BUILDING INFORMATION MODELING SCOPE OF SERVICES AND REQUIREMENTS FOR CONSTRUCTION CONTRACTOR IN A DESIGN-BID-BUILD PROCESS

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1. INTRODUCTION

This document defines the Contractor‘s scope of work and deliverables for using Building Information Modeling on NASA projects delivered using a design-bid-build methodology. If attached to an Invitation For Bid, the Contractor’s response should include the below tasks and deliverables within its proposal. If attached to the Contractor's contract with NASA, the tasks and deliverables required by this document will become an integral part of the contract. Services and deliverables must comply with NASA Facility Project Requirements NPR 8820 and _____ .[insert center design requirements, e.g. APD/APR 8829.1 for Ames] Statement of Purpose

1.1 Statement of Purpose

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

1.2 Building Information Model

“Building Information Model” (BIM) or “Model” is a parametric, computable representation of the project design developed by NASA’s design professional consultants (“Designers”), and construction details developed by the Contractor and its subcontractors that are integrated into the model. As used in this BIM Specification, references to Building Information Model, BIM, or the Model, include the primary design model or models and all linked, related, affiliated or subsidiary models developed for design, analysis, estimating, detailing, fabrication, construction, operation or maintenance of the project, or any portion or element of the project.

1.3 BIM Competence and Responsibilities

Contractor must provide NASA with a detailed written description of the BIM experience of its key project team members. At a minimum, the key project team members include the construction project manager, the construction cost estimator, scheduling engineer, construction project engineer, and construction superintendent. In addition, Contractor must designate a BIM Manager to oversee the technical aspects of developing, managing and maintaining the BIM model. Contractor’s proposal must describe the BIM experience and

responsibilities of these key personnel on at least three prior projects that are similar to the current project in size and complexity. The proposal must also describe how their prior BIM experience relates to specific BIM deliverables and tasks within the Contractor's scope of work or proposal.

Unless BIM software is being provided by NASA, Contractor must have, or must obtain at its own cost, sufficient software licenses and computer hardware to adequately perform the services required.

1.4 Data Ownership and Reuse

NASA owns the BIM, the data contained within it, and all copyrights to the BIM. Contractor must arrange by contract to have the ownership and copyright to those portions of the BIM created by Contractor and its subcontractor's assigned to NASA.

1.5 Relationship of BIM Requirements to other Requirements

Contractor's use and development of the BIM must satisfy the requirements of the Invitation For Bid, NASA Facility Project Requirements, this BIM Specification, and any additional requirements noted in the Contract. To the greatest extent practicable, the BIM should describe the project as it will be constructed, with the exception of elements that can not be practicably modeled because of software limitations or that are smaller than elements normally modeled on similar projects. All limitations to the extent of modeling must be identified in the BIM Execution Plan (Section 3) and agreed in writing by the NASA Project Manager. Those project elements that are not modeled must be constructed in accordance with supplementary design information prepared by Contractor that has been fully coordinated with the modeled information.

2. **MODEL** Communication **AND ACCESSIBILITY**

2.1 Security

The NASA Contracting Officer will advise Contractor of the security classification applicable to the BIM, including draft and related information. Contractor is responsible for maintaining the security of the BIM, including access to the BIM, in accordance with NASA regulations and guidelines. The obligation to keep the BIM secure continues throughout performance of this contract and survives termination. At the conclusion of the project, the BIM and all draft or related information must be given to NASA and any copies

destroyed in a manner appropriate for the security classification applicable to the information and as required by NASA regulations.

2.2 NASA Interaction

Contractor must maintain and administer the BIM and associated servers and provide secure access to NASA personnel and NASA contractors as designated by the NASA Project Manager. NASA's right to review, and NASA's review of the BIM is for NASA's convenience, alone, and does not create any duty for NASA to review the BIM or to take any action upon reviewing the BIM, nor does it relieve the Contractor of any of its responsibility for complying with the terms of its contract, including its responsibility to properly construct the project.

