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Cultivating a Cross-Disciplinary, Cross Temporal Collaboration on a Living 4D Model of the City -- In Real Life!

With special attention on application of concepts from the Reference Model for Open Archival Information Systems (OAIS)

How a digital humanities challenge became part of Boston's municipal data infrastructure

mposium on Spatiotemporal Data Science
arvard Center for Geographic Analysis
ly 15-16 2023

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Slides available now at cityschema.org/whatsnew

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Hacking Spatially and Temporally Extensive Design Data at the GSD*

*Harvard Graduate School of Design

In 1993, As a recent MIT Urban Studies graduate, steeped in GIS and relational databases, I took a position as GIS Specialist at the Harvard Graduate School of Design (GSD).

Students are always looking for contextual data for their architecture and landscape planning projects.

CAD and GIS interoperability became a rewarding set of challenges for me.

Difficulties of CAD and GIS interoperability persist to this day!

Computer Aided Design Tools
(Detailed 3D Model Authoring)

- Data structure is nested hierarchal, object oriented.
- Extent of datasets are liited in terms of extent and megabytes.
- Coordinate Systems:
  - local origin, limited extent (compared with GIS)
  - No support for geographic referencing.
- Working formats are typically proprietary

Geographic Information Systems
(Data development, management, and analysis)

- Data structure is relational, table oriented.
- Coordinate Systems:
- Projections and Latitude Longitude supported. On-the-fly transformation
- Virtually unlimited in terms of extent and file-size
- Plenty of tools for data management
- Working formats are proprietary.

Annual Course: Site Representation and Research

For several semesters I had the pleasure of running a seminar on Site Representation and Research.

The recurring theme of the seminar was: How to organize diverse data so that

- it sticks together in useful ways
- So that the collection will be re-useable and extendable by others.

The diagram on the left illustrates the **ideal** lifecycle of information in an intelligent design enterprise.

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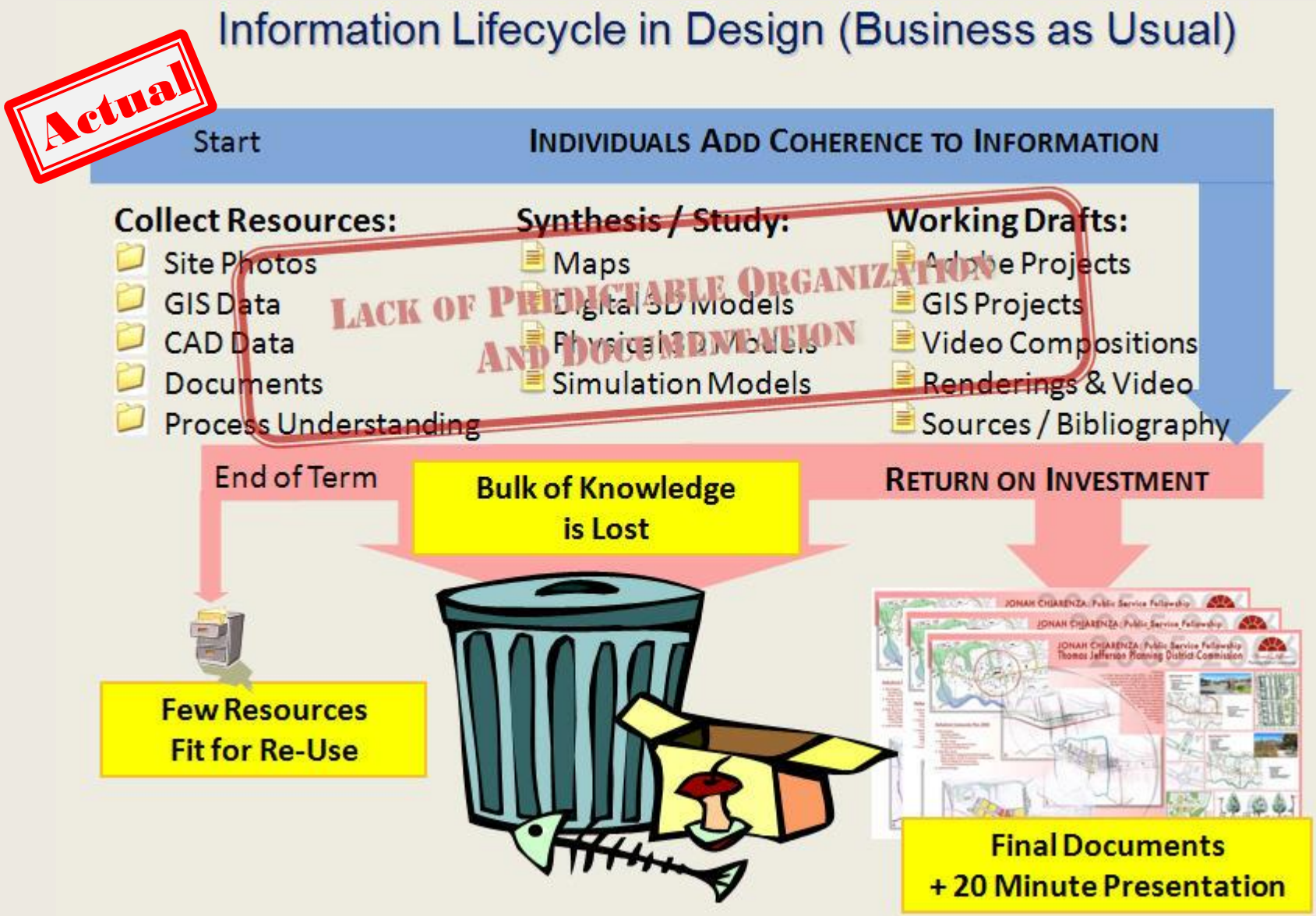
Intelligent Organizations Re-Use Their Knowledge!

Unfortunately most of the teaching and learning that design students are exposed to reinforces the pattern:

Collect, Rinse Repeat!



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City Models demonstrate the power of 4D Referencing as a value- multiplier for Digital Historical Imagery

One term we focused on developing a 4D model of the historic Scollay square which was demolished in the early 1960s to clear the area now known as Government Center.

1. Georeference old fire insurance maps, trace buildings to polygons in GIS.
2. Extrude 2.5-D building models. Add attributes for appear and disappear dates. Export to KMZ
3. Use photos to create detailed 3d model of old landmark Buildings using Sketchup.
4. In Google Earth use rough 3d model as reference for 3D georeferencing of perspective photos.
5. Use more georeferenced photos to locate building geographically,
6. When viewed in the context of these resources unknown information about the time-period and the viewpoint location of the photograph

This experience proved to be a huge Aha! moment pointing out the magic of 4D georeferencing systems as an EXPLOSIVE resource multiplier for historic maps, 3D Models and perspective imagery.

