BPDA 3D Model Management Scheme and Applications.

This document describes the organization of the 3D Models collection management system developed for the Boston Planning and Development Authority (BPDA). The 3D Model Management system is part of a broader Architecture for 3D City Modeling that includes Terrain, Groundplan, trees and other things and conditions. The broader scope is covered in the BPDA City Model User Guide.

A Collection of 3d Models of Structures

It can be useful to conceptualize the 3d Models geodatabase as being about a collection of 3D Models rather than about "Buildings" or other structures. In the context of this collection 3D models are digital resources that relate to geo-located physical structures. These real-world structures may be buildings, building parts, groups of attached buildings, bridges, or bridge parts. Structures represented may exist or may be historical or proposed or completely fictitious or hypothetical. It is possible to have more than one model for a given structure – for example we may have alternate models of city hall at different levels of detail.

Figure 1: Models of a structure observed at different times by different methods created by different authors.

A Platform for Multidisciplinary Research, Curation and Sharing

The 3D Model Management System supports research, encoding, sharing and integration of information about structures. Within the BPDA, the research is focused on urban planning and design review. In the private sector, the collection may be used to understand the present and future context of development alternatives. For people interested in understanding the history of places, the collection preserves information about structures that have been demolished and may be deepened to develop models of places that don't exist any more. Like 2D maps, a historical 3D model canbe used to understand the context of photographs or official documents.

Interoperability

Because different sorts of collaborators use domain specific tools for 3D modeling or digital archives, it is necessary to be able to publish the model collection – including the 3d Models and their attributes in a variety of formats and coordinate systems. The **Model_ID** attribute is designed to be a unique identifier that can be used to keep track models and attributes as they are passed to different tool-kits and potentially returned to the GIS. More details on formats and coordinate systems are provided in the 3D Models User Guide.

Geographic Information Systems View

The schema described in this document is designed for management using the ArcGIS Pro GIS platform. In this context, the collection of 3d models is segmented into Geodatabase feature classes which are relational database tables that include 3D geolocated features represented as multipatch objects.

Multipatch feature classes are useful for visualization and manipulating in 3d models the geographically referenced visualization environment of ArcGIS Pro.

The Bos3D Models geodatabase: In the GIS-based model management schema the model collection is published as an ESRI file geodatabase that is named with a date-string that identifies the date that it was issued from the model management system. This naming convention is useful for tagging updated editions of the model collection and for being clear about the baseline for updates.

Status-Based Segmentation: The 3D model collection is segmented into four feature classes so that applications involving the present configuration of buildings are not burdened with models of proposed, demolished, or alternative models. Each of the feature classes in the GIS-oriented scheme incorporates the same table schema.

- **The Active Models collection** contains models reflecting structures that are currently in existence or models of proposed structures that are in the review, permitting or construction process. This collection holds models with status: **Current**, **Approved**, **Permitted**, **Under Construction**.
- **The Historical Models collection** contains models of structures that have been replaced because of some change in the shape of the real-world structure represented. These changes might reflect a complete demolition of the entire structure, or the removal or addition of some part of the structure. Contains models with status: **Demolished**, or **Modified**
- **The Proposal collection** holds models referring to proposed buildings with status: **Prefile, Under Review**, **Pending Approval** or **Superseded Proposal**. Models of proposals with status **Approved**, **Permitted** or **Under Construction** may be shifted into the Active collection until a measured as-built model is obtained. At that time, the hand-made model is shifted back into the **Proposals** collection with status **Construction Complete.**
- **The Alternative Models class** provides a means of preserving models that are redundant with models in one of the other classes. Alternative models can be selectively portrayed by crafting a view with definition queries to filter the desired and conflicting models.

Dated Editions: Updates to the model collection may be applied continuously, but released to users as new editions of the model collection that are identified by the date appended to the name of the model collection geodatabase as pictured above.

