

# citySchema.org

## 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)

*A DH Project that began at the Harvard Design  
School and burst into the exciting world of day-to-  
day municipal administration and Open Data*

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Slides available now at  
[cityschema.org/whatsnew](http://cityschema.org/whatsnew)



# Hacking Spatially and Temporally Extensive Design Data at the GSD\*

\*Harvard Graduate School of Design

In 1993, As a recent MIT Course 11 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 hierachal, 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.



# Intelligent Organizations Re-Use Their Knowledge!

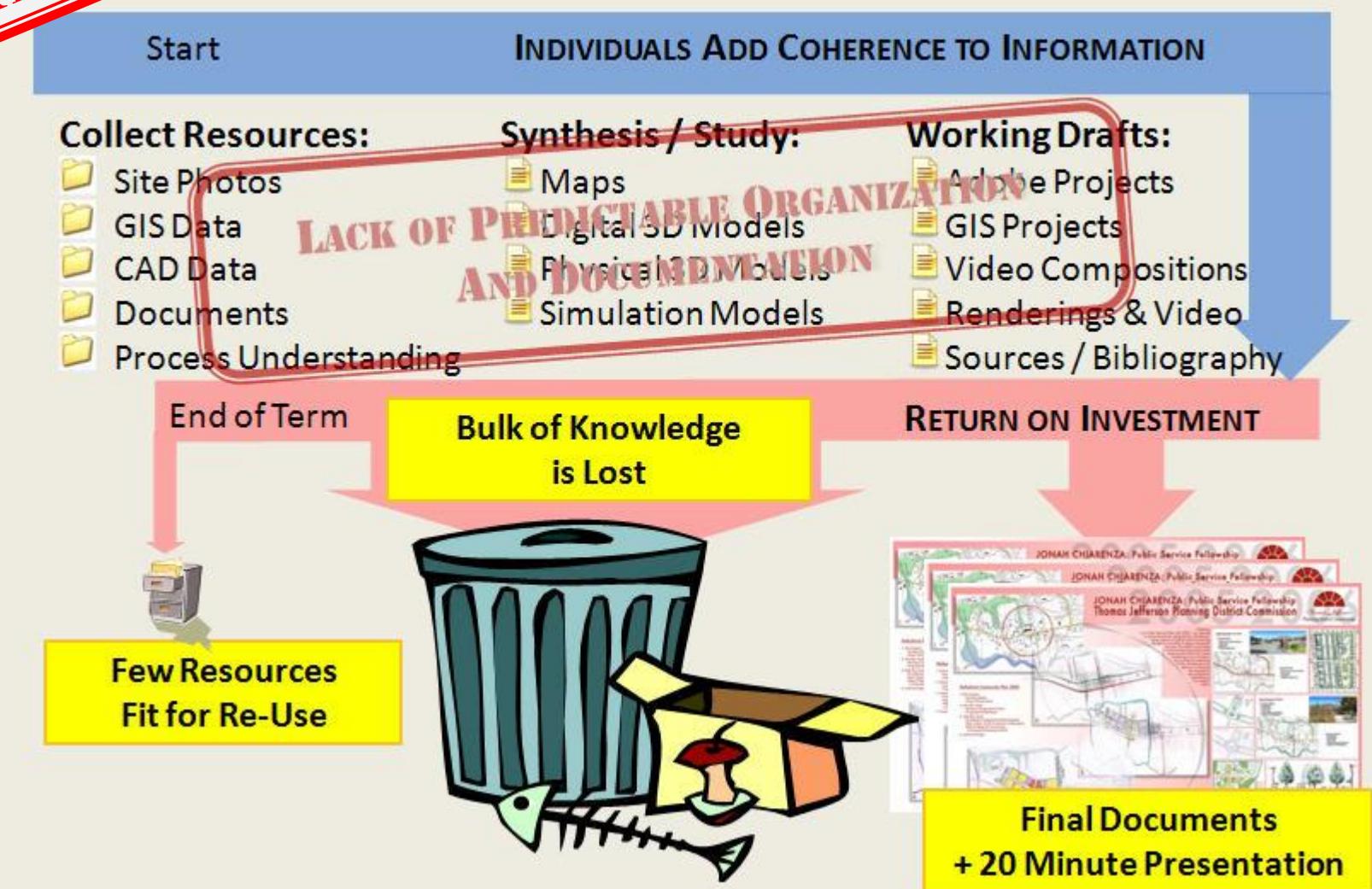
Actual

Information Lifecycle in Design (Business as Usual)

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

Collect, Rinse Repeat!

A habit that most of them will carry forward into their professional lives.