2.2.1 Commissioning

Contractor will provide the NASA designated commissioning authority with access to the BIM and associated servers. The Contractor must coordinate with the commissioning authority the integration of model view definitions into the BIM

2.2.2 Facility Management

Contractor will provide the NASA designated facility managers with access to the BIM and associated servers. The Contractor must coordinate with the facility managers the integration of model view definitions and the format and content of the Record BIM.

2.2.3 Reviews

Contractor will provide the NASA Project Manager and designated reviewers with access to the BIM and associated servers. The Contractor must coordinate with the NASA project manager and reviewers the use of the BIM for defined NASA reviews. The Contractor must enable NASA to document review comments into the BIM

2.2.4 Export information

Contractor will provide the NASA with access to the BIM and associated servers for exporting information. NASA reserves the right to utilize information exported from the BIM at any time during the contract.

2.3 Clash Detection and Conflict Resolution

2.3.1 Clash Identification and Resolution Period

The Contractor must conduct and manage an adequate and thorough Clash Detection process before commencing construction so that interferences between building components will be detected and resolved before fabrication and installation. Contractor is solely responsible for the cost of remedying any clashes that could have been discovered during this Clash Detection process. Before commencing construction, and as indicated in any shop drawing or submittal schedule [or a *date sufficiently before start of construction to allow for review and resolution of all conflicts*], Contractor must prepare or obtain all shop information, fabrication information, or layout information (Submittals) necessary to clash detect the Submittals against each other and against the Contract Documents. If the Submittals are not in an interoperable 3D modeled format, Contractor must model the Submittal information to allow digital clash detection.

2.3.2 General

The Contractor's BIM Manager must assemble a composite model from all of the model parts for the purpose of performing a visual check of the building design for spatial and system coordination.

The clash detection process should uncover and address hard clashes between modeled elements and soft clashes, such as infringements into code or maintenance required clearances and necessary clearances for fireproofing, insulation or other non-modeled elements. Prior to each scheduled coordination meeting, an updated clash report must be issued by the BIM Manager to technical and engineering subcontractors.

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

The Contractor must review the model and the clash reports in coordination meetings as required by the BEP, until all spatial and system coordination issues have been resolved. The clash report must be integrated and overlayed within the BIM.

Internal Clash Resolution – The Contractor must verify that the

Subcontractors responsible for multiple scopes of work are coordinating the clashes between those scopes prior to providing those models to the Contractor's BIM Information Manager for spatial and system coordination.

Spatial Coordination Verification: Contractor to maintain verification and tracking of resolved conflicts of all discipline coordination issues.

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

Trade colors for Clash Detection		
Trade Name	**Color Name**	**RGB Number**
Architecture	White	255,255,255
Structural Steel	Maroon	176,48,96
Concrete	Grey75	191,191,191
HVAC Equipment:	Brown	206,130,11
HVAC Supply Duct/Diffuser	Sky Blue	50,153,204
HVAC Return Duct/Diffuser	Dark Magenta	127,0,127
HVAC Pipe	Gold	255,215,0
Electrical Equipment	Dark Yellow	205,205,0
Electrical Conduits	Light Yellow	255,255,224
Communication Conduit	Light Blue	205,127,50
Electrical Cable Tray	Dark Orange	255,140,0
Electrical Lighting	Yellow	255,255,0
Plumbing Water	Cyan	209,238,238
Plumbing Sewer	Light Magenta	255,178,255
Plumbing Storm Drain	Green	0,255,0
Fire Suppression System	Red	255,0,0
Fire Alarm	Pink	255,188,188
Pneumatic Tube	Dark Green	47,79,47
Equipment	Light Green	152,251,152
Gas	Seaweed	99,171,43
Security Systems	Orange	255,165,0
Fire Alarm	Fuchsia	255,0,255

2.3.3 Minimum Requirements for Spatial Coordination and Clash Detection

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

MEPF (internal): Clash detection for MEPF elements.

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

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

Vertical shafts will be reviewed to ensure that adequate space has been allocated for all of the vertical mechanical systems. All of the shafts are to line up floor to floor.

