103] The key BIM personnel identified in the BEP shall perform the demonstration live and in person using the software and hardware specified in the Government- approved BEP.

7.12.7.1.3 [BIMR 104] The demonstration shall be an over-the-shoulder meeting where software and hardware demonstrations are observed by NASA and occur live and in person for key personnel as well as via a Web meeting for non-key personnel.

7.12.7.1.4 [BIMR 105] If modification(s) to the BEP are required as a result of non-acceptance of the BIM demonstration, the Contractor shall modify the BEP and resubmit to the Government for acceptance.

7.12.7.1.5 [BIMR 106] Upon official approval of the BEP by the Government Contracting Officer, the Contractor shall subsequently perform a BIM demonstration in accordance with the revised Government-approved BEP.

There will be no payment for Design until both the BEP and BEP demonstration are completed and accepted by the Government.

7.12.7.1.6 [BIMR 107] Use of BIM for design-related activities as described in the BEP shall not proceed until official acceptance of the BEP demonstration has occurred.

The Government may also withhold payment if there is unacceptable performance in executing the accepted BEP during design.

7.12.7.2 3-D Geometric Deliverables – Design Model

7.12.7.2.1 [BIMR 108] The A-E shall ensure that the design models remain current throughout design and construction phases of the project.

It is NOT expected that product-specific information will be added to these models. See 7.10.7.2.2 below.

7.12.7.2.2 [BIMR 109] The A-E shall be responsible for providing a fully coordinated and assembled BIM as well as separate copies of each technical discipline model in the original software authoring tool, model information, and the required instructions on file/folder setup as follows:

a. Native file format(s) of the design model (version as agreed in BEP).

b. IFC file format (version as agreed in BEP).

c. Collaboration software format (Navisworks® or equal or version as agreed in BEP) for fully coordinated and assembled BIM.

d. All models clash/collision free.

No clashes are allowed. If an object in the model is located within the prescribed Level of Accuracy (LOA) tolerance, and yet it is clashing/colliding with another object or an object's envelope, it has to be relocated to clear the clash/collision. This requirement does NOT apply to intentional penetrations through planes or masses such as floors, walls, ceilings, roofs, and steel rebar embedded in concrete.

e. Models gap-free.

f. All systems that are intended to connect do so and are free of any gaps or breaks.

Example 1: Pipes and wires have to connect to the intended equipment without any gaps or breaks.

Example 2: Building envelopes have to be tight and free of gaps. All contiguous surfaces intended to touch have to do so.

7.12.7.3 Data Deliverables

7.12.7.3.1 [BIMR 110] A-E shall provide room/space data in COBie format.

7.12.7.3.2 [BIMR 111] The BEP shall refer to a customized LOI Product Assets in Scope revised by the NASA Center to specify what COBie information is to be included in the BIM models.

7.12.7.4 2-D Deliverables

[BIMR 112] A-E shall produce printed sets of final documents generated from the design model as follows:

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

7.12.7.5 Digital Deliverables

a. [BIMR 113] Both BIM and COBie information shall be submitted.

b. [BIMR 114] All digital deliverables shall be submitted on digital versatile disc/compact disc (DVD/CD) or provided electronically through a secure Web site or other electronic portal with the data clearly organized and software version(s) labeled.

8. TAILORING/WAIVING OF SPECIFIC REQUIREMENTS

It is NASA policy that all prescribed requirements (requirements levied on a lower organizational level by a higher organizational level) are complied with unless relief is formally granted. If a requirement contained in this NASA Technical Standard cannot be achieved or cannot be achieved at a cost commensurate with the value of the requirement, A-Es may request, in writing, to the NASA Headquarters Facilities Engineering and Real Estate Division that the requirement be tailored or waived.

[BIMR 115] The tailoring/waiver request shall:

a. Certify that the A-E has diligently attempted to meet the requirement, the requirement cannot reasonably be met, and alternative approaches meet the intent of the requirement.

b. Be supported by evidence of the A-E's research and documentation that the alternative approach meets the function and interoperability requirements of this NASA Technical Standard.

NASA Headquarters Facilities Engineering and Real Estate Division, in its sole discretion, may waive or approve tailoring of requirements found to be currently unachievable or not commercially practicable.

APPENDIX A

REQUIREMENTS COMPLIANCE MATRIX

A.1 Purpose

The Requirements Compliance Matrix below contains this NASA Technical Standard's requirements and may be used to mark requirements that are applicable or not applicable to help minimize costs. Enter "Yes" in the "Applicable" column if the requirement is applicable to the program or project or "No" if the requirement is not applicable to the program or project. The "Comments" column may be used to provide specific instructions on how to apply the requirement or to specify proposed tailoring.

NASA-STD-10001				
Section	**Description**	**Requirement in this Standard**	**Applicable (Enter Yes or No)**	**Comments**
4. GENERAL REQUIREMENTS				
4.1.1	BIM Competence and Responsibilities	[BIMR 1] The Design Contractor shall provide a detailed written description of the BIM experience of its key project team members.		
4.1.2	BIM Competence and Responsibilities	[BIMR 2] The Design Contractor shall designate a BIM Manager possessing the following skills and experience, at a minimum, to oversee the technical aspects of developing, managing, and maintaining the BIM models: a. Bachelor's Degree in Architecture or Engineering. b. Three to seven years' experience with software modeling in an architectural or engineering environment. c. Two to three projects completed as a BIM coordinator or specialist. d. Experienced and proficient in Navisworks® Manage. e. General knowledge of integrated architectural and engineering practice. f. Strong supervisory, leadership, and communication skills.		