Collaborative city modeling is impractical. Why?

Some challenges and opportunities of the Scollay Square seminar proved to be formidable:

1. Lack of a ready-made editable 3D model of current terrain, groundplan and buildings to start with. Assembling this sort of base data is time-consuming and requires a lot of skill.
2. Designing a data organization and schema for 4-D georeferencing and archival metadata is a huge task.
3. A sharing framework for 3d standards based city models would multiply the value of individual projects.

Task: Develop tools and conventions to remove barriers of entry for 4-Dimensional city modeling!

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Fast forward 10 years!

A company named CyberCity 3D had made a lot of very nice 3d Models from the Cambridge and Boston and gave the to Cambridge and Boston GIS for free.

I was asked to help organize these and to make sites for sharing 3d data with designers.

ESRI created very efficient web-scene viewers for city models.

My first data download sites for Cambridge and Boston relied on the Sketchup-KMZ georeferencing.

Boston hired me to create administrative workflows for continuing routine development of their city model.

I started citySchema,org as a means of sharing documentation, tools and resources (MIT License.)

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Home YouTube GitHub

Templates & Tools

Now Open!

- Whats New: Recent Updates
- City Model Stewardship
  - Stakeholder Roles and Motivations
  - Archival Asset Management Approach
  - Features and Benefits
  - Coordination of Effort
  - Streetscapes are part of our cultural heritage
  - Acknowledgements
- Roles and Motivations of Intelligent Organizations
- Repository / Catalog
- Model Identifiers
- Tile Scheme and Coordinate System
- Model Submission Guidelines
- citySchema Modular File System
- City Tiler

Managing the Building Model Collection

- Building Model Collection
- Data Dictionary
- Model Management Workspace
- Initializing a New Model Management Workspace
- Importing Building Models
- Promoting / Demoting Model Status

for Cross-Disciplinary Collaboration on City Models

The goal of this project is to assist in bringing about a culture where people interested in representing buildings, street-scapes and neighborhoods as they are, as they were, as they might be or might-have-been, can easily share and re-use their work with each-other and with historians of the future.

This problem has not already been solved because there are a lot of contributors and diverse tools involved in creating a city model. There are difficulties exchanging data between detailed 3D design tools and scalable geographical information systems. The solutions to these problems are beyond the scope of the day-to-day work of municipalities, campus administrations and architecture firms. Several years of working with municipalities and designers and archival systems have led us to simple solutions that fulfil the principles of the ISO Reference Model for Open Archival Systems.

We hope that organizations interested in platform-independent digital asset management will find it expedient to adopt these free templates and tools. As a side effect, we may enjoy easier sharing of city model assets between agencies and applications. Fragmentary city modeling activities may begin to merge together. In this more fertile ecosystem of resources will support re-use of knowledge in city-modeling applications that has not been practical before -- including historical research and mobile augmented reality apps.

Intelligent City Models

Before digging into the technical details of **How** to manage a city-wide collection of 3D models, it will be useful to have a picture of the sorts of people for whom this scheme has been designed, and the personal and institutional **motivations** that make this effort worthwhile.

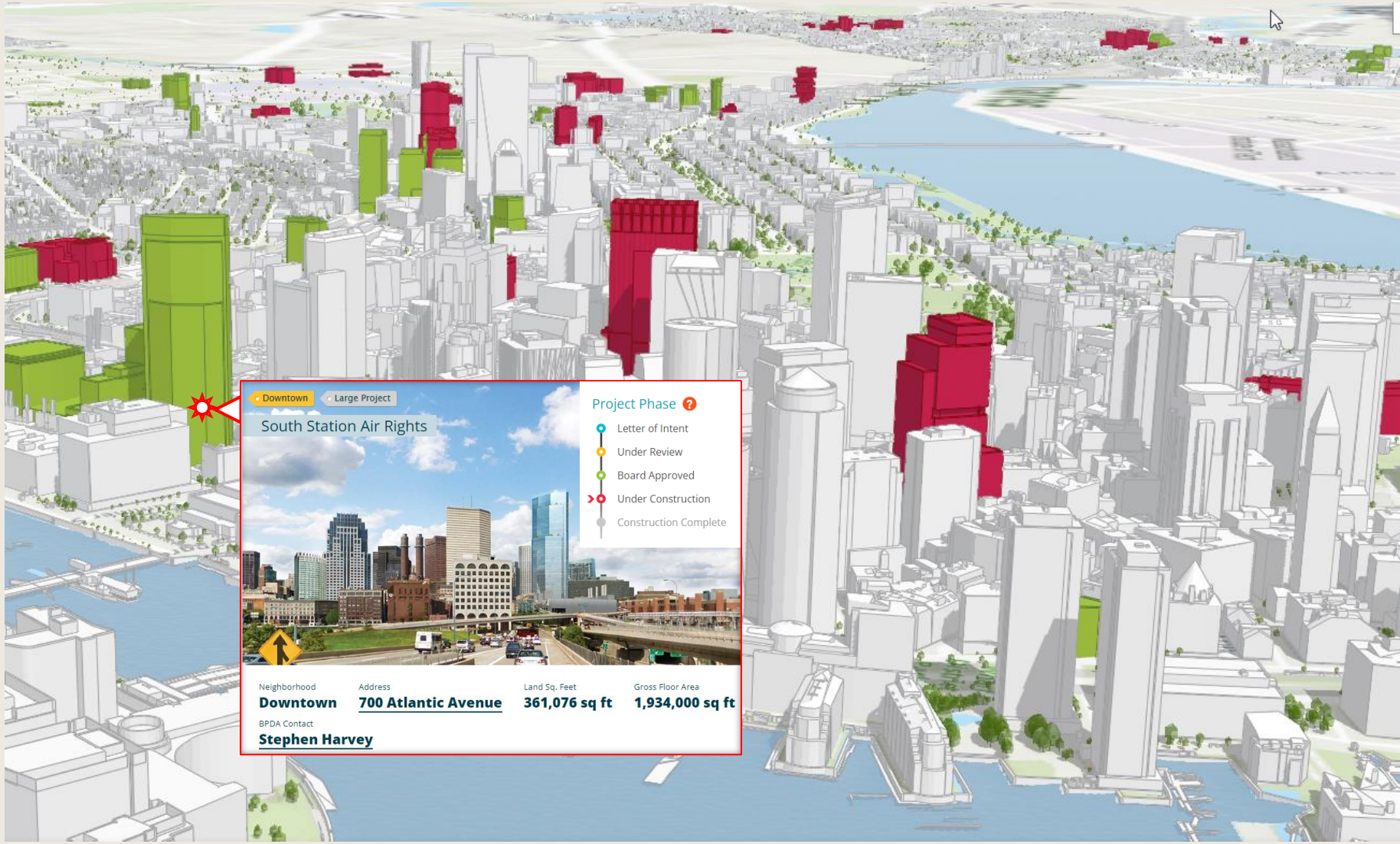
Fly-Through Tour of the Boston 3d Model

The easiest way to explore the Boston and Cambridge 3d models is through their on-line browser-based model.