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

Architecture/HVAC + Interiors: Merges must include ductwork and piping + ceilings and FF&E + HVAC.,

Space Validation: There must be no space gaps. Bounding boxes, designated enclosed floor areas, used to represent room and zone spaces must match with architectural requirements and data values, and all must be coordinated with values given in the program and engineering requirements as defined in the PER.

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

Security setbacks + structure + site: Include line of site coherence check for allowance of security zone as defined by NASA security criteria.

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

2.4 Scheduling

Reviews of the BIM during construction must be part of the required construction meetings. The BIM reviews must be included in the Contractor's construction meeting agenda. The BIM reviews must include clash detection, model view definitions and facility management requirements integration.

The BIM must be linked to Contractor's digital critical path method ("CPM") approved baseline construction schedule and subsequent CPM schedule updates to allow simulation of the construction phasing and sequencing.

Impacts to the schedule from change orders, which create modifications to the BIM, will require, through the link between the BIM and the schedule, the contractor to identify the schedule impacts in the BIM.

At a minimum, the digital schedule should link to the following modeled systems:

2.4.1 Structural: All structural framing components including foundations, grade beams, columns, load bearing walls, floor and roof decks and supports;

2.4.2 Exterior Building Envelope: Stud walls, Exterior panels and assemblies, curtain walls, openings, and glazing;

2.4.3 Interior partitions: Main plumbing walls and wall assemblies;

2.4.4 Mechanical systems: Main duct work and equipment (separated by floors);

2.4.5 Roof systems: Roof assemblies, major roof mounted equipment, openings;

2.4.6 Plumbing: Main connection lines from site, main plumbing lines;

2.4.7 Sitework: Excavation work, footings, foundations, on-grade slab; and

2.4.8 Site Logistics: Site layout, safety access; material storage; coordination.

2.5 LEED or other Environmental Certification.

2.5.1 Documentation

If the project requirements include designing and constructing the project to meet the requirements of USGBC LEED™, Green Globes™, Energy Star or similar environmental guidelines or standards, Contractor must develop and organize the BIM to incorporate information necessary for submission to the certifying or reviewing agency. Contractor must review the reports required for the relevant environmental submission and structure the BIM to facilitate creating or exporting these reports.

2.6 Construction Management

2.6.1 Submittals

In addition to any other requirements of the Contract Documents, submittals should be provided as:

2.6.1.1 Manufacturer's model elements that are interoperable with the BIM and provided by the manufacturer or vendor of materials, equipment or systems;

2.6.1.2 Custom created model elements prepared by the Contractor or its subcontractors that are interoperable with the BIM and model portions of the project, specific installations or details or equipment;

2.6.1.3 Fabrication or detail models that are prepared by Contractor or its subcontractors. These fabrication or detail models must be in software that is interoperable with the BIM or that can be compared to the BIM for clash detection or other purposes through the use of viewing software that is interoperable with the BIM and the fabrication or detail modeling software;

2.6.1.4 Contractor must submit for review an analysis report detailing the BIM coordination and clash detection activities. The report must include:

- Coordination and clash detection between the contract document design models and Contractor created models;
- Coordination and clash detection between all Contractor created models; and
- Identification of coordination issues and clashes

2.6.2 Change Orders

Design changes reflected in Change Orders approved by NASA must be promptly incorporated into the BIM such that the BIM reflects the current approved design. Design changes during construction must be clash-detected to determine the extent of impact due to the changed design prior to approval of the Change Order.

2.6.3 Commissioning

In addition to any other requirements for commissioning Contractor must:

- Coordinate with the commissioning authority throughout construction to update the BIM with model view definitions of the model elements.
- Provide the commissioning authority access to the BIM during construction to review and export out model information.

2.7 Record BIM

The BIM must be updated continuously throughout the construction process and must include all addenda, approved change orders, field orders, clarifications, Request for Information (RFI) responses and as-built conditions. The Record BIM includes the BIM at a Level of Detail 500 and includes a description of the relationship of each model in the Record BIM to the others. Contractor may reference the AIA Document E202 – 2008 for Level of Detail 500 description. In addition, the Record BIM must be accompanied by the final versions of all fabrication and detailing models prepared by Contractor and its subcontractors. All models must be provided in native file format with a description of the software used to create the model (software manufacturer, software name, version number, and operating system used for the software.