NASA-STD-10001				
Section	**Description**	**Requirement in this Standard**	**Applicable (Enter Yes or No)**	**Comments**
		g. Experience with project planning and tracking. h. Experience with Microsoft® Office® (i.e., Word®, Excel®, Access®, and Outlook®.		
4.1.3	BIM Competence and Responsibilities	[BIMR 3] Unless BIM software is being provided by NASA, A-E shall have, or obtain at their own cost, sufficient software licenses and computer hardware to adequately perform the services required.		
4.1.4	BIM Competence and Responsibilities	[BIMR 4] A-E shall provide NASA with project team members' experience from three of their past BIM projects.		
4.1.5.1	BIM/COBie Submittals	[BIMR 5] BIM submittals shall be listed in SpecsIntact, "Section 01 78 25, Building Information Modeling (BIM)"; "Section 01 79 00, Construction Operations Building information exchange (COBie)"; and in the BEP.		
4.1.5.2	BIM/COBie Submittals	[BIMR 6] The design review and closeout deliverable submittals shall be customized to the specific needs of the project.		
4.1.5.3	BIM/COBie Submittals	[BIMR 7] Both SpecsIntact sections shall list each submittal and the dollar value withholding amount for each submittal if BIM or COBie deliverables are not provided.		
4.2	Data Ownership and Reuse	[BIMR 8] All BIMs and supporting information shall become the property of NASA with unrestricted right of reuse.		
4.3.1	Relationship of Design BIM (DBIM) to Contract Documents	[BIMR 9] From the set of linked 3-D models, the A-E shall use the DBIM set to generate 2-D, printed documents and Industry Foundation Class (IFC) models as specified in the Request for Proposals contract documents for contractor bidding and construction.		
4.3.2	Relationship of Design BIM (DBIM) to Contract Documents	[BIMR 10] The DBIM set shall provide a clash-free and gap-free design solution to bidders and the selected contractor as an indication of the A-E's design intent and an aid in interpretation of the contract..		
4.4.1	Additional Uses for the DBIM	[BIMR 11] A-E shall coordinate with NASA and its commissioning agent regarding inclusion of operations and maintenance (O&M) information into the DBIM data as described in the BEP the inclusion of O&M and facility management information.		
4.4.2	Additional Uses for the DBIM	[BIMR 12] Commissioning data in the BIM models shall be COBie compliant.		
5. DBIM FUNCTIONAL REQUIREMENTS				
5.1.1	Program Space Validation	[BIMR 13] The A-E shall use the BIM Authoring software or other analysis tools to compare and validate stated program requirements provided by NASA.		

NASA-STD-10001				
Section	**Description**	**Requirement in this Standard**	**Applicable (Enter Yes or No)**	**Comments**
5.1.2	Program Space Validation	[BIMR 14) The space validation shall be based on the International Building Code (IBC), NPR 8800.15, Real Estate Management Program, and OmniClass Space and Facility Types Table, and include the comparison and validation of space allocations, adjacencies, and affinities.		
5.1.3	Program Space Validation	[BIMR 15] The following shall be developed automatically from the BIM: a. Assignable areas (ASF) and non-assignable areas (NaSF) measured to inside face of wall objects and designated boundaries of areas. b. Gross area (GSF) measured to the outside face of wall objects.		
5.2 Design Model				
5.2.1	Geometric Model	[BIMR 16] Using BIM Authoring software applications, the A-E shall deliver 3-D geometric models using 3-D geometries to represent building components and properly use available intelligent objects to embody information, including, but not limited to, material properties, functions, coding (naming conventions), standards, and dimensions.		
5.2.1.1	Architectural	[BIMR 17] The A-E shall provide 3-D BIM created with architectural components, including, but not limited to, slabs/floors, building envelop, walls, roofs, doors, windows, stairs, elevators, finishes, ceilings, millwork, and case goods, that embody proper object information and parametric relationships in accordance with good architectural practice.		
5.2.1.2	Furniture, Furnishings, and Equipment (FF&E)	[BIMR 18] The A-E shall provide a 3-D BIM created with architectural components, including, but not limited to, FF&E, that embody proper object information and parametric relationships in accordance with good architectural practice.		
5.2.1.3.1	Structural	[BIMR 19] The A-E shall provide 3-D BIM created with structural components, including, but not limited to, all substructure and superstructure components, that embody proper object information and parametric relationships in accordance with good structural engineering practice.		
5.2.1.3.2	Structural	[BIMR 20] The object information shall include member profile and dimension information.		
5.2.1.4.1	Mechanical	[BIMR 21] The A-E shall provide 3-D BIM created with mechanical components, including, but not limited to, all major mechanical equipment; cooling towers; chillers; air handling units; pumps; terminal boxes; hydrants; heating, ventilation, and air-conditioning (HVAC) piping and ductwork; hangers; and other HVAC equipment, that embody proper object information and parametric relationships in accordance with good mechanical engineering practice.		
5.2.1.4.2	Mechanical	[BIMR 22] The A-E shall provide an Energy Simulation at each phase of the project.		
5.2.1.5	Electrical	[BIMR 23] The A-E shall provide 3-D BIM created with electrical components, including, but not limited to, all major electrical equipment, transformers, switchgear, generators, panel boards, lights, duct banks, conduit 1-inch diameter and over, hangers, cable trays, raceways, and other electrical		