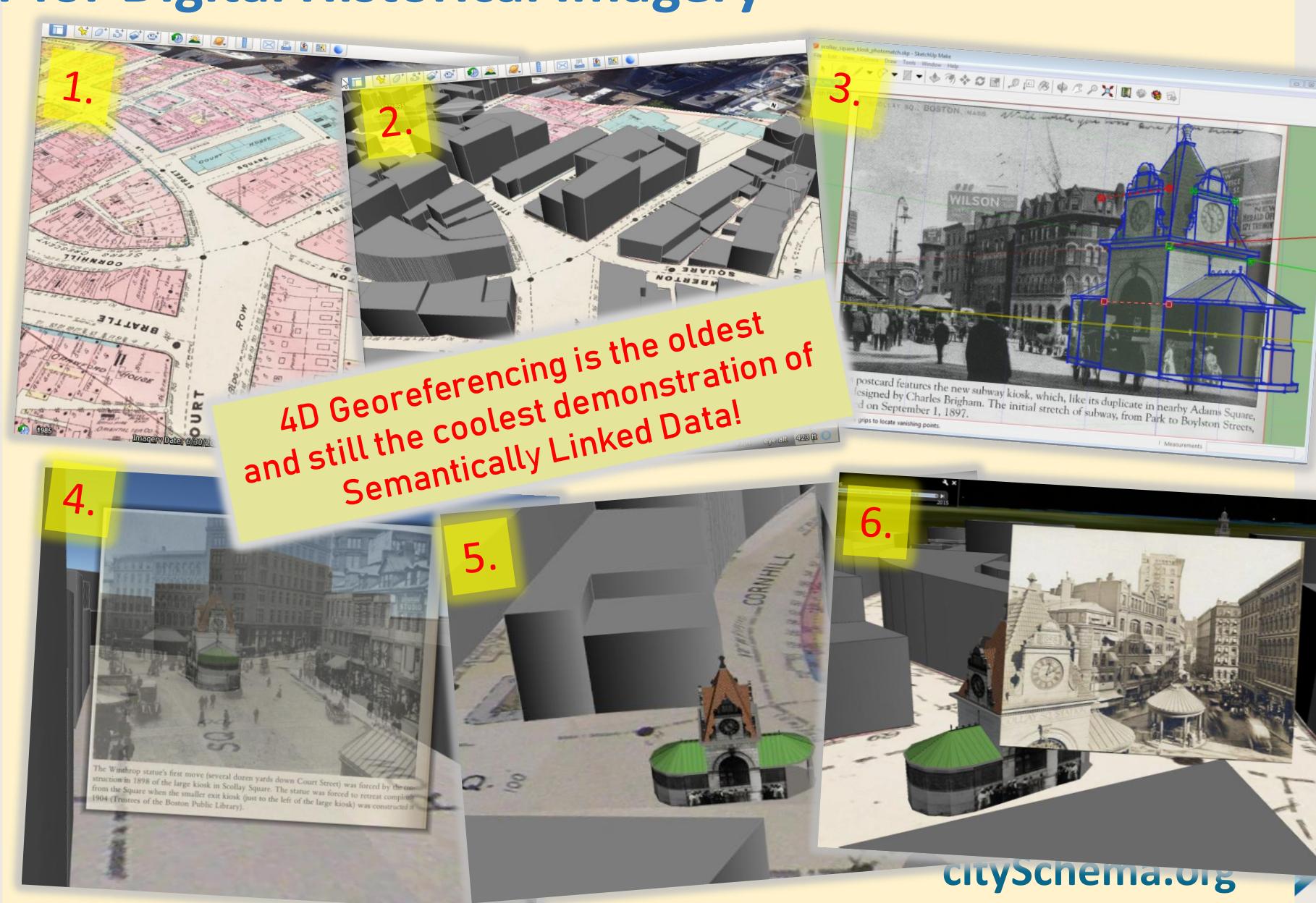


# City Models demonstrate the power of 4D Referencing as a value- multiplier for Digital Historical Imagery

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. Use Building location to contextualize more photographs.

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!**



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.)

