3D City Model Web Reference Service

- Representing the built environment as it changed or may be changed through time.
- Linking 3D models from the world of modeling with municipal data infrastructure
- Problems for data modeling encountered in several years of implementation in actual municipal infrastructure

Paul B. Cote Geographic Information Services
www.pbcGIS.com

cultivating spatial intelligence™

Presented at the Virtual Workshops on City Data Models sponsored by ISO/IEC JTC1 WG 11 on Smart Cities and the University of Toronto School of Cities

Background

20 years as GIS Specialist and Lecturer at the Harvard University Graduate School of Design

Thread Architect in 2007-2008 for the OGC Testbed for Integrating CAD GIS and BIM (OWS4)

15 years experience implementing municipal infrastructure for 4D City Modeling for cities of Boston and Cambridge, Massachusetts, USA

3D Reference Map, Web Feature Service

Visualization and Reference is Essential for understanding the context of:

- Sensor streams
- Analytical model feedback –
- eg: Shot-Spotter
- Emergency planning
- Routine planning concepts

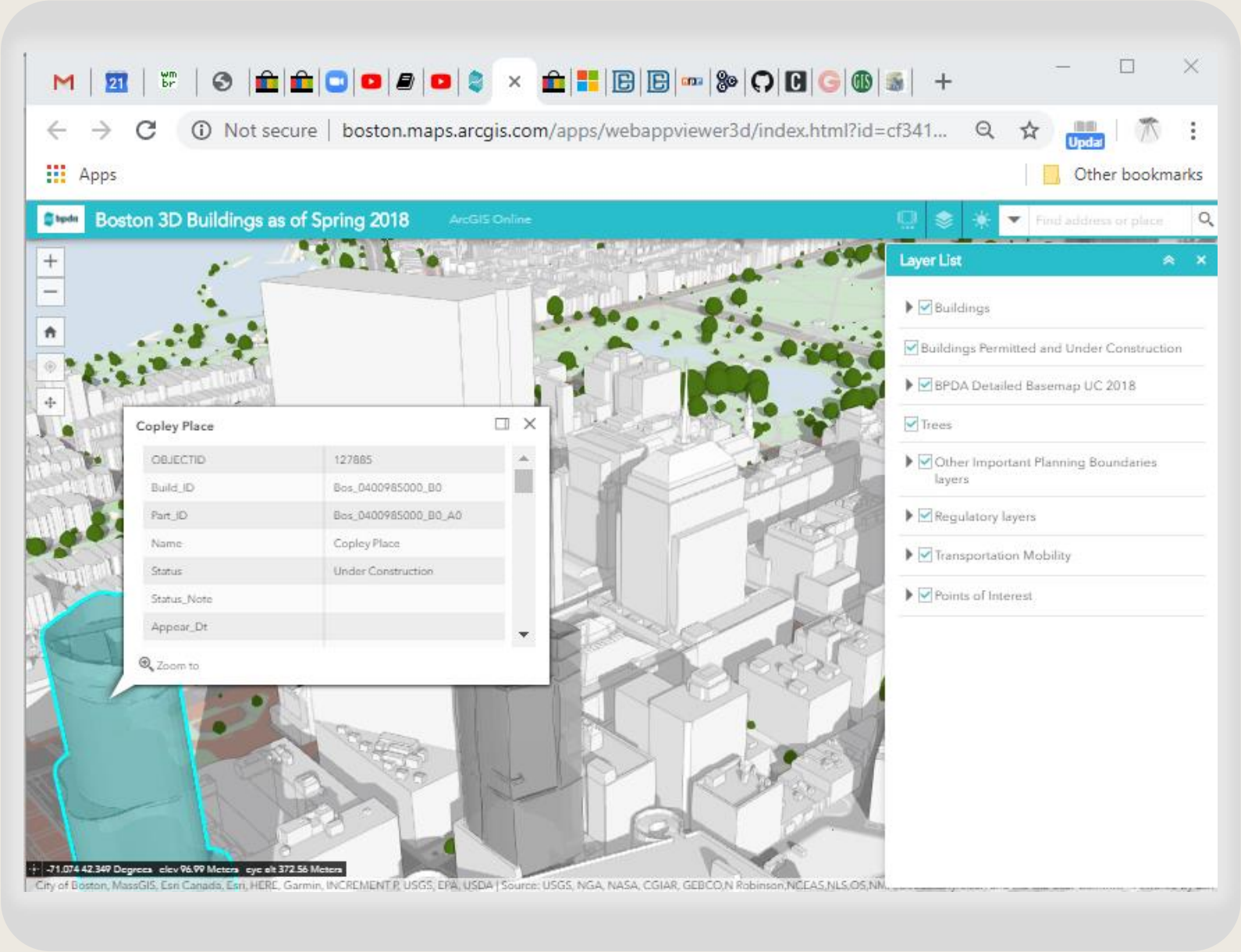
Mouse Rollover or Click in 3d interface returns links to administrative information