NASA-STD-10001				
Section	**Description**	**Requirement in this Standard**	**Applicable (Enter Yes or No)**	**Comments**
		equipment, that embody proper object information and parametric relationships in accordance with good electrical engineering practice.		
5.2.1.6	Plumbing	[BIMR 24] The A-E shall provide 3-D BIM created with plumbing components, including, but not limited to, all major plumbing equipment, fixtures, boilers, pumps, piping 1-inch diameter and over, hangers, and other plumbing equipment, that embody proper object information and parametric relationships in accordance with good mechanical engineering practice.		
5.2.1.7	Telecommunications/ Information Technology	[BIMR 25] The A-E shall provide 3-D BIM created with telecommunications and information technology components, including, but not limited to, all major equipment, panel boards, conduit 1-inch diameter and over, hangers, cable trays, raceways, and other equipment, that embody proper object information and parametric relationships in accordance with good engineering practice.		
5.2.1.8	Life Safety and Fire Protection	[BIMR 26] The A-E shall provide 3-D BIM created with life safety and fire protection components, including, but not limited to, fire alarm devices, fire alarm panels, the main sprinkler piping risers and related devices with piping 1-inch diameter and over, control valves, fire suppression equipment, pumps, hangers, and other equipment, that embody proper object information and parametric relationships in accordance with good mechanical and electrical engineering practice.		
5.2.1.9	Underground Utilities (Civil)	[BIMR 27] The A-E shall provide a 3-D BIM for underground utilities created with civil components, including all underground utilities, vaults, manholes, handholes, location of soil borings with associated data, and other civil features, that embody proper object information and parametric relationships in accordance with good civil engineering practice.		
5.2.1.10	Site/Campus (Civil and Landscape)	[BIMR 28] The A-E shall provide 3-D BIM for site and campus design with both civil and landscape components, including, but not limited to, topographic grading, streetscape, landscape including trees, planting stock including roof, storm water drainage features, exterior lighting, and other pertinent site and campus features, that embody proper object information and parametric relationships in accordance with good civil engineering and landscape architecture practice.		
5.2.2 Design Coherence				
5.2.2.1.1	General	[BIMR 29] The A-E's Information Manager shall 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.		
5.2.2.1.2	General	[BIMR 30] Prior to each scheduled coordination meeting, an updated clash report shall be issued by the A-E Information Manager to the technical discipline consultants.		

NASA-STD-10001				
Section	**Description**	**Requirement in this Standard**	**Applicable (Enter Yes or No)**	**Comments**
5.2.2.1.3	General	[BIMR 31] A-E shall use coordination software for assembling the various design models to electronically identify clashes, collectively coordinate resolutions, and track and publish interference reports among all disciplines and update their models to reflect the coordinated resolutions.		
5.2.2.1.4	General	[BIMR 32] The A-E shall review the model and the clash reports in coordination meetings throughout the design phases and as required by the BIM Execution Plan (BEP) until all spatial and system coordination issues have been resolved.		
5.2.2.1.5	General	[BIMR 33] The A-E BIM Manager shall present the composite model, all the current clashes and other problems, and discuss outstanding issues to resolve or note action that is being taken at face-to-face coordination meetings held in a room with a large screen to display the model and Webinar resources for those not present in the meeting space.		
5.2.2.1.6	General	[BIMR 34] Vertical shafts shall 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.		
5.2.2.1.7	General	[BIMR 35] For spatial coordination verification, verification and tracking of resolved conflicts of all discipline coordination issues that could result in change orders or field conflicts shall be provided to NASA during project milestone dates and be fully resolved before bidding.		
5.2.2.2 Minimum Requirements for Spatial Coordination and Clash Detection				
5.2.2.2.1a	Architecture + Structural	[BIMR 36] Clearance reservations shall be provided for all equipment that moves during use, including overhead and bay doors, overhead cranes, and moving platforms.		
5.2.2.2.1b	Architecture + Structural	[BIMR 37] Adequate space shall be provided for construction and maintenance access to structural elements, building equipment, and distribution systems.		
5.2.2.2.2	Architectural + Mechanical, Electrical, Plumbing, and Fire Protection (MEPF)	[BIMR 38] Possible future expansions shall be considered and clash-free.		
5.2.2.2.3a	MEPF/HVAC + Architecture, Structure, and Telecommunications	[BIMR 39] Clearance reservations for equipment maintenance filter removal and equipment removal and replacement shall be modeled with the equipment.		
5.2.2.2.3b	MEPF/HVAC + Architecture, Structure, and Telecommunications	[BIMR 40] Sign-off on the adequacy of the space reservations shall be obtained from NASA after specific coordination review meeting(s) with A-E BIM Manager navigating live through the 3-D BIM model.		
5.2.2.2.4	Architecture + Life Safety Fire Protection	[BIMR 41] Safe zone and fire suppression pipe and hanger location, egress paths, and exit distance requirements, equipment, and pipe penetrations shall be in compliance with the IBC.		