### 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.



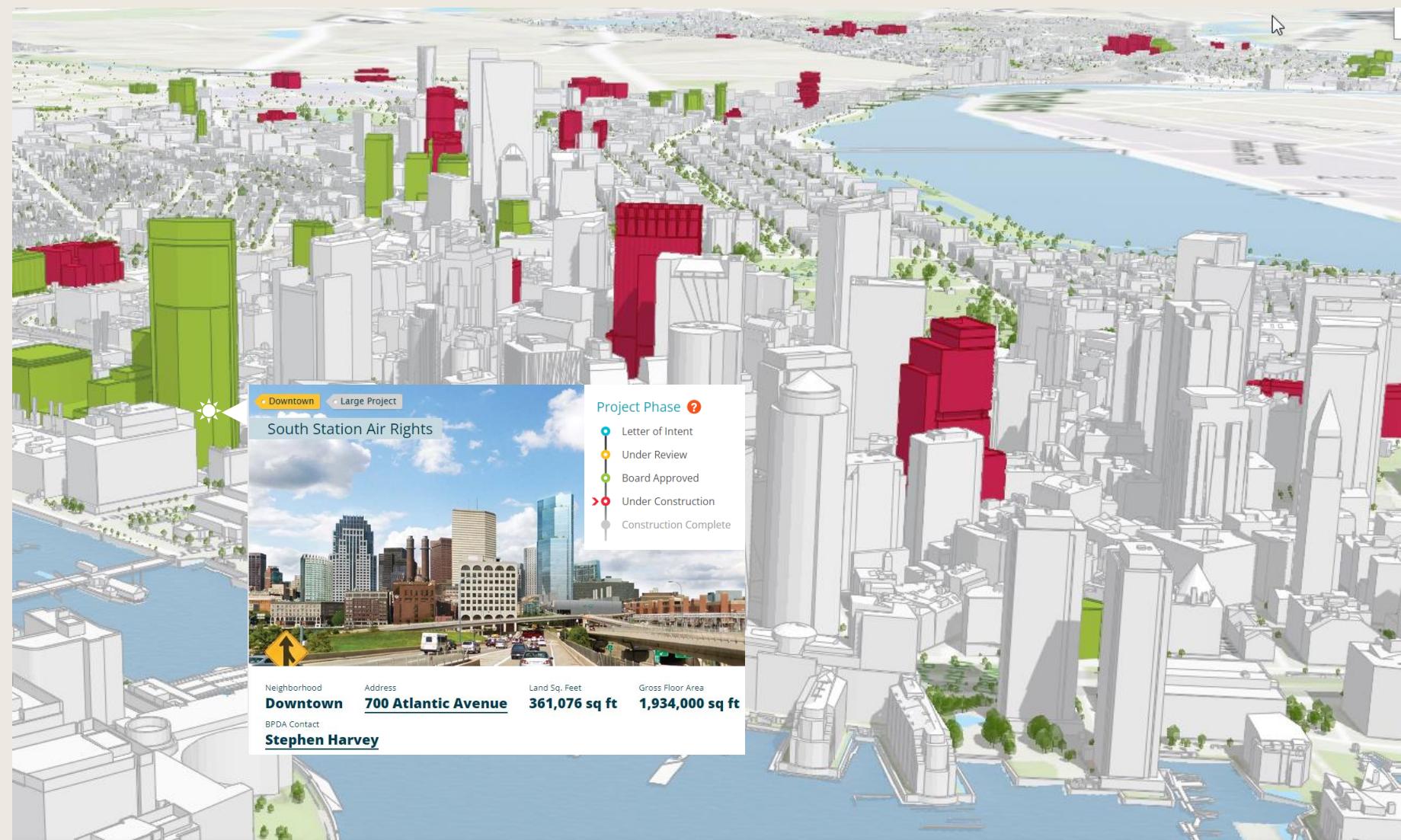
# Fly-Through Tour of the Boston 3d Model

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.