(Desired)

- Building ownership and use
- Current and future building permits
- Historical information

Links

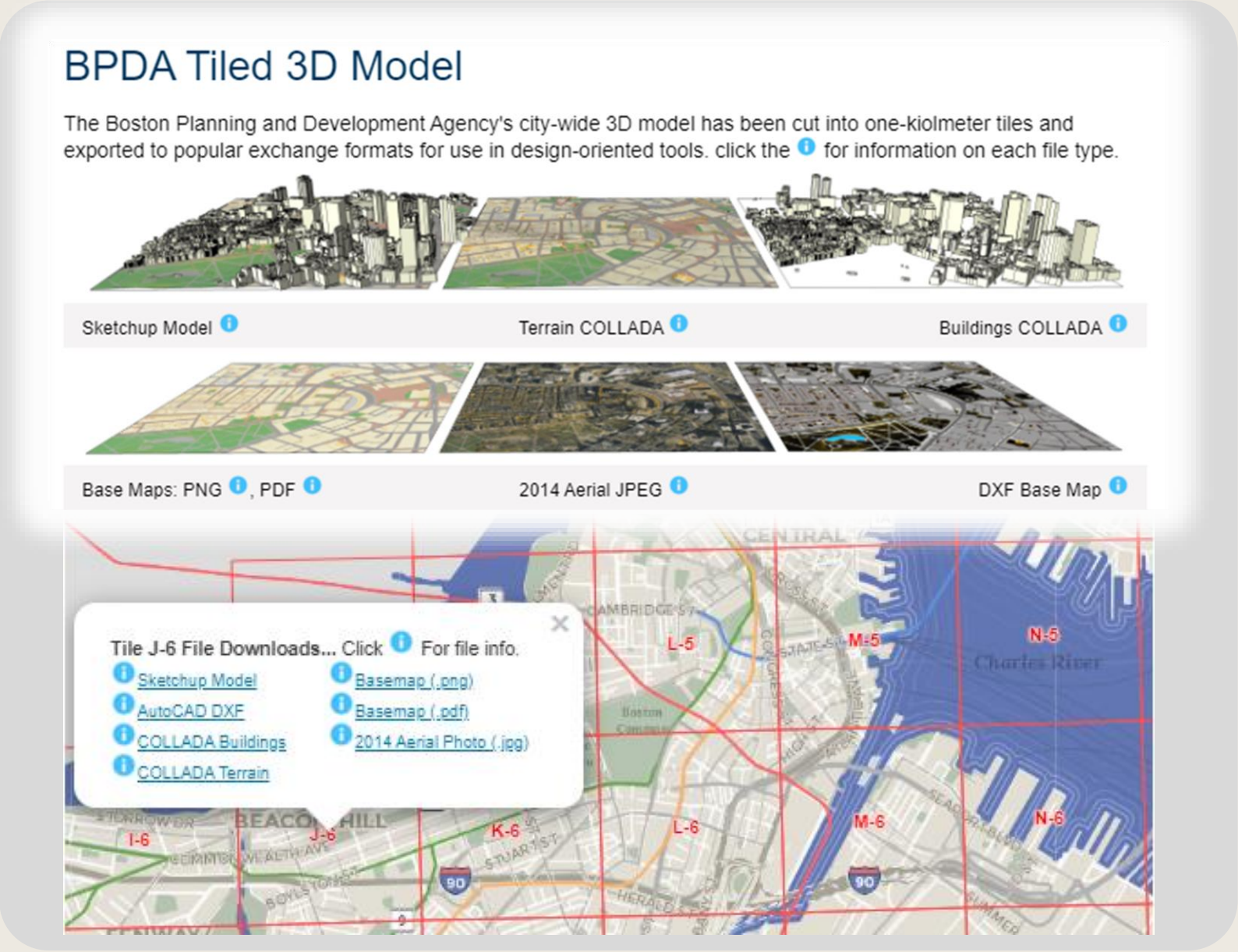
- Boston Model Viewer
- Cambridge Model Viewer