NASA-STD-10001				
Section	**Description**	**Requirement in this Standard**	**Applicable (Enter Yes or No)**	**Comments**
5.2.2.2.5	Space Validation	[BIMR 42] Bounding boxes used to represent room and zone spaces shall match with architectural requirements and data values, and all coordinated with values given in the program and engineering requirements as defined in the Preliminary Engineering Report (PER).		
5.2.2.2.6	General Model Quality Checking	[BIMR 43] All walls shall be properly joined to prevent “space leaks” in areas defined by enclosing walls with no conflicting bounding boxes.		
5.2.2.2.7	Security	[BIMR 44] Security setbacks + structure + site shall include line-of-site coherence check.		
5.2.2.2.8	Accessibility Compliance	[BIMR 45] Wheelchair pathways and clearances + structure + MEPF components shall include plumbing fixtures.		
5.2.2.3	Code Review	[BIMR 46] The A-E shall use the BIM Authoring software or other analysis tools to validate that the design is in compliance with stated building code requirements.		
5.2.2.4	NASA Building Requirements	[BIMR 47] The A-E shall use the BIM Authoring software or other analysis tools to validate that the design is in compliance with stated NASA building requirements.		
5.2.2.5 Analysis and Optimization				
5.2.2.5.1a	Lighting and Daylighting	[BIMR 48] Lighting and daylighting simulation and calculations shall be based on information within or extracted directly from BIM and validated by lighting and daylighting modeling.		
5.2.2.5.1b	Lighting and Daylighting	[BIMR 49] The model elements shall 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.		
5.2.2.5.2a	Energy	[BIMR 50] Energy simulation and life-cycle cost calculations shall be based on information within or extracted directly from BIM and validated by energy modeling.		
5.2.2.5.2b	Energy	[BIMR 51] The model elements shall 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.		
5.2.2.6.1	Carbon	[BIMR 52] Carbon output calculations shall be based on information within or extracted directly from BIM and validated by energy modeling.		
5.2.2.6.2	Carbon	[BIMR 53] The model elements shall 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.		
5.2.2.7.1	Wind	[BIMR 54] Wind simulation and calculations shall be based on information within or extracted directly from BIM.		
5.2.2.7.2	Wind	[BIMR 55] The model elements shall 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.		
5.2.2.8.1	Water	[BIMR 56] Water use calculations shall be based on information within or extracted directly from BIM.		
5.2.2.8.2	Water	[BIMR 57] The model elements shall 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.		

NASA-STD-10001				
Section	**Description**	**Requirement in this Standard**	**Applicable (Enter Yes or No)**	**Comments**
5.2.2.9.1	Indoor Air Quality	[BIMR 58] Indoor air quality analysis shall be based on information within or extracted directly from BIM.		
5.2.2.9.2	Indoor Air Quality	[BIMR 59] The model elements such as HVAC filters and finish surface materials shall 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.		
5.2.2.10.1	Acoustics	[BIMR 60] Acoustic simulation and calculations shall be based on information within or extracted directly from BIM.		
5.2.2.10.2	Acoustics	[BIMR 61] The model elements shall 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.		
5.2.2.11	Functional Analysis per Building Type	[BIMR 62] The BIM shall be utilized to: a. Analyze and forecast interior and exterior pedestrian circulation and activity patterns, including life safety egress, accessibility requirements for Federal properties, and wayfinding, within the project parameters. b. Analyze and forecast vehicular circulation and activity patterns, including parking, fire department vehicle access, and accessibility, within the project parameters. c. Analyze access for moving (removal and replacement routes) facility furniture, fixtures, and equipment throughout the project parameters. d. Analyze access to facility furniture, fixtures, and equipment throughout the project parameters.		
6.1	Construction Document Drawings	[BIMR 63] A-E shall produce construction document drawings utilizing IFC-compliant BIM Authoring software.		
6.2	Construction Document Drawings	[BIMR 64] All 2-D drawings shall comply with the graphic standards as referenced in NPR 8820.2.		
7.1	BIM Execution Plan (BEP)	[BIMR 65] Within 30 days after execution of the Agreement, A-E shall customize the prescriptive NASA BEP confirming the intended uses of the BIM, describing the communication paths, the model structure, and the LOD of the modeled elements at each contractual milestone or deliverable, and the BIM process design		
7.2	BIM Execution Plan (BEP)	[BIMR 66] The BEP shall be provided to NASA for its review and approval.		