3. BIM EXECUTION PLAN (BEP)

Within [default = 30] days after execution of the Contract, Contractor must prepare a

BIM Execution Plan (BEP) confirming the intended uses of the BIM during the construction phases of the project, describing the communication paths, and the model structure. The BEP must be provided to NASA for its review and approval. Once approved, the BEP can not be modified without NASA's written approval.

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

3.1 BIM Staffing Plan

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

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

3.2 Security Plan

Contractor must prepare a Security Plan that describes the procedures and safeguards used to preserve the confidentiality and integrity of the BIM and to demonstrate compliance with NASA requirements for data security and integrity.

3.3 Model Progression Matrix

The BEP must contain a model progression matrix substantially similar to the Model Progression Specification spreadsheet published by American Institute of Architects, California Council or the Model Element Table, Section 4.2 of American Institute of Architect's Document AIA E-202. The columns of the matrix should be modified to match Contractor's submittal schedule and the Level of Detail (LOD) shown must comply with Uniformat II, Level 3 model components and should include user level sub-categorization, (Uniformat Levels 4 & 5 if necessary to provide appropriately defined LOD and model component author responsibility).

3.4 BIM Process Design

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

3.5 Schedule

Contractor must prepare a schedule for BIM deliverables tied to the Model Progression Matrix. The schedule must include all BIM tasks of Contractor's subcontractors, 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 construction. The schedule must be submitted to NASA for review as directed by the contract documents.

3.6 Model Structure

3.6.1 File Naming Structure

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

Model	**Designator**

Model	Designator
Energy Model	ENERGY-
Coordination Model	COORD-
Construction Model	CONST-
Other Model Types as Required	

3.6.2 Model Structure and Division of Modeled Information

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

3.6.3 Measurement and Coordinate Systems

The measurement and coordinate systems are to be confirmed and documented in the BEP for this project. The Contractor must provide the following

All measurements must be in units of measurement required by standards applicable to the specific NASA center. Site plans and building models must be geo-referenced to _____, North American Datum 1983.

3.7 Software and Operating Systems

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

3.8 Electronic Communication Procedures

3.8.1 File Access and Archiving

The BEP must specify:

- The physical and logical locations of BIM files and related electronic information;
- The protocols for archiving and disaster recovery;
- The protocols for user access and file permissions;
- The directory/subdirectory/file structure used to organize the BIM files and related electronic information;
- 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; and
- Maintenance of BIM as-built information during construction

3.8.2 Electronic file formats and use.

The BEP must specify:

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

3.8.3 Contractor Information Manager(s)

The BEP must identify and provide contact information for the persons responsible for managing and executing the responsibilities of this section.

3.9 Site Survey Modeling

If the Contractor's scope of services includes surveying the existing project site and preparing a model of the existing facilities, the BEP must include the following:

- Description of tasks and schedule for developing the site survey model;
- Description of recommended methodology for developing the existing site information, such as:
    - Development of model based on as-built documents for facility;
    - Optical surveying facility to develop a new model or validate the accuracy of existing information used to create a model;

- Laser scanning all or a portion of the facility to develop new model or validate the accuracy of existing information used to create a model;
- or Combination of tasks or approaches to accomplish the goals.

When laser scanning is required or will be used by the Contractor, the BEP should identify:

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

Contractor may reference the GSA BIM Guide Series 03, BIM Guide For 3D Imaging in developing this portion of the BEP.

3.10 Change Management

The BEP should specify the process for integrating submittals, change orders, RFI responses, clarifications and similar construction phase information into the BIM. The process should describe:

- Who is authorized to integrate the construction level information into the BIM;
- How construction level information will be coordinated and clash detected with the existing BIM information;
- How changes to the BIM will be logged; and
- How construction level information will be identified to distinguish it from Design BIM information.