# 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

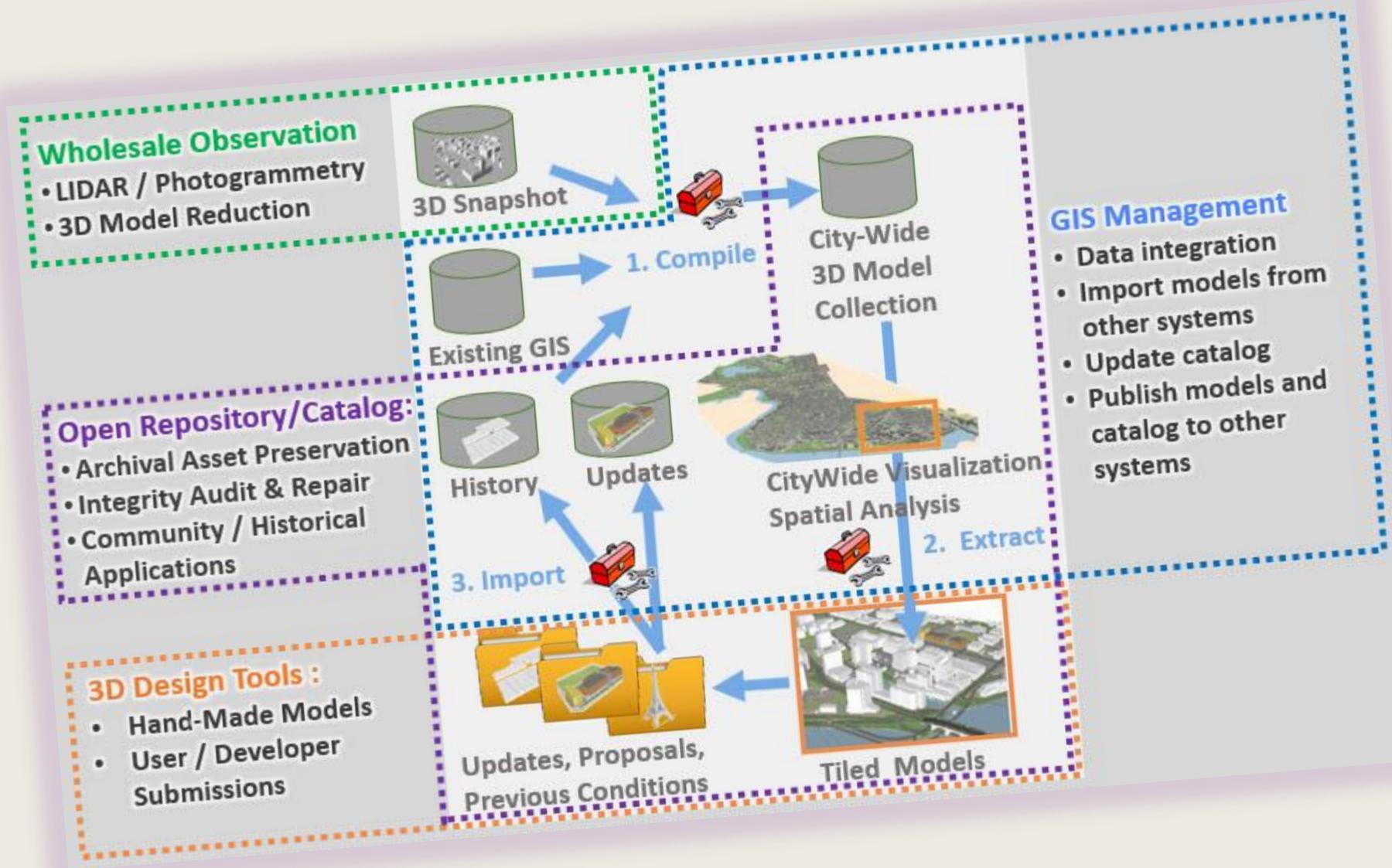
Anticipate potential use-cases that  
are not currently seen as necessities

- 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.**

# An Ecosystem of Data Exchanges and Specialized Transformations`

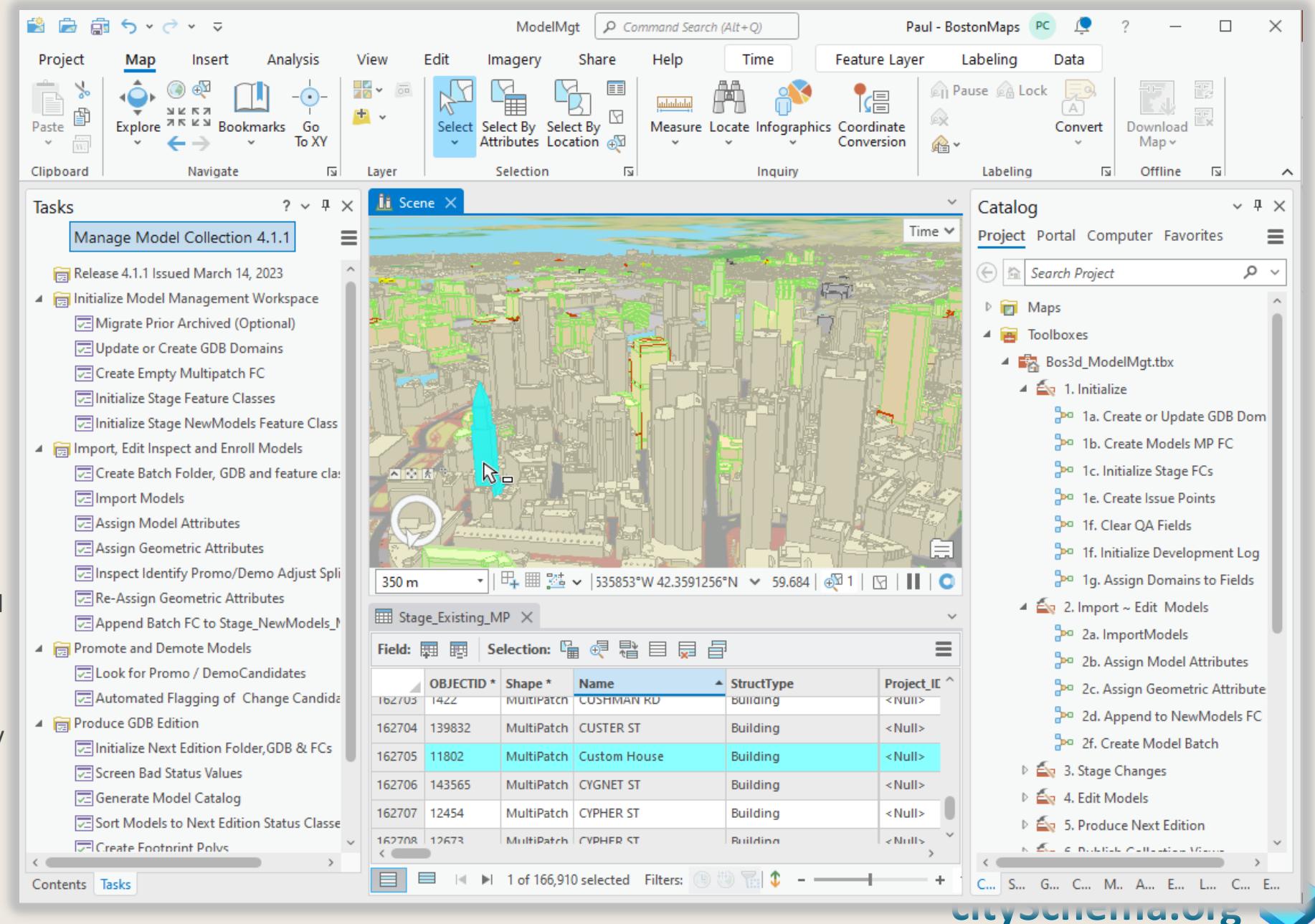
All of these tools and workflows are shared and documented at