NASA-STD-10001				
Section	**Description**	**Requirement in this Standard**	**Applicable (Enter Yes or No)**	**Comments**
7.3	BIM Execution Plan (BEP)	[BIMR 67] The BEP shall, at a minimum, contain the following elements: a. Instructions and Reference Information This section identifies the source of the template and what areas are to be completed/customized. It also refers back to SpecsIntact, Section "01 78 25 Building Information Modeling." b. Table of Contents This section lists Section A through Section M with Hyperlinks to each section in the document. c. Section A: Project Information (1) This section begins with instructions followed by the project site photo. (2) Next, the basic project information is listed as follows: A. Facility owner. B. Project name. C. Project location. D. Contract type. E. Facility type. F. Brief project description. G. Additional project information regarding COBie implementation. H. Agent. I. Project numbers include: i. Agent contract number. ii. Task order number. iii. Agent project number. iv. Contractor project numbers as applicable. d. Section B: Key Project Contacts		

NASA-STD-10001				
Section	**Description**	**Requirement in this Standard**	**Applicable (Enter Yes or No)**	**Comments**
		(1) This section begins with instructions. (2) The project contract matrix columns include the following: A. Role. B. Organization. C. Name. D. Email. E. Time zone. F. Phone. (3) Example role rows include, but are not limited to: A. Administrative Contracting Officer. B. NASA (owner) Project Manager. C. Procurement Project Manager. D. BIM/COBie Technical Lead Manager. E. BIM.		
7.4	BIM Staffing Plan	BIMR 68] A-E shall**,** in the BIM Staffing Plan, identify for itself and each of its consultants the persons that within their organizations responsible for managing the BIM, or portion of the BIM, by providing the following information: a. Name. b. Title. c. Contact information (location, primary phone number, mobile phone number, and email address). d. Description of the duration and extent of the person's experience with the BIM software the A-E proposes to use. e. Identification and description of prior projects where the person used BIM software and the extent it was used on that project. f. Role (i.e., BIM structural design lead, BIM mechanical design leader, etc.). g. Anticipated time devoted to the project in hours per week.		

NASA-STD-10001				
Section	**Description**	**Requirement in this Standard**	**Applicable (Enter Yes or No)**	**Comments**
7.5.1	Model Progression Matrix	[BIMR 69] The BEP shall 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, Building Information Modeling Protocol Exhibit.		
7.5.2	Model Progression Matrix	[BIMR 70] The model progression matrix shall be executed by each party that is assigned responsibility as a model component author in the matrix.		
7.5.3	Model Progression Matrix	[BIMR 71] The LOD shall comply with ASTM E-1557, Standard Classification for Building Elements and Related Sitework—UNIFORMAT II, Level 3 model components.		
7.5.4	Model Progression Matrix	[BIMR 72] The model progression matrix shall show the LOD to 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.		
7.6.1	BIM Process Design	[BIMR 73] A-E shall lead a workshop for Construction of Facilities (CoF) level projects that includes all design level participants, including A-E's staff, A-E's consultants, and NASA staff.		
7.6.2	BIM Process Design	[BIMR 74] At the conclusion of the workshop, the A-E shall prepare the process overview and detailed BIM process maps and distribute them to the workshop participants.		
7.7	Schedule	[BIMR 75] A-E shall prepare a schedule for BIM design deliverables tied to the model progression matrix that includes 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.		
7.8 Model Structure				
7.8.1	File Naming Structure	[BIMR 76] File names for models shall be formatted as discipline-project number-building number.file extension.		
7.8.2	Model Structure and Division of Modeled Information	[BIMR 77] The BEP shall 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 to be used by A-E to ensure that all of the models remain current and consistent.		
7.8.3	Measurement and Coordinate Systems	[BIMR 78] The A-E shall confirm and document the measurement and coordinate systems in the BEP for this project and provide the following: a. All measurements in metric units unless a waiver is provided by the Contracting Officer or is contained in standards applicable to a specific NASA Center. b. Site plans and building models geo-referenced in accordance with Table 5, GEO-References.		

<table>
<tr><th colspan="5">NASA-STD-10001</th></tr>
<tr><th>Section</th><th>Description</th><th>Requirement in this Standard</th><th>Applicable (Enter Yes or No)</th><th>Comments</th></tr>
<tr><td></td><td></td><td>