Sources:

- Existing Buildings, Terrain and Walls generated from stereo photogrammetry.
- Classic photogrammetry yields extruded polygons, which can make rough building and wall models.
- The same imagery can be used to generate detailed roof anatomy in a semi-automated process.
- Models of proposed buildings and bridges are created by the BPDA's in-house modelers.

Think of this project as curating a collection of hundreds of thousands of individual documents that are 3d models.



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Existing Use-Cases for Municipal City Models

Conceptual Motivation

- The role of the municipal GIS agency is to manage the city's representation of itself.
- To understand the needs for information in the city's essential functions
- To plan and contract for regular photogrammetry.
- To digest and make geographic information products available for users.

Existing Applications

- 3D city model information is useful as a 3d base map for understanding the context of other data.
- As a context for visualizing design proposals for during project design (private) and review (public).
- Analytical studies including line of sight and shadow impacts.
- Many architecture firms have downloaded the model and are maintaining parallel versions.

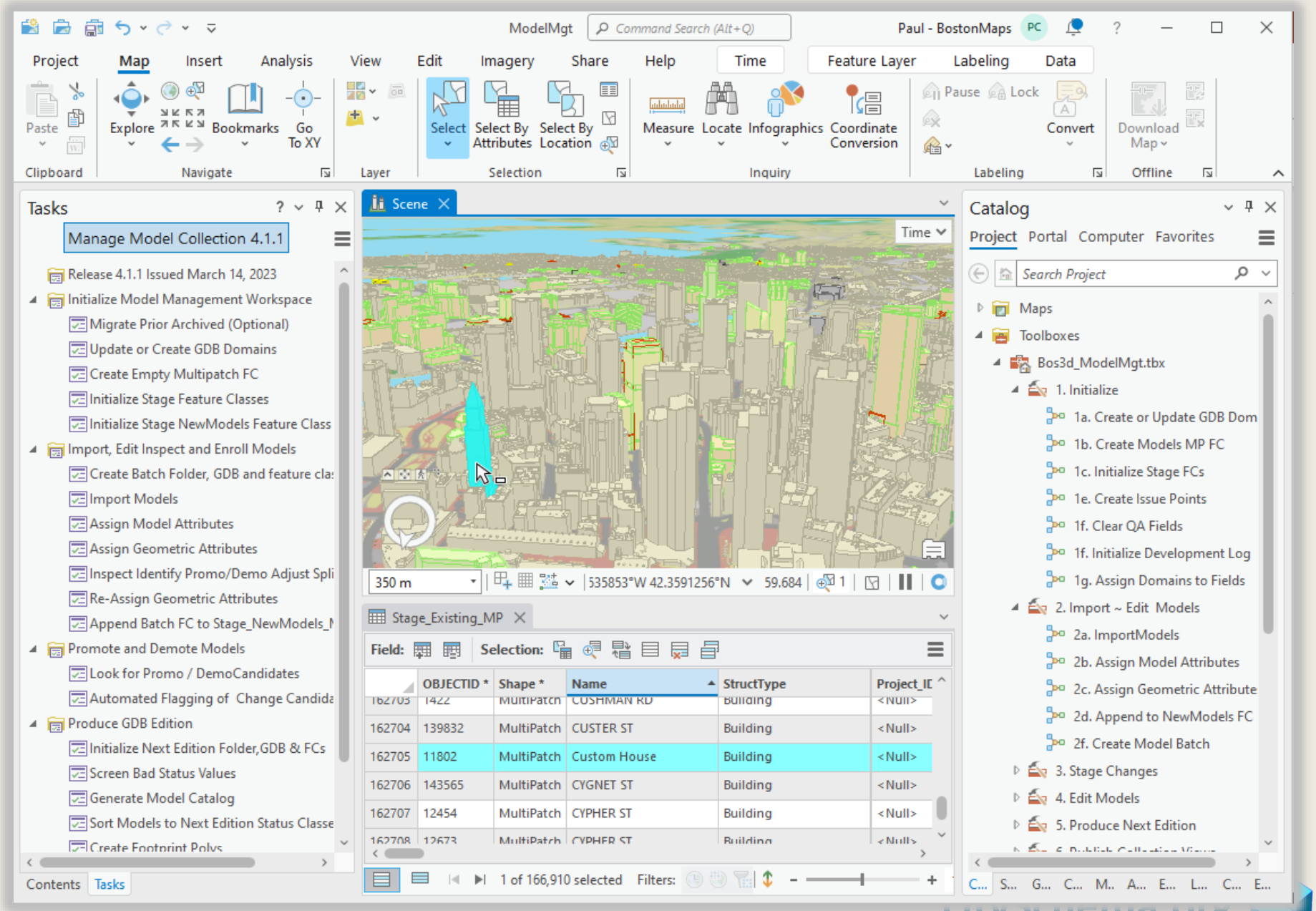
Anticipating Use-Cases for Municipal 3D models

Anticipate potential use-cases that are not currently seen as necessities

- Integrate city models across municipal boundaries and with campus in-holdings. Context Matters!
- Provide updates as particular models that collaborators can use to update their independent model collections.
- Large Project Review should require proponents to submit a 3D model in our preferred exchange format.
- The agency or other city archive should **preserve share historical measured models and models of proposed projects**.

