BUILDING INFORMATION MODELING SCOPE OF SERVICES AND REQUIREMENTS FOR DESIGN/BUILD

Final – November 12, 2010

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1. INTRODUCTION

This document defines the Design-Builder ("Contractor") scope of work and deliverables for using Building Information Modeling on NASA projects delivered using a design construct methodology. If attached to a Request for Proposal for Design-Build Services, the Contractor's response should include the below tasks and deliverables within its proposal. If attached to the Contractor's contract for services, the tasks and deliverables required by this document become an integral part of the Contractor's contract for services. 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 to achieve the required purposes. This document describes NASA's requirements for use of Building Information Models (BIM) in the design and 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 the Contractor, its consultants, and any design/build subcontractors, and includes construction details developed by the Contractor and its respective consultants and 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, whether the model is prepared by Contractor or prepared by Contractor's subcontractors or consultants.

1.3 BIM Competence and Responsibilities

The architects, engineers, designers and technicians involved with providing services under Contractor's Agreement, must be trained and experienced in using BIM technology and processes. 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.

Contractor will 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 principal project designer, the design discipline lead designers, the construction project manager, the construction cost estimator, scheduling engineer, construction project engineer and construction superintendent. In addition, Contractor will designate a BIM Manager to oversee the technical aspects of developing, managing and maintaining the BIM model. Contractor's proposal will 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 will also describe how their prior BIM experience relates to specific BIM deliverables and tasks within the Contractor's scope of work or proposal.

1.4 Data Ownership and Reuse

NASA owns the BIM, the data contained within it, and all copyrights to the BIM. If portions of the BIM are not authored by Contractor, Contractor will arrange by contract to have the ownership and copyright to those portions exclusively assigned to NASA.

1.5 Relationship of BIM Requirements to other Requirements

The BIM developed by the Contractor must satisfy the requirements of the Request for Proposal, 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 Contracting Officer. Those project elements that are not modeled will 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 will 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 Review

The BIM must be reasonably available for NASA review and comment throughout the project. The NASA Project Manager, and others designated by the Project Manager shall be provided with secure access to the server or servers where the BIM is located and with a reasonable method for providing comments regarding the BIM.

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 Design/Builder of any of its responsibility for complying with the terms of its contract, including its responsibility to properly design and construct the project.

2.3 NASA Interaction

Contractor will maintain and administer the BIM and associated servers. The contractor will provide BIM access to NASA and NASA contractors as designated by the NASA Project Manager for the following purposes:

2.3.1 Commissioning

The NASA designated commissioning authority will be provided access to the BIM and associated servers. The contractor will coordinate with the commissioning authority the integration of model view definitions into the BIM

2.3.2 Facility Management

The NASA designated facility managers will be provided access to the BIM and associated servers. The contractor will coordinate with the facility managers the integration of model view definitions and the format and content of the record BIM.

2.3.3 Reviews

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

2.3.4 Export information

NASA will be provided 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.

3. BIM FUNCTIONAL REQUIREMENTS

3.1 Models

The Contractor will provide a BIM of the following systems during design and construction. For as-built model requirements refer to Section 6 of this building information modeling scope of services and requirements for design/build document. The contractor(s) shall properly use available "intelligent objects" to embody information about the building component requirements and properties (e.g., material properties, functional information, dimensions, uniformat assembly information, etc). The following sections describe more specific information that shall be included in, but not limited to, the following models:

3.1.1 Architectural

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

3.1.2 Furniture, Furnishings and Equipment (FF&E)

The Contractor will provide a 3D BIM created with architectural components that embody proper object information and parametric relationships in accordance with good architectural practice. These components include, but are not limited to, furniture, furnishings and equipment, including both Contractor furnished and Government furnished

items.

3.1.3 Structural

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

3.1.4 Mechanical

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

3.1.5 Electrical

The Contractor will provide a 3D BIM created with electrical components that embody proper object information and parametric relationships in accordance with good electrical engineering practice. These components include, but are not limited to, all major electrical equipment, transformers, switchgear, generators, panel boards, lights, conduit over 2" (50.8mm) nominal O.D, hangers, cable trays, raceways and other electrical equipment. Conduit bends are to be modeled for coordination with other trades.