[www.Github.com/cityschema](https://www.github.com/cityschema)  
[www.cityschema.org](https://www.cityschema.org)



# Model Development and Management Tools for ArcGIS Pro

- Tools:  
[www.github.com/cityschema](http://www.github.com/cityschema)
- Documentation:  
[www.cityschema.org/mgmt\\_project](http://www.cityschema.org/mgmt_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)



# 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](http://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.



[Home](#) [YouTube](#) [GitHub](#)

## Templates & Tools

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- > Whats New: Recent Updates
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- > Repository / Catalog
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- > Tile Scheme and Coordinate System
- > Model Submission Guidelines
- > citySchema Modular File System
- > City Tiler

Managing the Building Model Collection

- > Building Model Collection
- > **Data Dictionary**
  - Concept of Built-Structure Model
  - Data Dictionary for Model Catalog
  - Status Classes and Model Stores
  - Model Status Dictionary
  - QA\_Flags Dictionary
  - Levels of Detail and other Recommendations for Model Structure
- > Model Management Workspace
- > Initializing a New Model Management Workspace
- > Importing Building Models

## Data Dictionary for Models of Built Structures

The Bos3d City Model includes a **Model Collection** of more than 100,000 models representing built structures. These models originate from many different sources. The Model Management Schema provides a system of attributes that can be used to understand the provenance of models and to keep track of models through their life-cycle.

The **Model Catalog** is a single table with a reference for each model in the structure model collection.

### Table of Contents

- Concept of Built-Structure Model
- Data Dictionary for Model Catalog
- Status Classes and Model Stores
- Model Status Dictionary
- QA\_Flags Dictionary
- Levels of Detail and other Recommendations for Model Structure

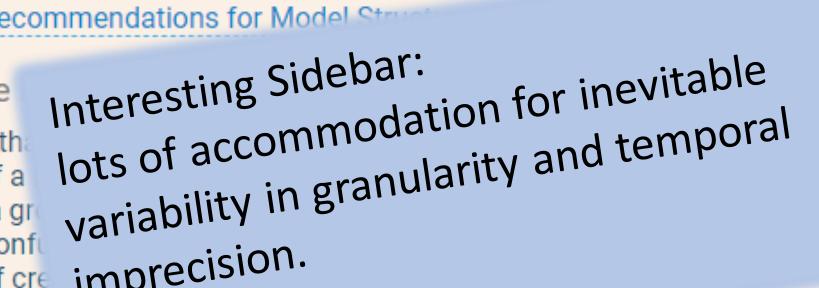
#### Concept of Built Structure

It is essential to keep in mind that a record is related to a model of a building, a part of a building, a group of buildings, or a group of parts of buildings. As Building models leads to confusion, the semi-automated means of creating "buildings" especially when these come to linking structure models, creates a difficulty when it comes to linking structure models to individual buildings. Such a one-to-one link may be possible to make for some models. It is always possible to split or merge structure models to achieve a representation of an individual building, but this can be a labor-intensive process.

#### Model Catalog Attributes Dictionary

Note: field names have 10 or few characters to retain compatibility with ESRI Shapefile format.