Model Development and Management Tools for ArcGIS Pro

- **Tools:** www.Github.com/cityschema
- **Documentation:** www.cityschema.org/mmgt_project
- This project requires a high degree of curatorial motivation and mindset compared with ordinary municipal GIS projects
- The same patterns could be implemented in a combination of open-source packages, such as Blender with Django
- One unique feature of ArcGIS Pro is the tight integration of 3D models as a data type (Multipatch) extension of a relational data base
- The workflow for model curation is handled as a long transaction with indefinite rollback and auditing capability.
- Production of validated OBJ models and Sketchup format models is accomplished by Safe Software's Feature Manipulation Engine (FME)



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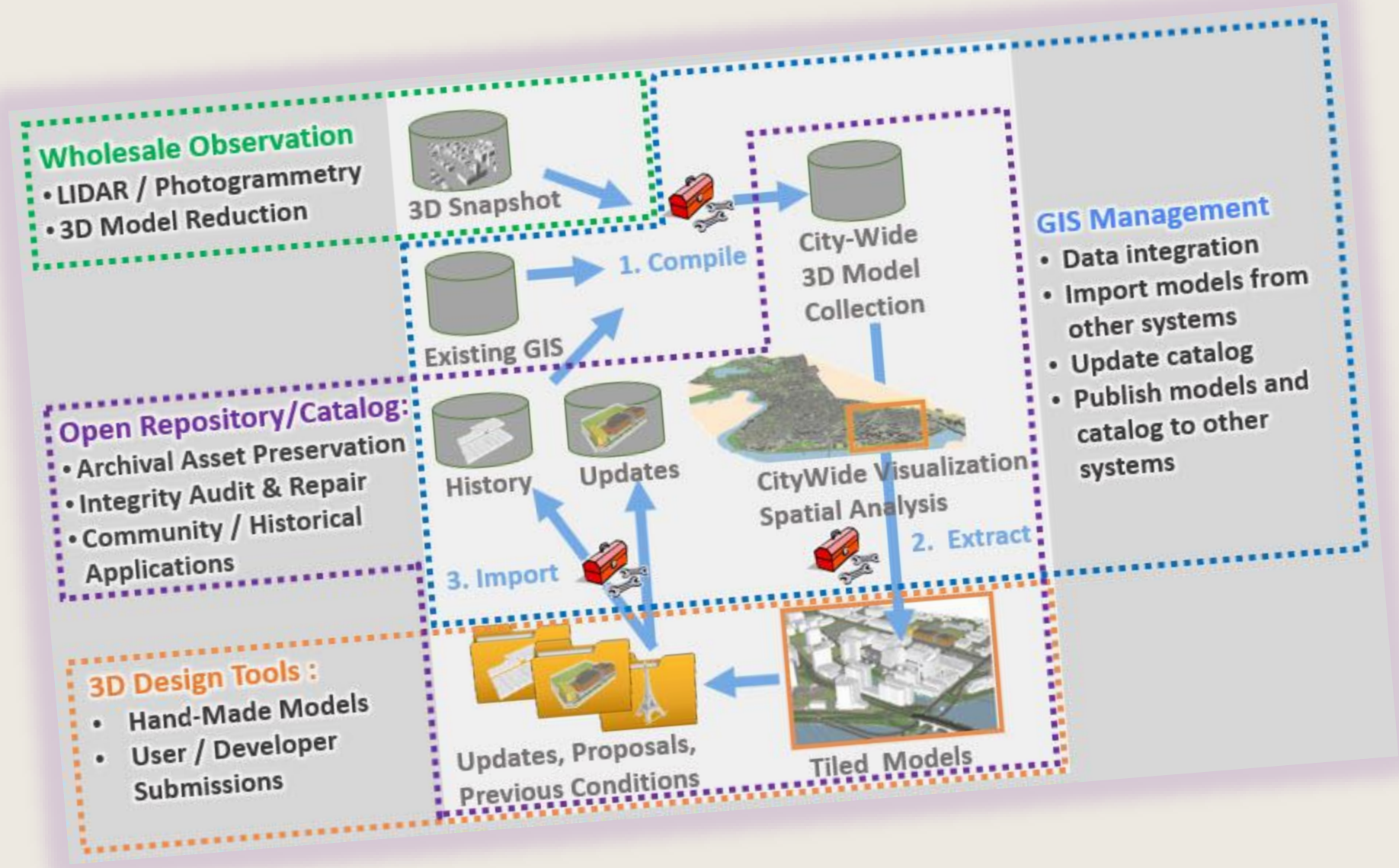
An Ecosystem of Data Exchanges and Specialized Transformations`

All of these tools and workflows are shared and documented at

www.Github.com/cityschema

www.cityschema.org



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The Model Schema

A simple one-table schema that carries fields necessary for documenting a Temporally and geographically referenced 3D Model.