3.1.6 Plumbing

The Contractor will provide a 3D BIM created with plumbing components that embody proper object information and parametric relationships in accordance with good mechanical engineering practice. These components include, but are not limited to, all major plumbing equipment, fixtures, boilers, pumps, piping over 1 1/2" (38.1 mm) nominal O.D., hangers, and other plumbing equipment. Pipe bends are to be modeled for coordination with other trades.

3.1.7 Telecommunications / Information Technology

The Contractor will provide a 3D BIM created with telecommunications and information technology components that embody proper object information and parametric relationships in accordance with good engineering practice. These components include, but are not limited to, all major equipment, MDFs, IDFs, panel boards, conduit over 2" (50.8mm) nominal O.D., hangers, cable trays, raceways and other equipment. Conduit bends are to be modeled for coordination with other trades.

3.1.8 Life Safety and Fire Protection

The Contractor will provide 3D BIMs created with life safety and fire protection components that embody proper object information and parametric relationships in accordance with good mechanical and electrical engineering practice. These components include, but are not limited to, fire detection devices, fire alarm devices, fire alarm panels, the main sprinkler piping risers and related devices piping 1 ½" (38.1mm)or larger nominal O.D., sprinkler heads, control valves, fire suppression equipment, pumps, hangers, and other equipment. Pipe bends are to be modeled for coordination with other trades.

3.1.9 Underground Utilities (Civil)

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

3.1.10 Site / Campus (Civil and Landscape)

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

3.2 Program Space Validation

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

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

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

3.3 Design Coherence

3.3.1 General

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

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

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

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

Internal Clash Resolution – Subcontractors who are responsible for multiple scopes of work are expected to coordinate 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:	Gold	255,215,0
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 Protection	Red	255,0,0
Pneumatic Tube	Dark Green	47,79,47
Equipment	Light Green	152,251,152

Trade colors for Clash Detection		
Trade Name	**Color Name**	**RGB Number**
Gas	Light Green	152,251,152
Security Systems	Orange	255,165,0
Fire Alarm	Fuchsia	255,0,255

3.3.2 Minimum Requirements for Spatial Coordination and Clash Detection

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

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 will be considered and will be clash-free.

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

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

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

Space Validation: There will be no space gaps. Bounding boxes, designated enclosed floor areas, used to represent room and zone spaces will match with

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

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

Security 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 will include plumbing fixtures. (If using Solibri Model Checker or other rules-based model checking software, accessibility compliance can be checked automatically.

3.4 Code Review

The Contractor will use the BIM Authoring software or model checking software to validate the design is in compliance with stated building code requirements.

3.5 NASA Building Requirements

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

3.6 Analysis and Optimization

3.6.1 Lighting and Daylighting

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

3.6.2 Energy

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

3.6.3 Carbon

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

3.6.4 Wind

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

3.6.5 Water

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

3.6.6 Indoor Air Quality

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

3.6.7 Acoustics

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

3.6.8 Functional Analysis per Building Type

Utilize the BIM to analyze and forecast interior and exterior pedestrian

circulation and activity patterns within the project parameters. Life safety egress, accessibility requirements for Federal properties and wayfinding will be included in the analysis.

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

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

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

3.7 Construction Document Drawings

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

3.8 Contractor BIM Model During Construction

3.8.1 Scheduling

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

The BIM must be linked to Design/Builder's digital critical path method ("cpm") approved baseline construction schedule and subsequent cpm schedule updates to allow simulation of the construction phasing and sequencing. At a minimum, the digital schedule should link to the following modeled systems:

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

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

3.8.1.3 Interior partitions: Main plumbing walls and wall assemblies;

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

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

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

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

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

3.8.2 LEED or other Environmental Certification.

3.8.2.1 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, Design/Builder will develop and organize the BIM to incorporate information necessary for submission to the certifying or reviewing agency. Design/Builder will review the reports required for the relevant environmental submission and structure the BIM to facilitate creating or exporting these reports.

3.8.3 Construction management

3.8.3.1 Submittals

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

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

or systems;

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

3.8.3.1.3 Fabrication or detail models that are prepared by Design/Builder 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;

3.8.3.2 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.

3.8.3.3 Commissioning

In addition to any other requirements for commissioning contractor will provide the follwing:

3.8.3.3.1 The contractor will coordinate with the commissioning authority throughout construction to update the BIM with model view definitions of the model elements.

3.8.3.3.2 The contractor will provide the commissioning authority access to the BIM during construction to review and export out model information.