**Real-World Structure Attributes:** These are attributes that refer to the real-world structure



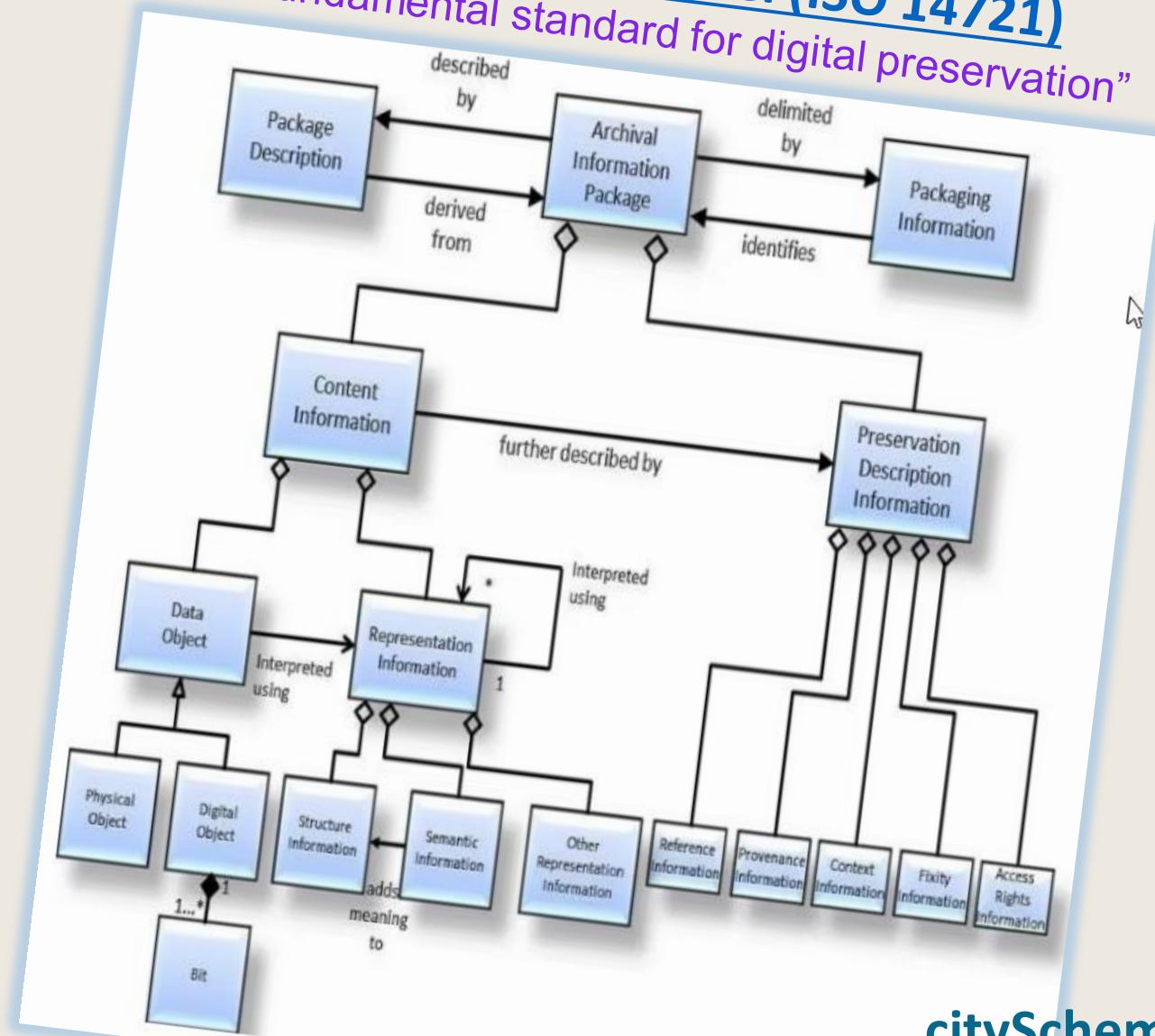
# OAIS: Roadmap for Cross-disciplinary, Collaborative Data Development

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”