Conception of Entities and Relationships:

Managing the 3d model collection requires setting and adjusting the values of model attributes in a consistent manner. To that end it is helpful for model curators have a shared conceptual framework for understanding how the attribute columns and values relate to real-world structures and digital 3d models.

The **fundamental entities** that are the subject of table rows in this schema are **3D Models**.

- 3d Models attribute table as being about a collection of 3D Models rather than about "Buildings" or other structures.
- 3D Models can have messy relations with real world or imaginary structures. Models may represent individual free-standing structures or parts of structures or groups of structures. Any structure may be represented by more than one model.
- Most 3D models represent observations of structures that were measured by a particular method at a known time. The entity that made the measurements, their method and the date of the measurement is recorded as **Survey_Src.** If a model has been created from drawings, This fact would be recorded in the Survey_Scr attribute, including the title of the document containing the drawings if this is known.
- Surveyed measurements or architectural drawings are digested into digital 3d models by an author designated in the Model_Cred attribute.
- The methodology used for modeling that yields a particular level of detail.
- The structures represented my models may Exist or may have passed out of existence at a known or unknown time. Or the models may represent fictitious scenarios from the past present or future.

Tolerating Imperfection

While this schema is designed to be able to represent changes in places at a fine granularity, it is necessary to tolerate imperfections in order to meet the current needs in a reasonable investment time. A useful mindset will do what is necessary to make the model collection perform for current purposes. This data model and our model management procedures do not require that these inconsistencies be sorted out until they make a difference in the visual or practical aspects of the collection in a specific place.

Normalization and Cardinality

Relational database hawks will notice that this schema embodies some redundancies, awkward overlaps and potential contradictions. Because of the varying methodology and purposes used to measure and model structures, it is often the case that historical or current models represent groups of attached structures. In these cases, some of the attributes that would apply to singular structures may be left as blanks or null values.

Splitting and Modification of Existing and Historical Models.

it is common that new models end up replacing ***parts*** of models representing current or historical building groups. For example, the new model may represent substantial modifications to a single building that is part of a group of attached row-houses. To integrate the new model, the previous model has to be split. When this happens, the model manager has a choice as to how to handle the historical representation. If it is not extraordinarily complicated, the process of splitting the existing building group will yield at least two new models: The parts of the building group that remain in the Active feature class, and the part that ends up in the History feature class. In cases where making a closed model of the historical piece of the structure is too complicated to deal with, then the prior model of the entire building group will end up in the History feature class with a status of Modified.

In all cases, curators should preserve models that have been modified to operate logically with new models. This will make sure that future collaborators who are interested in looking at past configurations will have a complete model to look at, even if it may require some work to make the historical rendition behave logically with a time-slider.

Attitude Concerning Attributes and Values

The attitude we have taken to schema design is to provide enough fields for model managers and curators to record their observations concisely. When enrolling new models and checking the status of existing active models, or researching historical shape places, facts are established, and documentation is at hand. On the other hand, just because an attribute field exists, does not mean that it must be uniformly populated in cases where the facts are not readily available.

Although the primary tool for assembling and managing the model collection is a collection of tables in a geographic information system, it is important to keep in mind that subsets of the collection may be shared with 3D modeling tools or archival systems that are detached from the relational database management system. These sharing needs require encapsulating models with attributes that need to remain coherent outside of a normalized schema with all of its automatic look-ups. This need justifies a certain amount of redundancy.

The schema has been criticized for being bloated. We have taken this criticism to heart and worked hard to make the schema as concise as we can while still maintaining the information that will be necessary to understand and use the model assets in the future.

The Model Management workflow (described in another user guide) provides many tools that assist with the management of these attributes and for publishing specialized views of the model collection. Users are certainly welcome to hide or remove fields in views of the model collection for specific applications such as web scenes or derived data-sets that are shared with the public.