3.11 Construction Management

The Execution Plan must outline the strategy and schedule for utilizing BIM Technology to execute construction related activities and project coordination. The Execution Plan must address the following:

- Constructability analysis with BIM
- Animation/graphic showing installed major building equipment space

clearance reservations for operations, repair, maintenance, and replacement

- Proposed trade coordination strategy (clash detection)
- Proposed use of digital fabrication
- Updating as-built conditions in Record BIM
- Utilization of 4D scheduling and construction sequencing technology
- List of subcontractors using digital fabrication
- Proposed BIM Software to be used by the builder and fabrication modelers
- Strategy to assure all trade information is modeled and coordinated
- Proposed subcontractor BIM workshops and training integrated into project schedule
- Integration of construction changes and commissioning data into BIM
- Strategy for COBie2 integration and submittals

3.12 Facility Management

The BEP must specify a workflow to identify model elements that are significant for operations and maintenance of the facility and to map data structures from NASA's Computerized Maintenance Management System (CMMS) and Computer Aided Facility Management (CAFM) to Systems attributes of the identified model elements. Where the CMMS and Facility Management System (FMS) data structure does not have a comparable attribute in a modeled element, the BEP should define an additional custom model element attribute to provide congruent mapping to the CMMS data structure.

The BEP should specify a workflow for transferring FM data from the BIM to the CMMS either directly or through middleware that manages the interchange of information between the Record Model and the CMMS.

4. INTEROPERABILITY

Contractor is responsible for selecting BIM software that is adequate for Contractor's tasks. Moreover, Contractor must demonstrate that the software used by it and its subcontractors 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 5.2. 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. Contractor must demonstrate, through the technical specification of the software, that it can meet the required functional requirements, whether or

not the proposed software is listed below.

4.1 BIM Software

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

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

Additional software not listed below may be found on the BuildingSMART Alliance web site, http://www.buildingsmartalliance.org/

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 BIM, ArchiCAD, Tekla, Vectorworks
Authoring - MEPF (Engineering & Construction)	ArchiCAD MEP, Revit MEP, Bentley BIM, CAD-Duct, CAD- Pipe, AutoSprink, PipeDesigner 3D
Authoring – Civil	Bentley Inroads and Geopak, Autodesk Civil 3D
Coordination (clash detection)	NavisWorks Manage, Bentley Navigator, Solibri Model Checker, Horizontal Glue, EPM Model Server, BIMServer
4D Scheduling	Synchro, Vico, NavisWorks Simulate, Primavera, MS Project, Bentley Navigator
5D Cost Estimating	Innovaya, Vico, Tokmo
Model Checking Validation, IFC File Optimizer	Solibri
Construction Operations Building Information Exchange (COBie2)	Tokmo,
3D CMMS/BAS Integration Software	EcoDomus
Energy Analysis	EcoDesigner, Ecotect, eQuest, Green Building Studio, EnergyPlus, Trane/Trace, DOE2

4.2 Open Source File Formats/Open Standards

4.2.1 Statement of Principal

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

4.2.2 Current Version IFC Model View Definition (MVD) Formats:

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

4.2.3 Portable Document Format:

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

4.2.4 GBxml

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

4.2.5 COBie2

BIM authoring software must support data export and import from the COBie2 table databases.

4.2.6 FM/BAS Integration Export

NASA currently uses Maximo by IBM as its primary Computerized Maintenance Management System (CMMS). The Record BIM must map Maximo input fields as required by this Specification to allow CMMS data export from the Record BIM into Maximo. Mapping should follow the guidelines of USACE Engineer Research and Development Center, *COBie2 Data Import/Export Interoperability with the MAXIMO Computerized Maintenance Management System*, November 2008. In addition, and if required by the contract, the Record BIM must be interoperable with NASA specified middleware, that manages the interchange of information between the Record Model and the CMMS.

The Record BIM must map BAS software input fields as required by this specification to allow data export from the Record BIM into the BAS software. Mapping between the BIM and BAS software should utilize the established COBie2 guidelines for model view definitions and be coordinated with the commissioning authority.

To create a BIM(s) that contains the actual population of architectural, structural, mechanical, electrical, plumbing, and civil objects for building services such as Fire and Life Safety, HVAC, Data/Communications, Security, and Lighting that may be utilized for building design, construction, and operation.