# The Open Format Repository Catalog

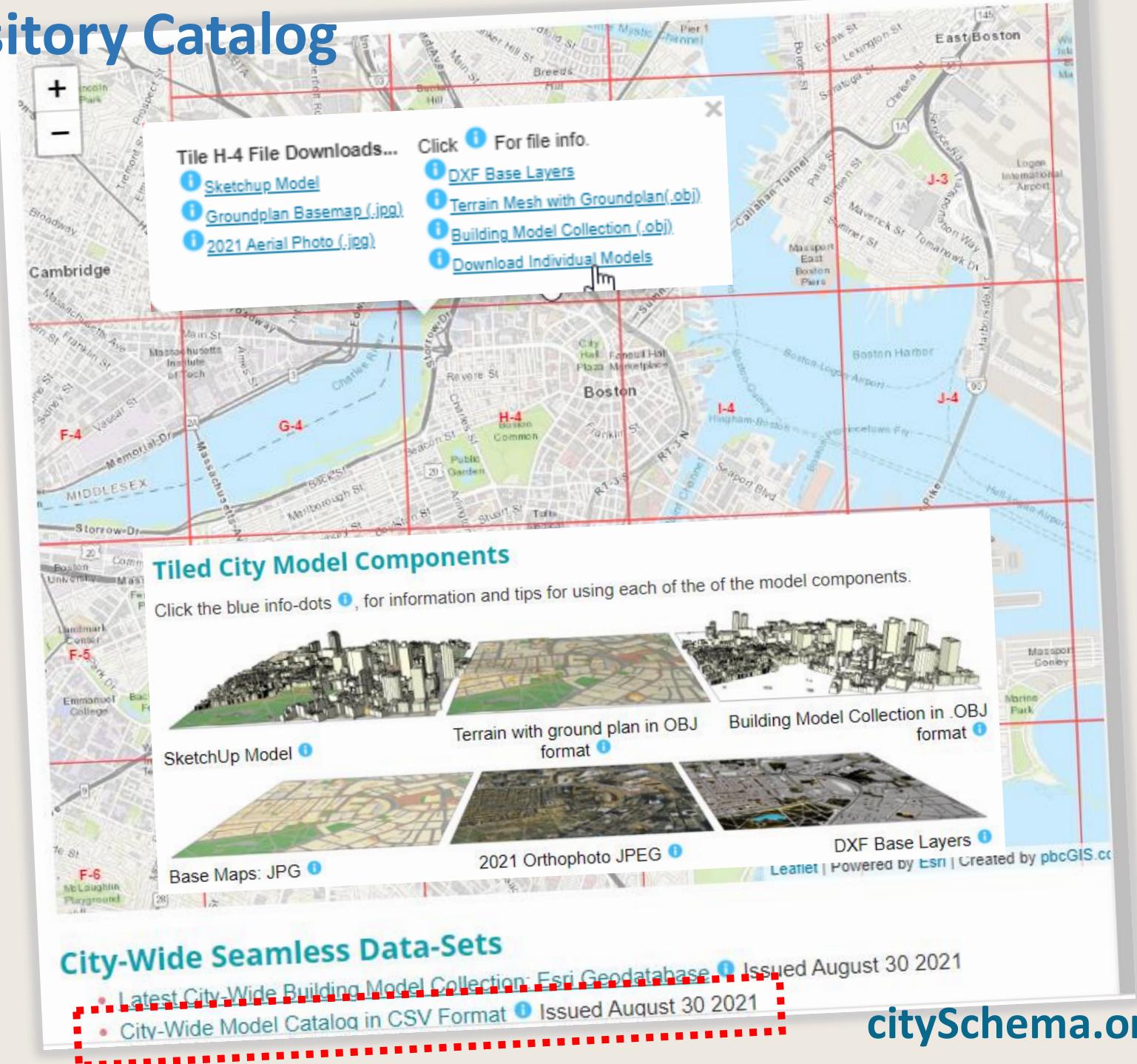
[Boston Download site](#)

[Cambridge Download Site](#)