Cityschema.org/data_dictionary

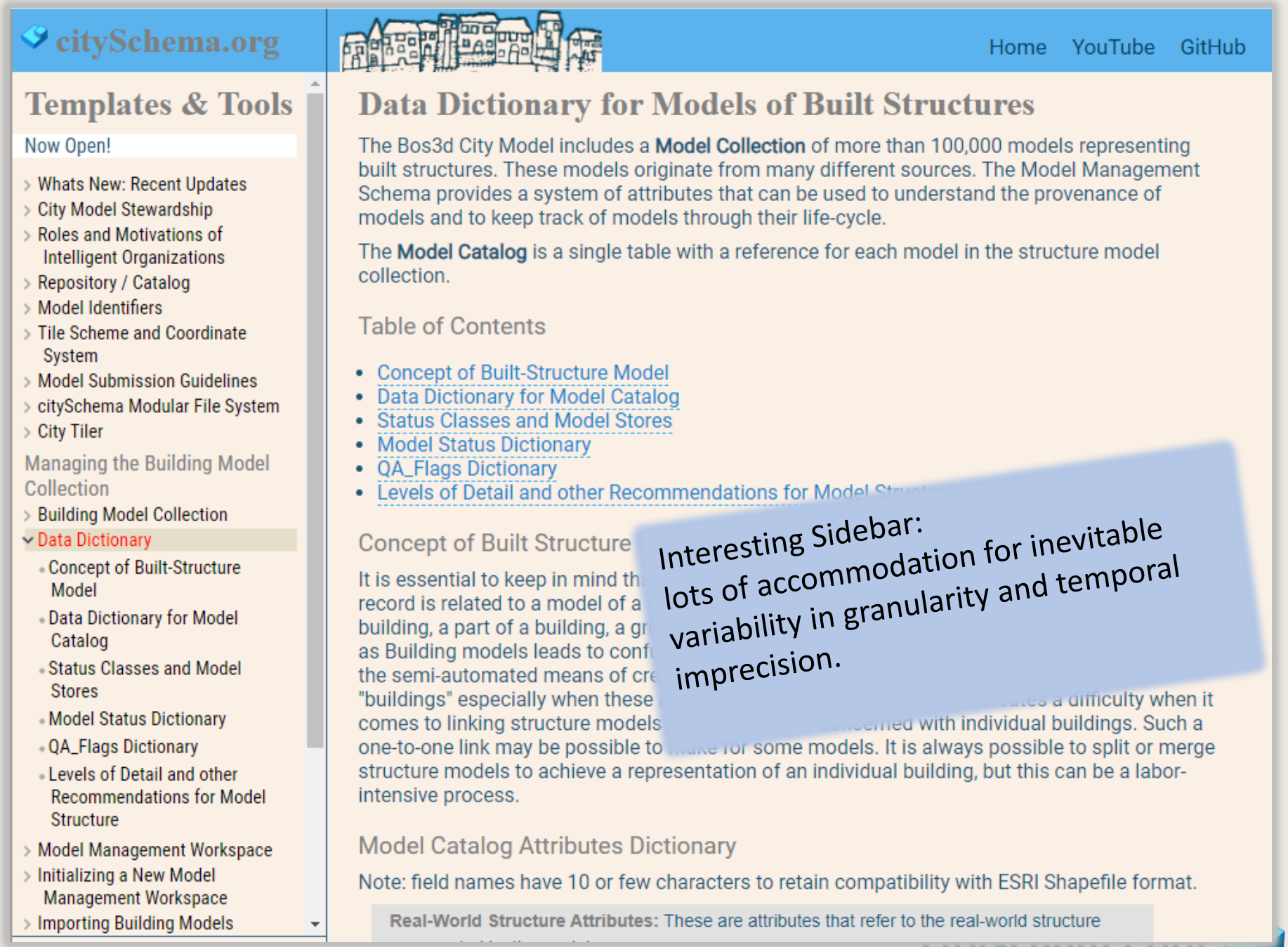
Attribute Families

- Unique Model ID
- Model Attributes
- Structure Attributes
- Geometric Attributes
- Reference Fields

Dates:

- Model Accession Date w/Attribution
- Survey Date w/Annotation
- Appear Date w/Annotation
- Disappear Date w/Annotation
- Last Edit Date w/Annotation

Many possibilities for visualization with time-slider.



Replicability Viewpoint

A focus of this conference is on the challenges of creating replicable geotemporal models. The primary motivation of the CitySchema.org project is to disseminate a ready-made data architecture that will enhance replicability of the model implementation across the following domains:

- **Among model contributors / Users of design tools**
- **Among neighboring municipalities and campuses**
- **Between application domains: Data Visualization / Wayfinding / Design / Historical**
- **Between Time periods**

Cross-Disciplinary / FlexibleViewpoints on Temporal Bracketing

In this version of this presentation, focused on geo-temporal data architectures, the next two slides will discussed out an interesting lesson learned about accommodating flexibility in terms of the definition of temporal windows for the existence of structures or models to support the level of interest or the limitations of knowledge among different user groups.

- **Historical Research**
- **Collection History (asset development)**

Notice that this is an example of an Abductive data model as discussed by Dr. Tsui in his keynote address!

Temporal Brackets: Historian vs. Collection Manager's Perspective

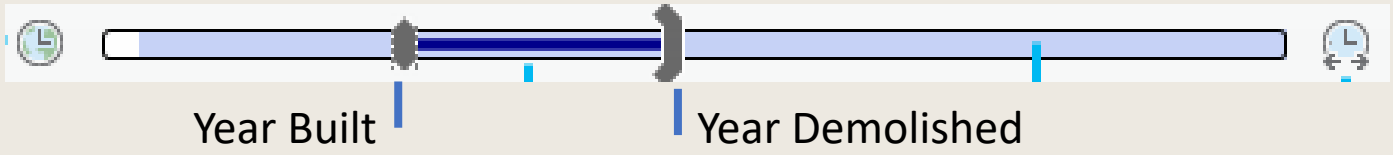
As a digital humanities project our first stab at defining temporal brackets was based on a Historian's Viewpoint on buildings as historical entities.

This ideal viewpoint presents practical problems from a research point of view. For many buildings it is not easy to learn the precise Year Built or Year Demolished. One may have this precise information for structures that a researcher is particularly concerned about.

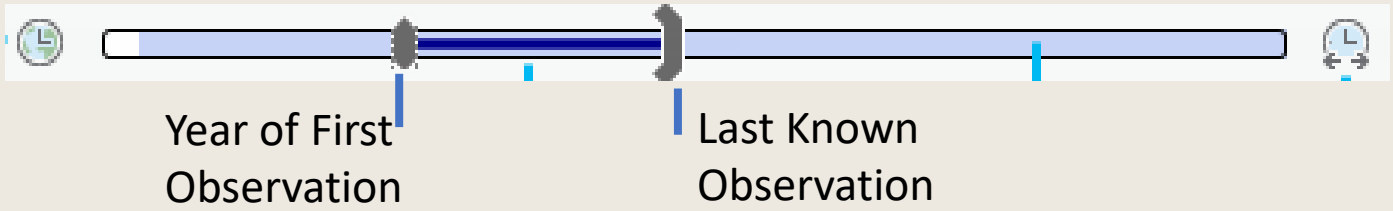
Most of the time, sources can tell you the date of the earliest recorded observation that the building existed in this location and the earliest observation that the structure is no longer there.

For the municipal data manager, there is not a strong motivation to do this sort of research. But a more "Collection" oriented viewpoint on brackets makes the preservation of historic al data automatic.

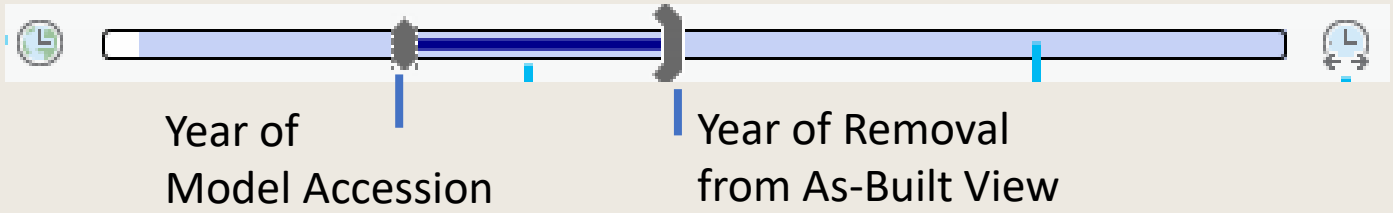
Historian Viewpoint
Ideal



Historian Viewpoint
Practical



Municipal Data Manger Viewpoint



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Automatic Capture of Temporal Brackets

In municipal data management it is not uncommon for data-sets to be updated by simply deleting old features when they are replaced by new observations.