To populate the critical mechanical, electrical, plumbing, and civil objects with the appropriate performance requirements and as-built information. The object attribute information that is captured will be used throughout the building lifecycle and potentially integrated into NASA's ArcGIS system as implemented at each NASA Center.

To create an accurate current-condition record of the existing building conditions.

4.3 Requirements

Contractor must update the BIM to accurately reflect all design and construction changes from the final pre-construction DBIM submitted to NASA.

Contractor must create a Record Building Information Model that accurately reflects "as-built" conditions for all building systems including but not limited to, architectural, civil, structural, mechanical, life safety, and electrical systems.

The Contractor must model the following:

- Underground Utilities (within building footprint and 15’ beyond its perimeter);
- Architectural models;
- Structural models;
- Furniture, Furniture and Equipment models;
- Civil models:
    - All underground utilities
    - Site lighting
    - Topography
    - Landscape (trees, plants, surface material, water elements
    - Hardscape (parking, pavement, sidewalks, curbs)
- Mechanical elements limited to:
    - All fixed mechanical ducts;
        - Calculation information and sustaining information tied into models views
        - Space – Zone/Circulation Information
    - All fixtures and equipment (Manufacturer, Model size, and Weight);
    - Equipment performance information (Input/Output);
    - All piping, 3/4” or greater and terminations;
- Electrical elements limited to:
    - Electrical conduit 3/4” (19.05mm)or greater and terminations;
    - All fixtures and equipment (Manufacturer, Model size, and Weight);
    - Equipment performance information (Input/Output);
    - Power distribution (Panels and Circuits);
    - Lighting
- Plumbing elements limited to:
    - Plumbing piping 1/4” (6.35mm) or greater and terminations;
    - All fixtures and equipment (Manufacturer, Model size, and Weight);
- Life Safety elements limited to:
    - Life safety piping 1/4” (6.35mm) or greater and terminations;
    - All fixtures and equipment (Manufacturer, Model size, and Weight);
    - Equipment performance information (Input/Output);
- Telecommunications/Data Communications
    - Conduit ¾” (19.05mm) or greater and terminations;
    - All fixtures and equipment (Manufacturer, Model size, and Weight);

The following must be defined for all systems:

- Materials;
- Finishes;
- All electrical circuiting;
- Cable trays and raceways;
- Tags;
- Labels;
- All Warranty information tied to the model objects and presented in views;
- Product Data / Cut Sheets tied to the objects; and
- Maintenance Schedules and operations data

4.4 Facility Management Information

Record Model must be consistent with the COBie2 Model View Definition published by the National Institute of Building Science in the Whole Building Design Guide.

The Contractor will assist NASA in the integration of the project BIM into the NASA computerized maintenance management system (CMMS). This Contractor's effort will consist of collecting, validating, updating, and exporting design, construction and commissioning data for NASA's use, and if required by the contract, entering the information into NASA's CMMS.

The Contractor will integrate the building systems into the BAS software by providing a Record BIM which maps to BAS software input fields. Mapping between the Record BIM and the BAS will utilize the established COBie2 guidelines for model view definitions and be coordinated with the commissioning authority.

The Contractor must prepare the BIM at each phase with the following defined information

4.4.1 Construction Phase:

- Type information updated by providing manufacturer, model number, warranty information (parts and labor and duration), replacement cost;
- Component information updated by providing serial number, installation date, warranty start date, and optionally tag number or barcode. Installation date for major equipment will be the finish date of the corresponding

schedule activity;

- Spare parts provided for types; and
- Attributes provided for types and components.

4.4.2 Commissioning Phase:

- Documents assigned (uploaded) to corresponding BIM objects (types, components, spaces, facility); and
- Attributes corrected based on real measurements.

5. MODELING REQUIREMENTS

5.1 General

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

5.2 Types of Model Elements

Model elements must be derived from the following sources:

Manufacturer's Model Elements - elements created by and acquired from manufacturers often have more information than is prudent to keep in the BIM model; the appropriate level of detail should be retained for the design element. However, embedded performance data must remain for analysis and specification purposes.