## DAIS Design:

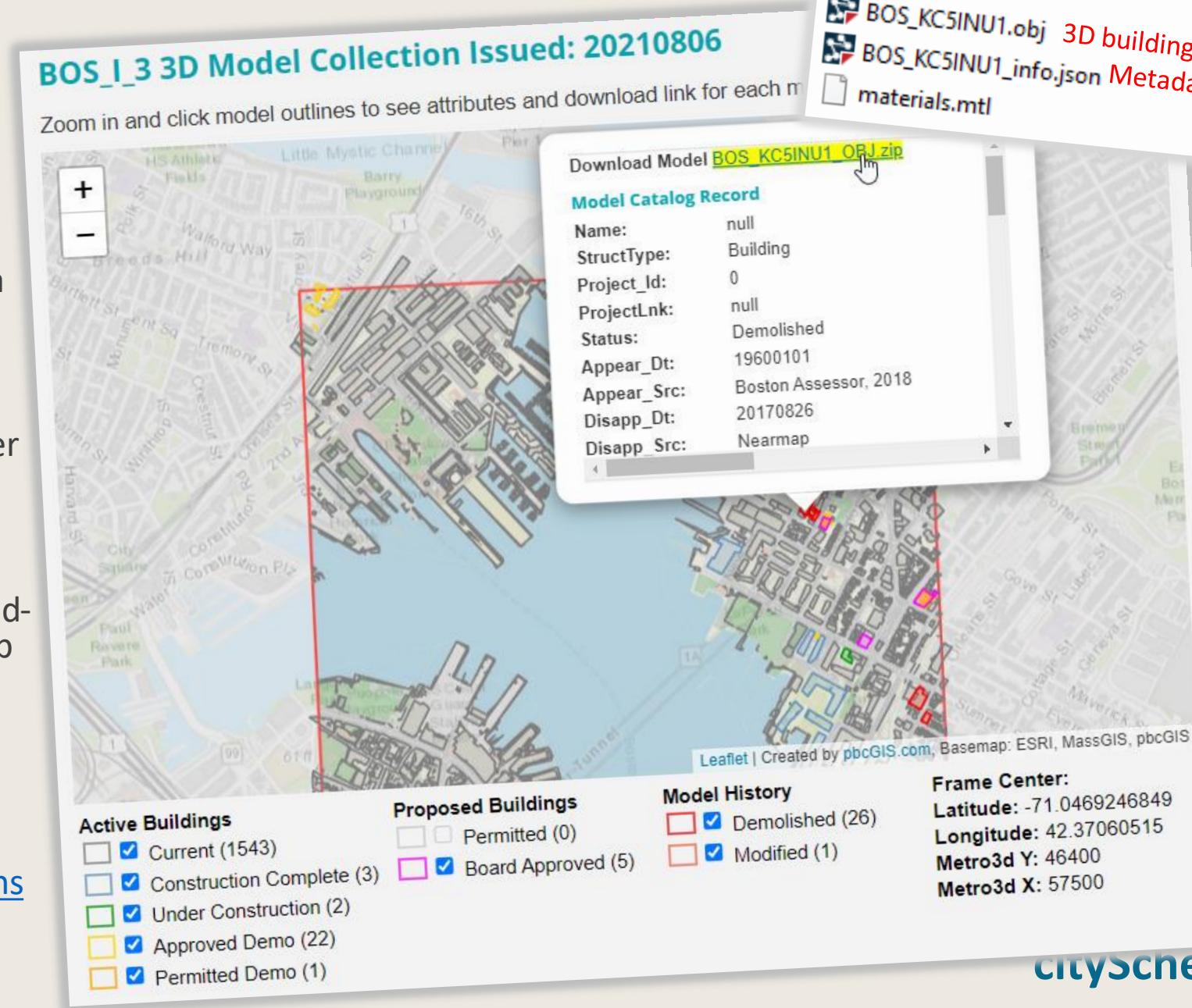
- Systematic addressing of individual model components
- Easy Harvesting
- Updating parallel models
- Off-Line use

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



# 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 endpoint made from the Project web server/3d\_download/Tile-ID/Model-ID
- Format guidelines for model submissions:  
[www.cityschema.org/submissions](http://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](http://www.cityschema.org/repoCat)

Working Demo:

[github.com/CitySchema/repository-catalog](https://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.

The screenshot shows the citySchema.org website's repository catalog interface. At the top, there is a navigation bar with the citySchema.org logo, a cityscape icon, and links for Home, YouTube, and GitHub. Below the navigation bar, the title "Introducing the Repository Catalog" is displayed. A descriptive text explains that the catalog is a means of publishing a city model as a single package, including all model components, catalog information, feature level metadata, and finding aids in a single data-set accessible via tools. The main content area features a map of Cambridge, MA, divided into a grid with labels like C-3, D-3, E-3, F-4, G-4, H-4, I-4, J-4, K-4, L-4, M-4, C-5, D-5, E-5, F-5, G-5, H-5, I-5, J-5, K-5, L-5, M-5, C-6, D-6, E-6, F-6, G-6, H-6, I-6, J-6, K-6, L-6, M-6, C-7, D-7, E-7, F-7, G-7, H-7, I-7, J-7, K-7, L-7, M-7, C-8, D-8, E-8, F-8, G-8, H-8, I-8, J-8, K-8, L-8, M-8, C-9, D-9, E-9, F-9, G-9, H-9, I-9, J-9, K-9, L-9, M-9. A callout box over one of the map tiles provides detailed information about tile H-4 file downloads, including links for Sketchup Model, AutoCAD DXF, Building Models (.obj), and Terrain (.obj). Below the map, there are three 3D building models labeled "Sketchup Model", "Terrain with groundplan in OBJ format", and "Buildings in .OBJ format". At the bottom of the map area, there are links for "Base Maps: PNG", "PDF", "2020 Aerial JPEG", and "DXF Base Map". A footer at the bottom of the page states "A Self-Contained Web Publishing Scheme" and "Guided by Sound Asset Management Principles".

## 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

Boston Planning and Development Agency

- Alla Ziskin, GIS Manager
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- John Cowart, 3D GIS Analyst
- Te-Ming Chang Urban Design Technology Group

Cambridge GIS

- Jeff Amero, GIS Manager
- Katie Grillo: 3D GIS Analyst

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