The conceptual model behind citySchema temporal brackets provides a means of automatic recording of the time-stamps fro when models were admitted or removed from the As-Built view of the city.

Model Status clarifies the temporal frame that a model would appear:

- As-Built
- Historical
- Proposed

There are some interesting permutations on the temporal brackets for proposals that turned out to have not been built.

Status (Text)	**Historian and Collection Manager:** Status regards the Structure as **Current**, **Historical**, **Proposed**. Determines which view a model will appear or be suppressed.
Appear_Dt Date	**Historian:** Date of the latest observation or document that confirms the current value of Status. **Collection Manager:** The date that the model was admitted to the database. (Automatically Applied)
AppearSrc Text	**Historian:** Provides a reference to the observation or document and the date that confirms the Appear_Dt. **Collection Manager:** Reference to the date of the geometric measurement or other source material in the case of a hand-made model. Same as Model_Src attribute which is set whem models are admitted.
Disapp_Dt Date	**Historian:** Date of the earliest observation or document that confirms the current value of “Not there” Status. **Collection Manager:** The date that the model was removed from the As-Built view of the model. (Automatically Applied)
DisappSrc Text	**Historian:** A short reference to the document that established the Dissap_Dt. **Collection Manager:** Time-stamp for status change to “History” (Automatically Applied)

Replicability and Temporal Utility
The Archival Preservation Aspect

Given the focus of this conference on Replicability in Geo-Temporal data models, The next slides will highlight an important aspect of this problem;

In order to assure replicability of our models for geo-temporal research, it is necessary that the model collection is accessible across time and in formats that are likely to be useful in a diverse software ecosystem for the indefinite future.

One aspect of this project is related to storage of model collection assets in validated stable open formats.

Another is the packaging of the model collection as an Archive Repository. A key take-away for this short presentation is a recommendation of the **Reference Model for Open Archival Information Systems OAIS**.

OAIS: Roadmap for Cross-disciplinary, Collaborative Data Development

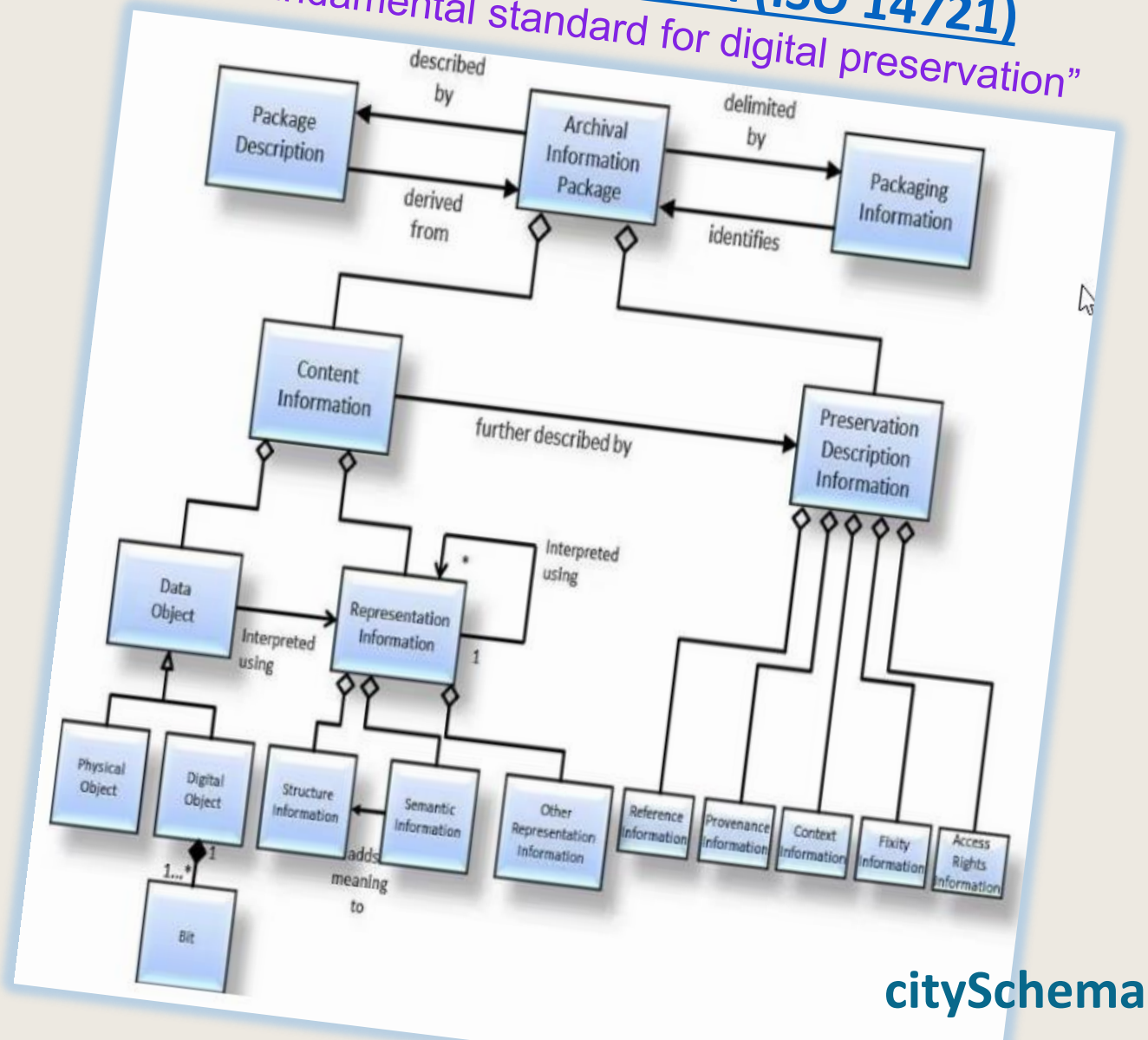
The Reference Model for Open Archival Information Systems was originally developed for NASA to guide the preservation and retrieval of information developed for very large engineering projects.

Archival Information Packages that bundle data with necessary metadata and catalog information.

The citySchema Tiled Download system with its repository catalog is based on OAIS principles.