Whole Year Dates

When referring to historical dates for the appearance and disappearance of structures, we often don't know the exact dates. Yet our date format in ArcGIS does not make it easy to store generalized years. Our convention is to use January 1 for date references intended to be rounded at the year.

3D Model Attributes Data Dictionary

Real-World Structure Attributes: These are attributes that refer to the real-world structure represented by the model. **Any of these can be left blank or Null if not applicable.**

Name	Text	The name of the structure. If the model reflects one phase of a development project, you can mention it here.
Struct_ID	Text	If there is a table about structures, this would be a reference to the primary key of that table.
Struct_Type	Text	Type of structure. See domain values. Refers mostly to the physical aspect of the structure. **Examples:** Building, Bridge
Struct_Use	Text	Use of the structure. More specific than Type. Refers to the functional aspect of the structure. . **Examples:** Residential, Commercial, Subway Headhouse, Bus Shelter
Struct_Lnk	Text	A URL that provides more information about the structure. For example the Article80 page or a Wikipedia page.
Project_ID	Text	A string that relates to the Project ID in the BPDA's Article 80 Development log.
ProjectLnk	Text	A URL linking model to the BostonPlans landing page for the project (if it exists, otherwise Null.)

Temporal Status Fields: These attributes relate to the relation of the model to portrayals of historical, current or future scenarios. Think about how you would like the model to behave with a time-slider.

Status Text (Domain)	**Model Status:** A phase in the lifecycle for proposed, built, demolished or rennovated structures. Values of Status are taken from the Status_Code domain (described in more detail, below.
Status_Dt	**Status Date:** Describes date of the latest observation or document that confirms the current value of Status.
AppearSrc Text	Elaborates on how the Appear date was established. Provide a reference to the observation, the document and the date. **Example:** "*Building appears or be finished in NearMap 04/01/2020. "*
Disapp_Dt Date	This is a date field that designates when the model would be turned off if a time-slider were used. Usually the date of the earliest observation that confirms that a structure has been demolished or substantially renovated. In the case of models whose status id "Modified", this date refers to the date when the modification took place.
DisappSrc Text	This text elaborates on how the Disappear date was established. Provide a reference to the observation, document and the date. **Example**: "*Site is cleared per NearMap 04/01/2020*"

Continued…

Model Attributes: Each record in this dataset regards a 3d building model. The collection of fields described below provide the information for identifying these models and understanding their provenance.

Model_ID	Text	A unique ID for each model. This ID is assigned when the model is introduced, and is kept with the model as it is shifted from pipeline through Current and any other feature class. The ID is prefixed with BOS and composed with a random arrangement of seven upper-case letters and numerals.
Model_Cred	Text	This short reference to the person or enterprise responsible for creating the model.
Model_Batch	Text	This field provides the folder within the Bos3d_Archive/ModelWork/Buildings folder where the original file can be found.
Model_File	Text	This is the name of the original source file for the model.
Model_Dt	Date	Reflects the date when the model was created.
ModelNote	Text	This note can describe aspects of the model, such as if it was split or has a problem. **Example:** Bottom extended by 8 feet 02/03/2020.
Model_LOD	Double	Level of detail. 1= Extruded polygon, 2 = 3d model. 3 = a 3d model with overhangs.
Model_Lnk	Text	A URL reference for the model. If applicable.
Survey_Src	Text	The observations that were used for establishing the shape of the model. Should describe the document or firm and the methodology where possible. **Examples:** • "Photogrammetry by Infotech" • "Model hand-made from design documents by Sasaki and Associates"
Survey_Dt	Date	The date that the model geometry was captured or published.

Model Geometric Attributes: These attributes are computed from the geometry of the 3d models. These attributes are automatically generated by the model enrollment process. These may be recalculated at times to synchronize with new parcels or re-configured tiles or the possibilitiy that models have been moved or re-shaped.