Table 5—GEO-References

<table>
<tr><th>CENTER</th><th>GEO-REFERENCE</th></tr>
<tr><td>Ames Research Center</td><td>California State Plane Coordinate System Zone III as defined by NAD 1983 US Feet</td></tr>
<tr><td>Armstrong Flight Research Center</td><td>NAD 27 (US Feet) California Zone V</td></tr>
<tr><td>Glenn Research Center</td><td>HARN/Ohio State Planes, North Zone, US Survey Foot</td></tr>
<tr><td>Goddard Space Flight Center</td><td>Maryland State Plane Grid NAD83 NGVD88</td></tr>
<tr><td>IV and V Facility</td><td>NAD 83 State Plane West Virginia North FIPS 4701.</td></tr>
<tr><td>Jet Propulsion Laboratory</td><td>NAD 83 (US Feet) California Zone V</td></tr>
<tr><td>Johnson Space Center</td><td>NAD_1983_HARN_StatePlane_Texas_South_Central_FIPS_4204_Feet</td></tr>
<tr><td>Kennedy Space Center</td><td>Horizontal: Florida State Plane Coordinate System, East Zone, North American Datum 1983/1990 adjustment based on Second Order Class II horizontal control monument.
Vertical: North American Vertical Datum (NAVD) 1988</td></tr>
<tr><td>Langley Research Center</td><td>NAD 83 HARN (1993) US State Plane Coordinate System Virginia South Zone, in meters. All vertical coordinates shall be reported in NAVD88, as orthometric height derived from GEOID03 in meters.</td></tr>
<tr><td>Marshall Space Flight Center</td><td>NAD 1983 State Plane, Alabama, East (FIPS 0101) Feet
Vertical Datum: NAVD88, feet</td></tr>
<tr><td>Michoud Assembly Facility</td><td>NAD 1983 State Plane Louisiana South FIPS 1702 Feet</td></tr>
<tr><td>NASA Headquarters</td><td>Maryland State Plane coordinate system of the American Datum of 1983 (NAD83), as updated in 1991. For vertical coordinates, the standard is the North American Vertical Datum of 1988 (NAVD88). Coordinates are stored in meters.</td></tr>
<tr><td>NASA Safety Center</td><td>HARN/Ohio State Planes, North Zone, US Survey Foot</td></tr>
<tr><td>Plum Brook Station</td><td>HARN/Ohio State Planes, North Zone, US Survey Foot</td></tr>
<tr><td>Stennis Space Center</td><td>Mississippi East State Plane NAD 27, US Survey Foot</td></tr>
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<tr><th colspan="5">NASA-STD-10001</th></tr>
<tr><th>Section</th><th>Description</th><th>Requirement in this Standard</th><th>Applicable (Enter Yes or No)</th><th>Comments</th></tr>
<tr><td></td><td></td><td><table><tr><td>Wallops Flight Facility</td><td>NAD 83 HARN (1993), Virginia State Plane Grid, South Zone, US Survey Feet</td></tr><tr><td>White Sands Test Facility</td><td>New Mexico State Plane Central Zone NAD 83, in feet</td></tr></table></td><td></td><td></td></tr>
<tr><td>7.8.4.1</td><td>Software and Operating Systems</td><td>[BIMR 79] The BEP shall list the BIM software and computer operating system or systems to be used by A-E and its consultants for this project,</td><td></td><td></td></tr>
<tr><td>7.8.4.2</td><td>Software and Operating Systems</td><td>[BIMR 80] Listed software and listed operating systems shall not be changed or upgraded 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 and requires NASA's written approval.</td><td></td><td></td></tr>
<tr><td colspan="5">7.8.5 Electronic Communication Procedures</td></tr>
<tr><td>7.8.5.1</td><td>File Access and Archiving</td><td>[BIMR 81] The BEP shall specify:

a. The physical and logical locations of BIM files and related electronic information;

b. The protocols for archiving and disaster recovery;

c. The protocols for user access and file permissions;

d. The directory/subdirectory/file structure used to organize the BIM files and related electronic information; and

e. 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.</td><td></td><td></td></tr>
<tr><td>7.8.5.2</td><td>Electronic File Formats and Use</td><td>[BIMR 82] The BEP shall specify:

a. The types of digital information that will be transmitted between project participants;

b. The acceptable methods of transmission;

c. The acceptable file format(s) to be used for the type of digital information.</td><td></td><td></td></tr>
<tr><td>7.8.5.3</td><td>A-E Information Manager(s)</td><td>[BIMR 83] The BEP shall identify the persons responsible for managing and executing the responsibilities of this section.</td><td></td><td></td></tr>
</table>

NASA-STD-10001				
Section	**Description**	**Requirement in this Standard**	**Applicable (Enter Yes or No)**	**Comments**
7.8.5.4.1	Pre-Design Site Survey Modeling	[BIMR 84] 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 shall include the following: a. Description of tasks and schedule for developing the pre-design model; b. Description of recommended methodology for developing the existing site information, such as: (1) Development of model based on as-built documents for facility; (2) Optical surveying facility to develop a new model or validate the accuracy of existing information used to create a model: A. 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 B. Combination of tasks or approaches to accomplish the goals.		
7.8.5.4.2	Pre-Design Site Survey Modeling	[BIMR 85] If laser scanning is required or will be used by the A-E, the BEP shall identify: a. Primary and secondary objectives of laser scanning; b. Areas of interest; c. Resolution requirements and measurement units; d. Type of deliverable; e. Control network or other dimensional control; and f. Quality control procedures.		
7.9	Interoperability	[BIMR 86] A-E shall demonstrate that the software used by them and their 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.		
7.10.1	BIM Software	[BIMR 87] BIM software for NASA projects shall support intelligent objects and parametric relationships.		
7.10.2	BIM Software	[BIMR 88] The software shall comply with current industry interoperability standards and be usable in a collaborative environment		
7.10.3	BIM Software	[BIMR 89] All software platforms used for NASA projects shall be compliant with: a. The most current version of Industry Foundation Classes (IFC) file format. b. Commercially available collaboration software that provides interoperability between the different software applications as specified in Table 6.		