3.8.4 Record BIM

The BIM must be updated continuously throughout the construction process and must include all addenda, approved change orders, field orders, clarifications, 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 Design/Builder 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.

4. BIM EXECUTION PLAN (BEP)

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

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

4.1 BIM Staffing Plan

Contractor will 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 (i.e, BIM structural design lead; BIM mechanical design leader, etc.)
- Anticipated time devoted to the project in hours per week. If the level of activity will vary throughout the project, th 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.

4.2 Security Plan

Contractor will 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.

4.3 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 model progression matrix must be executed by each party that is assigned responsibility as a model component author in the matrix. The phasing columns of the matrix should be modified to match the phasing of project deliverables in the Contractor contract and the Level of Detail (LOD) must comply with Uniformat II, Level 3 model components and should include user level sub-categorization, (Uniformat Levels 4 & 5 if necessary to provide appropriately defined LOD and model component author responsibility). The model progression matrix must show the LOD that must be accomplished on or before the completion of each phase, or the date of each contract deliverable or milestone, as identified in Contractor's agreement with NASA.

4.4 BIM Process Design

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

4.5 Schedule

Contractor will prepare a schedule for BIM design deliverables tied to the Model Progression Matrix. The schedule must include all BIM tasks of Contractor's consultants and

subcontractors, 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.

4.6 Model Structure

4.6.1 File Naming Structure

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

Model	**Designator**
Architectural Model	ARCH-
Civil Model	CIVIL-
Mechanical Model	MECH-
Plumbing Model	PLUMB-
Electrical Model	ELEC-
Structural Model	STRUCT-
Fire Protection Model	FP-
Furniture, Furnishings and Equipment (FF&E) Model	FFE-
Telecommunications / Information Technology Model	IT-
Energy Model	ENERGY-
Coordination Model	COORD-
Construction Model	CONST-
Other Model Types as Required	

4.6.2 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.

4.6.3 Measurement and Coordinate Systems

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

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

4.7 Software and Operating Systems

The BEP must list the BIM software and computer operating system or systems to be used by Contractor and its consultants for this project. The software and operating systems should be identified by vendor, product name, version identifier, build identifier, patch number, and data architecture (32bit/64bit). Listed software, and listed operating systems, can not be changed or upgraded without NASA's written approval, which will not be granted unless 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.

4.8 Electronic Communication Procedures

4.8.1 File Access and Archiving

The BEP will 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; and
- ◊ The internet address and directory structure for a secure web site, internet accessible project manager, or web portal used to store and access BIM files.
- ◊ Maintenance of BIM as-built information during construction

4.8.2 Electronic file formats and use.

The BEP will specify:

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

4.8.3 Contractor Information Manager(s)

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

4.9 Pre-Design Site Survey Modeling

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

- Description of tasks and schedule for developing the pre-design model;
- Description of recommended methodology for developing the existing site information, such as:

  - ◊ Development of model based on as-built documents for facility;
  - ◊ Optical surveying facility to develop a new model or validate the accuracy of existing information used to create a model;
  - ◊ Laser scanning all or a portion of the facility to develop new model or validate the accuracy of existing information used to create a model;
  - ◊ or Combination of tasks or approaches to accomplish the goals.

If laser scanning is required or will be used by the 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.

4.10 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.

4.11 Construction Management

The Execution Plan will outline the strategy and schedule for utilizing BIM Technology to execute construction related activities and project coordination. The Execution Plan will 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 sub-contractors 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 sub-contractor BIM workshops and training integrated into project schedule
- Integration of construction changes and commissioning data into BIM
- Strategy for COBIE[5] integration and submittals

4.12 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 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.

5. 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 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 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.

5.1 BIM Software

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

- The most current version of Industry Foundation Classes (IFC) file format
- Commercially available collaboration software that provides interoperability between the different software applications (see below).
- 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
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 (COBie2)	Tokmo,
3D CMMS/BAS Integration Software	EcoDomus
Energy Analysis	EcoDesigner, Ecotect, eQuest, Green Building Studio, EnergyPlus, Trane/Trace, DOE2

5.2 Open Source File Formats/Open Standards

5.2.1 Statement of Principal

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

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

Coordination---This format will be required for all deliverables needed to demonstrate the coordination of design 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.

5.2.3 Portable Document Format:

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

5.2.4 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.

5.2.5 COBie2

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

5.2.6 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.

6. Record **MODEL**

6.1 Objectives

To create a BIM(s) that contains the actual population of critical 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.