Centr_Lat	Double	Latitude of the model centroid (2D) in decimal degrees. Centroid is calculated by ArcGIS using the "Inside" option.
Centr_Lon	Double	Longitude of the model Centroid (2D) in decimal degrees.
Min_El_Ft	Double	The lowest elevation of the model. This may be below ground.
Max_El_Ft	Double	Elevation of the highest point of the model .
Gnd_El_Ft	Double	The elevation where the model intersects the ground. (this measure uses vertices of the 2dfootprint to sample elevations.
Height_Ft	Double	The relative height from the Max Elevation of the model to the lowest corner.
Tile_ID	Text	This is ID for the tile that the model centroid falls within.
Parcel_ID	Text	The Parcel ID for the parcel that fall sunder the centroid of the model's footprint.

Parcel_Lnk	Text	A url that opens the Assessor's web map centered on the parcel that identified by the Parcel_ID.
GoogleLnk	Text	A hyperlink that brings up an oblique view of the building in Google Streetmap.
NearMapLnk	Text	A hyperlink that brings up an oblique view of the building in NearMap. Requires a NearMap login.

Edit Tracking Fields: The edit fields refer to the last edit made on the table row. These can be compiled into an edit history and tracked in case anyone wants to see the change history for a model.

Editor	Text	Name of the user making the last edit
EditDate	Date	The date and time for the last edit.
EditAction	Text	A description of the action taken.

Model Status and Status Class Domain

The Status domain populates the status field in each of the feature-classes in the Bos3dModels.gdb. This provides a pull-down list and assures that the models will be properly sorted by the various definition query driven layers. The table, Status_Code within Bos3dModels.gdb provides a way of managing the domain or applying it to another geodatabase, if necessary, using the **Domain From Table** geoprocessing tool.

Status Class is a way of segmenting the model collection into groups that are most commonly rendered (the Active model class) or rendered under specific scenarios (Historic or Proposed.) The segmentation purpose of Status Class is discussed in detail above.

Model Status in Applications:

Most visualizations of the 3d Models collection involve thematic coloring of models according to their status. In visualizations intended tomirror the shape of places as they currently exist or existed at a specific date, models with a proposed status are shaded with no color, while the models of structures proposed for demolition are shaded using the normal model color.

Alternative views can be produced by suppressing the color of models proposed for demolition while thematically coloring models of future structures according to their stage in the review process.

Status Domain: These are the values that can be used to control the visibility of a model in views that portray the current scene for a specific point in time. Such scenes may or may not portray projects that are at particular stages of the design review process.

Status Value	Feature Class	Description
Current	**Active or Alt**	The structure exists. Use this version when representing the current condition.
Proposed Demo	**Active**	This is a model that would be demolished to make way for a project that would be cleared for a new project but still exists.
Prefile	**Proposed**	Submitted to the Article 80 process but not yet a complete application.
Under Review	**Proposed**	The model represents a scenario that has been proposed.
Board Approved	**Proposed**	The building project was approved by the BPDA Board
Permitted	**Proposed**	The building project has been given construction permits.
Under Construction	**Active**	Demolition has taken place. The site is prepared for construction.
Demolished	**History or Alt**	Real-world structure(s) represented have been completely demolished or substantially modified.
Modified	**History or Alt**	Models has been taken out of the Active collection because the real-world structure(s) represented have been substantially modified due to renovation or demolition of attached structures.
Fictitious	**Alt**	Structure is a fiction. Not an official proposal.
Other		Undefined status. Needs attention.

Levels of Detail

0 Polygon footprint

1.0 Extruded footprint

1.5 Massing model made from extruded roof prints when a structure has substantial parts having different heights

2 3D roof detail, extruded to the ground along drip-line.

3 Model portrays undercuts and parapets when appropriate.

3.25 Architectural details indicated by image textures or applied materials.

3.5 Building model expresses location of windows and entryways in 3D .

4.0 Model represents interior spaces (floor plates)

4.5 Model represents interior spaces rooms or zones.