<table>
<tr><th colspan="5">NASA-STD-10001</th></tr>
<tr><th>Section</th><th>Description</th><th>Requirement in this Standard</th><th>Applicable (Enter Yes or No)</th><th>Comments</th></tr>
<tr><td></td><td></td><td>
Table 6—Commercially Available Collaboration Software Providing Interoperability between Different Software Applications
<table>
<tr><td>TYPE (These are general categories. Listed software can be used for more than one “Type.”)</td><td>SOFTWARE (no order of preference)</td></tr>
<tr><td>Planning/Preliminary Cost Estimates</td><td>Onuma Planning System™ (OPS), DProfiler™, Tokmo, CodeBook</td></tr>
<tr><td>Authoring – Design (Architecture, Structural)</td><td>Revit® Architecture, Revit® Structure, Bentley® AECOsim Building Designer, ArchiCAD®, Tekla®, Vectorworks®</td></tr>
<tr><td>Authoring - MEPF (Engineering and Construction)</td><td>ArchiCAD® MEP Modeler™, Revit® MEP, Bentley® AECOsim Building Designer, CAD-Duct, CADPIPE, AutoSPRINK, PipeDesigner 3D®</td></tr>
<tr><td>Authoring – Civil</td><td>Bentley® Inroads and Geopak, Autodesk® Civil 3D</td></tr>
<tr><td>Coordination (clash detection)</td><td>NavisWorks® Manage, Bentley® Navigator, Solibri® Model Checker, Horizontal Glue, EPM Model Server, BIMServer™</td></tr>
<tr><td>4-D Scheduling</td><td>Synchro, Vico, NavisWorks® Simulate, Primavera, MS® Project®, Bentley® Navigator</td></tr>
<tr><td>5-D Cost Estimating</td><td>Innovaya, Vico, Tokmo</td></tr>
<tr><td>Specifications (Management software for linking data between BIM and specification editing software utilizing UNIFORMAT codes)</td><td>Speclink-e, E-Specs</td></tr>
<tr><td>Model Checking Validation, IFC File Optimizer</td><td>Solibri®</td></tr>
<tr><td>Construction Operations Building information exchange (COBie)</td><td>Tokmo COBIE</td></tr>
</table>
</td><td></td><td></td></tr>
</table>

NASA-STD-10001				
Section	**Description**	**Requirement in this Standard**	**Applicable (Enter Yes or No)**	**Comments**
		Energy Analysis: EcoDesigner, Ecotect®, eQuest®, Green Building Studio®, EnergyPlus™, Trane®/TRACE, DOE2, Bentley® AECOsim Energy Simulator		
7.11 Open Source File Formats/Open Standards				
7.11.1	Statement of Principal	[BIMR 90] The formats used shall be specified in the BEP and include, at a minimum, the following current version IFC Model View Definition (MVD) formats: a. **Coordination View Files**—Required for all deliverables needed to demonstrate the coordination of design disciplines prior to construction and a report provided by the A-E highlighting automatically detected (hard and soft) collisions, identifying those collisions requiring further work by the A-E. b. **Portable Document Format (PDF)—**Transform non-modeled information authored directly by the A-E to PDF to allow selection of text within the document. c. **GBxml—**Support accurate and reliable data export to GBxml for environmental analysis, optimization, and sustainability classifications such as LEED, Green Globes, and EnergyStar by the Architectural, Mechanical, and Electrical BIM software, at a minimum. d. **COBie—**COBie-compliant BIM authoring software. e. **Documents Authored by Others but Used by the A-E**—Provide documents such as manufacturer product data sheets in the format made available by the manufacturer or scanned as image-based PDF documents.		
7.12 Modeling Requirements				
7.12.1.1	General	[BIMR 91] BIM shall 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.		
7.12.1.2	General	[BIMR 92] During the defined design phases, BIM technology shall be used to develop and establish building performance and the basis of design in accordance with the project requirements.		
7.12.1.3	General	[BIMR 93] BIM authoring software element libraries shall be used when creating model objects.		
7.12.1.4	General	[BIMR 94] Model objects shall contain parts and components as opposed to simple 3-D geometry (e.g., walls, doors, windows, railings, stairs, furniture, etc.) and IFC parameters and associated data applicable to building system requirements.		

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7.12.1.5	General	[BIMR 95] Elements, objects, and equipment shall be tagged with unique identifiers (GUIDs) and provide the following: a. OmniClass number. b. IBM® Maximo® asset number assigned by the NASA Center maintenance program manager when required.		
7.12.2	Types of Model Elements	[BIMR 96] Manufacturer's model elements shall be derived from the following sources: a. Embedded performance data for analysis and specification purposes. b. Custom-created model elements using appropriate BIM Authoring tool templates.		
7.12.3.1	Model Geographical Location	[BIMR 97] The spatial coordination (coordinates) of the master BIM file shall be set at the beginning of the project and 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.		
7.12.3.2	Model Geographical Location	[BIMR 98] The A-E Information Manager shall geo-reference site plans and building models for site layout surveying and future geographic information systems (GIS) use in accordance with the State Plane Coordinate system where the project is located.		
7.12.4	Points of Reference	[BIMR 99] The A-E Information Manager shall provide a 3-D grid for incorporation into the spatial coordination model.		
7.12.5	Requirements for Modeling Space	[BIMR 100] Modeling space shall comply with the following requirements: a. The source for space creation in BIM is the space information imported from the NASA Project Program Requirements. b. Track and identify by name areas of 4 square feet or greater, even if those spaces are not listed in the program narrative. c. Generate spatial data and associate it with bounding elements (walls, doors, windows, floors, columns, ceilings). d. Model the Assignable Areas Square Footage (ASF), Non-Assignable Areas Square Footage (NaSF), and Gross Square Footage (GSF) for each functional space, using the appropriate space/object BIM tool to capture and carry the information.		