Custom Created Model Elements – custom model elements that are created must utilize appropriate BIM Authoring tool templates to create custom elements. Custom models elements need to be assigned as a part of a family or group with parametric model view definition information.

Fabrication Model Elements – elements created by the construction sub-contract fabricators must have embedded model view definition information required by the commissioning authority for transfer from the BIM to the facility management software. The fabrication model elements must be parametric model objects.

5.3 Model Geographical Location

The spatial coordination (coordinates) of the master BIM file will be set at the beginning of the project. Once established, spatial coordinates will only be changed by mutual consent of the Contractor and the NASA project manager, with the matter recorded in the meeting minutes and the BIM Execution Plan. Once the 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 building.

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

5.4 Points of Reference

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

5.5 Requirements for Modeling Space

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

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

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

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

geometry.

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

5.6 Space Naming and Coding

Contractors space naming and coding must use the following format:

- Building Name;
- Building Number – NASA Center Building Numbering System;
- Floor (and/or Level);
- Department;
- Sub-department;
- Space Name – English Name & Abbreviation;
- Room Number – NASA Wayfinding Room Number;
- Room Number – Construction Document Number (used on large complex projects for builder use);
- Space Code – NASA Room Code;
- Unique Space Number – GUID;
- Space Type - OmniClass;
- Space Type - Uniformat; and
- Space Measurement - Net Square Footage (NSF), Department Net Square Footage (DNSF), Department Gross Square Footage (DGSF), and Building Gross Square Footage (BGSF)

5.7 Requirements for Record BIM and Facility Management Information

Contractor must incorporate model view definition information into the BIM as defined by COBie2. The Contractor must utilize the Omniclass™ Construction Classification System (OCCS) for the classification structure of the data

5.8 Contractor BIM Deliverables

5.8.1 Models

The Contractor must ensure that the models remain current throughout construction of the project. During construction the Contractor will be responsible for providing a fully coordinated and assembled model compatible with the original software authoring that is consistent with the:

- Native file format(s) of Models (version as agreed in BIM Execution Plan);
- IFC file format (version as agreed in BIM Execution Plan); and
- Collaboration software format (Navisworks Manage or equal or (version as agreed in BIM Execution Plan) for fully coordinated and assembled BIM.

The Contractor must provide record model(s) for all building systems. The model(s) must be fully coordinated and the required instructions on file/folder setup must also be included:

- Native file formats of the final consolidated record model(s) for building systems used in the multi-discipline coordination process (version as agreed in BIM Management Plan); and
- IFC file format of the consolidated building systems models (version as agreed in BIM Management Plan).

5.8.2 Data Deliverables

Contractor must provide facility management data, model view definitions, in COBie2 format.

5.8.3 2D Deliverables

Contractor's 2D deliverables must be provide in:.

- In PDF format with fully bookmarked pages, where not prepared or maintained in CAD formats; or
- DWG format meeting NASA requirements.
- All 2D drawings must comply with the graphic standards as referenced in NASA Facility Project Requirements, NPR 8820

If the contract requires Contractor to design portions of the project and if, for the portion designed by Contractor will be reviewed by inspection or permitting agencies, Contractor must produce printed drawings from the model, signed and sealed by licensed professional architects and engineers, as required by the reviewing or permitting agency.

5.8.4 Digital Deliverables

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

6. WAIVERS OF SPECIFIC REQUIREMENTS

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

7. ABBREVIATIONS LIST

ADA	Americans with Disabilities Act
BEP	BIM Execution Plan
BIM	Building Information Model (also Modeling or Management)
COBie2	Construction Operation Building Information Exchange
DBIM	Design Building Information Model
FM/BAS	Facility Management / Building Automation System
FF&E	Furniture, Furnishings, & Equipment
GBxml	Green Building XML
GSA	General Services Administrations
GUID	Globally Unique Identifier
HVAC	Heating, Ventilation, and Air-Conditioning
IFC	Industry Foundation Classes
LOD	Level of Detail
MEPF	Mechanical, Electrical, Plumbing, Fire Protection
NASA	National Aeronautics and Space Administration
PER	Preliminary Engineering Report