OAIS Reference Model (ISO 14721)

"The fundamental standard for digital preservation"



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The Open Format Repository Catalog

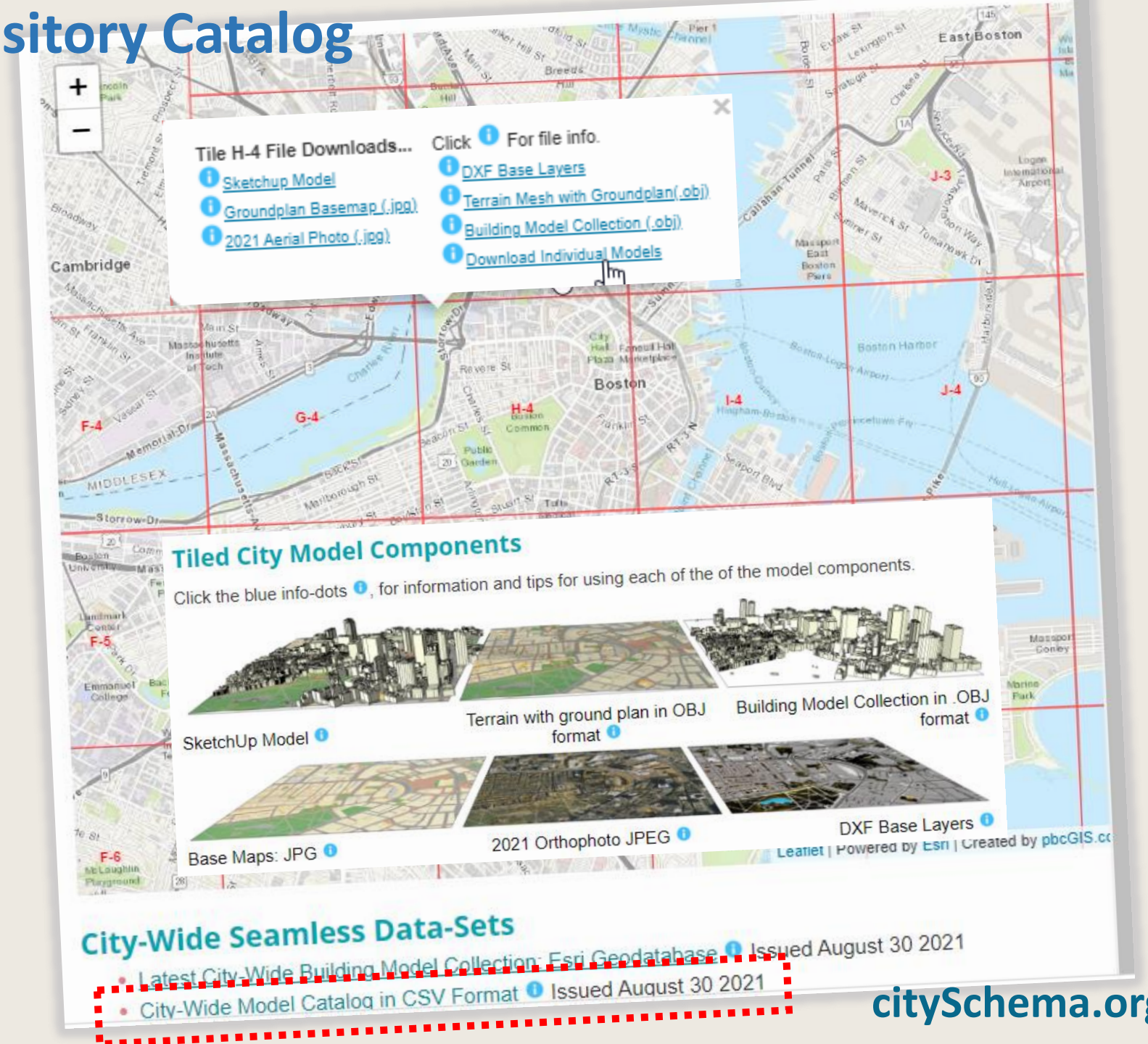
[Boston Download site]

[Cambridge Download Site]

OAIS Design:

- Systematic addressing of individual model components
- Easy Harvesting
- Updating parallel models
- Off-Line use

The template can easily be used for small projects to publish and share their project resources.
[github.com/CitySchema/repository-catalog]



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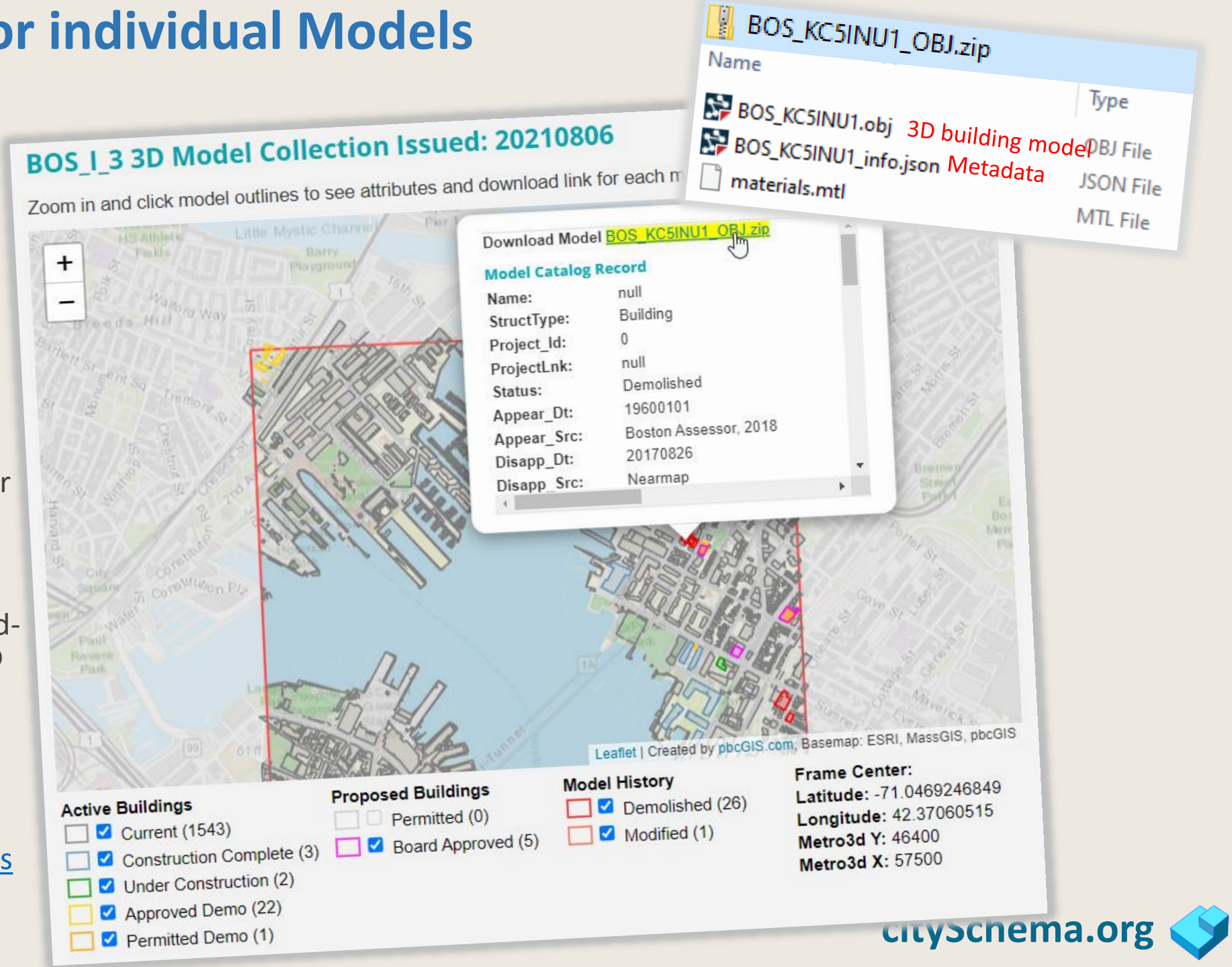
Exchange Package for individual Models