6.2 Requirements

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

Contractor will 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 Design/Builder Contractor shall model the following:

- Underground Utilities (within building footprint and 15' beyond its perimeter)
- Architectural models
- Structural models
- Mechanical, Electrical, Life Safety, and Plumbing elements limited to:
- All fixed mechanical ducts,
- Electrical conduit 3/4" (19.05mm)or greater
- Plumbing and life safety piping 1/4" (6.35mm) or greater,
- All fixtures and equipment (Manufacturer, Model size, and Weight)
- Equipment performance information (Input/Output)
- Power distribution (Panels and Circuits)
- Lighting
- All piping and terminations
- All ductwork
- Calculation information and sustaining information tied into models views
- Space – Zone/Circulation Information

The following will 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
- Maintenance Schedules and operations data

6.3 Facility Management Information

Record Model will 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, entering, validating, updating, and exporting design, construction and commissioning data.

The contractor will prepare the BIM at each phase with the following defined information

6.3.1.1 Design Phase:

- Facility and Floors are defined
- Spaces should be classified using OmniClass and Net Area is provided (Gross Area is generated by Authoring Software)
- Zones should have Categories assigned
- Types should have Name, Category (OmniClass), Description, AssetType
- Components should have Name, Description, Type and Space
- Systems should have Name, Category (OmniClass), Components

6.3.1.2 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
- Attributes provided for types and components

6.3.1.3 Commissioning Phase:

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

7. MODELING REQUIREMENTS

7.1 General

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

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

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

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

7.2 Types of Model Elements

Model elements will be derived from the following sources:

Manufacturer's Model Elements - elements created by and acquired from manufacturers often have more information than is prudent to keep in the BIM model; the appropriate level of detail should be retained for the design element. 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 will 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 will be parametric model objects.

7.3 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 design coordinate system is agreed upon, any model(s) of existing buildings relevant to the project will be converted into the coordinate system used for each designed building.

As is standard practice, NASA requires that a building within a BIM file include a geo-reference to accurately locate that building within the site and to give it a physical location context at larger scales. The 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 will be located at the SW corner of the structural grid.

7.4 Points of Reference

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

7.5 Requirements for Modeling Space

Space information imported from the NASA project program requirements will be the source for space creation in BIM.

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

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

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

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

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

7.6 Space Naming and Coding

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

- 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
- Space Measurement - Net Square Footage (NSF), Department Net Square Footage (DNSF), Department Gross Square Footage (DGSF), and Building Gross Square Footage (BGSF)

7.7 Requirements for Record BIM and Facility Management Information

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

7.8 Contractor BIM Deliverables

7.8.1 Models

The Contractor will ensure that the models remain current throughout design and construction of the project. During design and construction the Contractor will be responsible for providing a fully coordinated and assembled BIM as well as separate copies of each technical discipline models in the original software authoring tool, model information and the required instructions on file/folder setup:

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

The Contractor will be responsible for providing record model(s) for all building systems. The model(s) will be fully coordinated and the required instructions on file/folder setup will 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)
- ◊ IFC file format of the consolidated building systems models (version as agreed in BIM Management Plan)

7.8.2 Data Deliverables

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

7.8.3 2D Deliverables

Contractor will produce printed sets of final documents generated from the Design Model and the Record Model.

- ◊ In PDF format with fully bookmarked pages.
- ◊ DWG format meeting NASA requirements

In addition, where required for review by inspection or permitting agencies, Contractor will produce printed drawings from the model, signed and sealed by licensed professional architects and engineers, as required by the reviewing or permitting agency.

7.8.4 Digital Deliverables

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

8. 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.

9. ABBREVIATIONS LIST

A-E	Architect-Engineer
ADA	Americans with Disabilities Act
BEP	BIM Execution Plan
BIM	Building Information Model (also Modeling or Management)
COBie2	Construction Operation Building Information Exchange

Contractor	Design/Build or Design/Builder
DBIM	Design Building Information Model
FF&E	Furniture, Furnishings, & Equipment
GBxml	Green Building XML
GSA	General Services Administrations
GUID	Globally Unique Identifier
HVAC	Heating, Ventilation, and Air-Conditioning
IFC	Industry Foundation Classes
LOD	Level of Detail
MEPF	Mechanical, Electrical, Plumbing, Fire Protection
NASA	National Aeronautics and Space Administration
PER	Preliminary Engineering Report