NASA-STD-10001				
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		e. Represent and break down spaces into functional spaces, even though they may be parts of a larger physical space. f. Update dynamically space/area schedules and diagrams from the model geometry. g. Validate spatial requirements through reports generated from the BIM.		
7.12.6	Space Naming and Coding	[BIMR 101] Each space shall include the following attributes and be maintained throughout the DBIM models: a. Building. b. Floor (and/or Level). c. Department. d. Sub-department. e. Space Name – English Name and 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).		
7.12.7 BIM Deliverables				
7.12.7.1.1	BIM Demonstration	[BIMR 102] To ensure that the Design Contractor is capable of executing the planned use of BIM for the project, the Design Contractor shall demonstrate the planned BIM uses, information exchanges, workflows, and processes as described in the Government-approved BEP.		
7.12.7.1.2	BIM Demonstration	[BIMR 103] The key BIM personnel identified in the BEP shall perform the demonstration live and in person using the software and hardware specified in the Government-approved BEP.		
7.12.7.1.3	BIM Demonstration	[BIMR 104] The demonstration shall be an over-the-shoulder meeting where software and hardware demonstrations are observed by NASA and occur live and in person for key personnel as well as via a Web meeting for non-key personnel.		
7.12.7.1.4	BIM Demonstration	[BIMR 105] If modification(s) to the BEP are required as a result of non-acceptance of the BIM demonstration, the Contractor shall modify the BEP and resubmit to the Government for acceptance.		

NASA-STD-10001				
Section	**Description**	**Requirement in this Standard**	**Applicable (Enter Yes or No)**	**Comments**
7.12.7.1.5	BIM Demonstration	[BIMR 106] Upon official approval of the BEP by the Government Contracting Officer, the Contractor shall subsequently perform a BIM demonstration in accordance with the revised Government-approved BEP.		
7.12.7.1.6	BIM Demonstration	[BIMR 107] Use of BIM for design-related activities as described in the BEP shall not proceed until official acceptance of the BEP demonstration has occurred.		
7.12.7.2.1	3-D Geometric Deliverables – Design Model	[BIMR 108] The A-E shall ensure that the design models remain current throughout design and construction phases of the project.		
7.12.7.2.2	3-D Geometric Deliverables – Design Model	[BIMR 109] The A-E shall be responsible for providing a fully coordinated and assembled BIM as well as separate copies of each technical discipline model in the original software authoring tool, model information, and the required instructions on file/folder setup as follows: a. Native file format(s) of the design model (version as agreed in BEP). b. IFC file format (version as agreed in BEP). c. Collaboration software format (Navisworks® or equal or version as agreed in BEP) for fully coordinated and assembled BIM. d. All models clash/collision free. e. Models gap-free. f. All systems that are intended to connect do so and are free of any gaps or breaks.		
7.12.7.3.1	Data Deliverables	[BIMR 110] A-E shall provide room/space data in COBie format.		
7.12.7.3.2	Data Deliverables	[BIMR 111] The BEP shall refer to a customized LOI Product Assets in Scope revised by the NASA Center to specify what COBie information is to be included in the BIM models.		
7.12.7.4	2-D Deliverables	[BIMR 112] A-E shall produce printed sets of final documents generated from the design model as follows: a. In PDF format with fully bookmarked pages. b. DWG format meeting NASA requirements.		
7.12.7.5.1	Digital Deliverables	[BIMR 113] Both BIM and COBie information shall be submitted.		

NASA-STD-10001				
Section	**Description**	**Requirement in this Standard**	**Applicable (Enter Yes or No)**	**Comments**
7.12.7.5.2	Digital Deliverables	[BIMR 114] All digital deliverables shall be submitted on digital versatile disc/compact disc (DVD/CD) or provided electronically through a secure Web site or other electronic portal with the data clearly organized and software version(s) labeled		
8.	Tailoring/Waiving of Specific Requirements	[BIMR 115] The tailoring/waiver request shall: a. Certify that the A-E has diligently attempted to meet the requirement, the requirement cannot reasonably be met, and alternative approaches meet the intent of the requirement. b. Be supported by evidence of the A-E's research and documentation that the alternative approach meets the function and interoperability requirements of this NASA Technical Standard.		

APPENDIX B

REFERENCES

B.1 Purpose and/or Scope

This Appendix provides useful references for the users.

B.2 Reference Documents

BIM Guide 03 - 3-D Imaging, General Services Administration (https://www.gsa.gov/real-estate/design-construction/3d4d-building-information-modeling/bim-guides/bim-guide-03-3d-imaging)

BIM Project Execution Planning Guide, developed by the Computer Integrated Construction Research Program at The Pennsylvania State University (http://www.bim.psu.edu/)

National Institute of Building Sciences, National Building Information Model Standard-U.S., V3, Washington DC, 2015. (http://www.nationalbimstandard.org/nbims-us)

National Institute of Building Sciences, National BIM Guide for Owners, Washington, DC, January, 2017. (https://www.nibs.org/page/nbgo_form)

National Building Information Modeling Standard-United States (NBIMS-US), Version 3, Section 2.7. (http://www.nationalbimstandard.org/files/NBIMS-US_V3_4.2_COBie.pdf)

NPR 7120.5, NASA Space Flight Program and Project Management Requirements