- OBJ format: An old, open, stable simple format. Capable of being validated and transformed with open-source tools.
- Each model packaged with JSON Metadata that carries all schema attributes
- Each model is named with its unique ID (a random 15-character string pre-pended with 3-digit origin code.
- Each model has a unique URL end-point made from the Project web server/3d_download/Tile-ID/Model-ID
- Format guidelines for model submissions: www.cityschema.org/submissions



Entire Repository Catalog is an OAIS Archival Information Package: Simple HTML with JavaScript

Fully self-contained Data, Metadata, Catalog, clickable map finding aids.

Documentation:
www.cityschema.org/repocat

Working Demo:
github.com/CitySchema/repository-catalog

Requires only a browser – no web server required

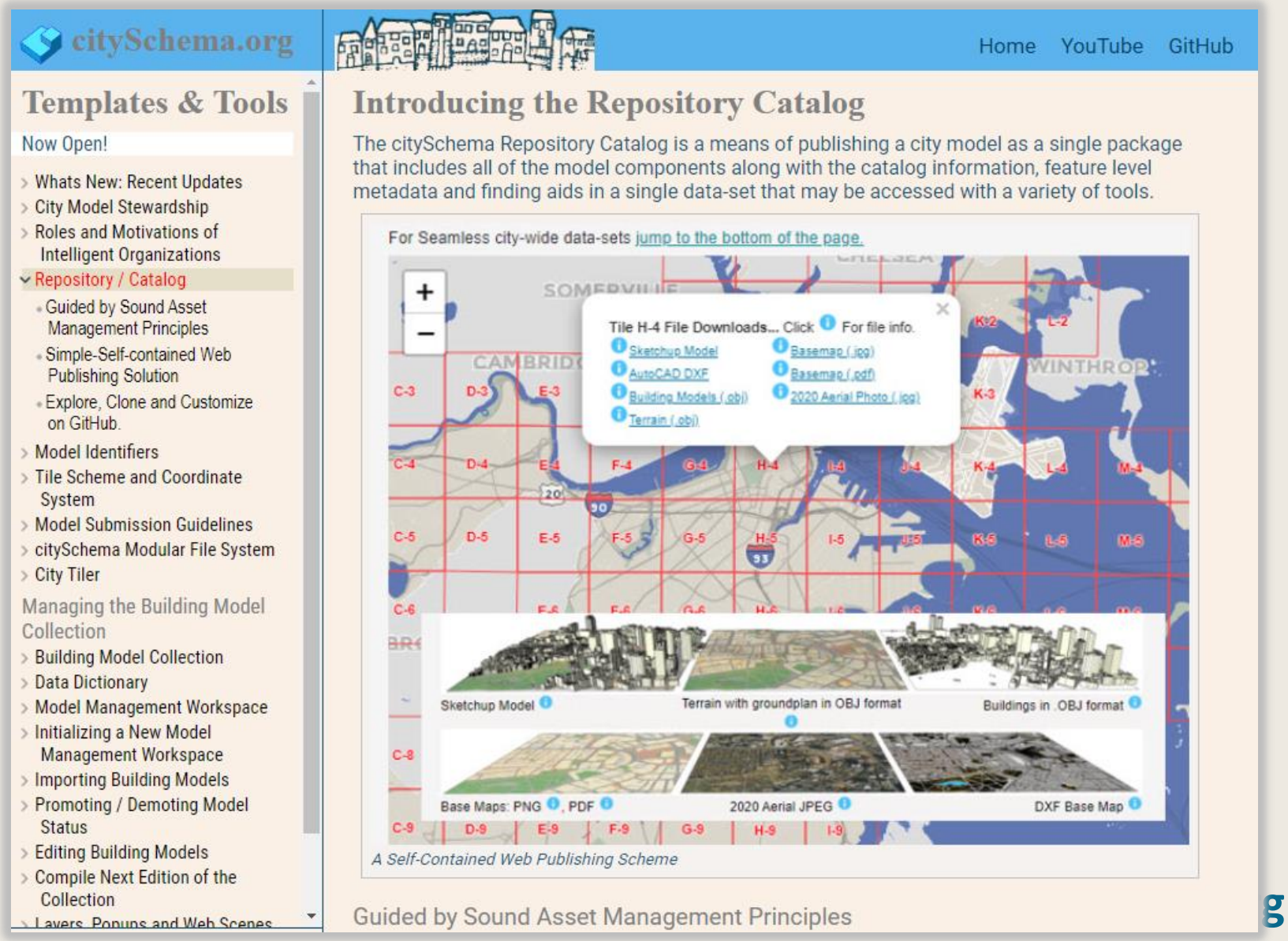
Easy to install on any web server. Just copy to a web-accessible folder.

Works just as well on a local file-system

May be harvested by the Internet Archive

Shared via bit-torrent

Archived anywhere as a zip file.



To Do

The models are ready to go for cool digital humanities projects!

Development opportunities for courses, IAP Hackathons and Open Source Demo projects

- ✓ Blender
- ✓ ThreeJS viewer for tiled models
- ✓ Time-Slider Apps
- ✓ Export for CesiumJS: Open-Source Browser Based Google Earth

citySchema.org is actively looking for new collaborators & Partners. Talk to us!

Acknowledgements

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Cambridge GIS

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- Katie Grillo: 3D GIS Analyst

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