Base Model Available in CAD Formats

Provide a common operating picture for area developers and architects:

- Downloadable model includes
- Detailed terrain
- Vector and raster groundplan
- Current and approved buildings



Links

- [Boston Model Download]
- [Cambridge Model Download]

Collect, Manage and Share Georeferenced Building Models

Working with Architectural community on exchange formats and workflows

GIS Export for CAD

- COLLADA
- DXF
- Mesh and Raster Terrains

CAD Export for GIS

- COLLADA
- KMZ

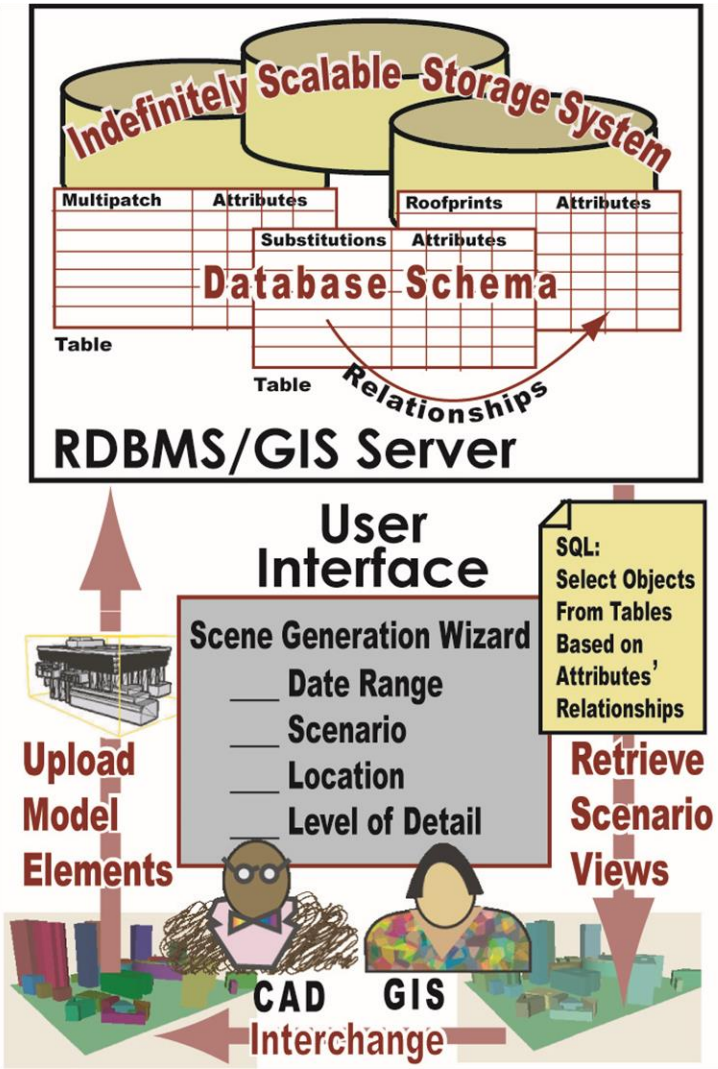
Boston has an In-House Digital Model Maker

- Creates models of all projects subject to design review
- The boston system maintains a history of proposal revisions.

Developers and review agencies are not enthusiastic adopters.

Interoperability is a big issue

- Levels of detail
- Georeferencing
- Support for Exchange Standard (KMZ would be great)



Cambridge Architectural Survey and History

Diigitizing Historical Documents about Buildings

- Photos
- Systematic building and street inventories
- Articles, Essays, Ephemera
- Official documents

All resources are georeferenced

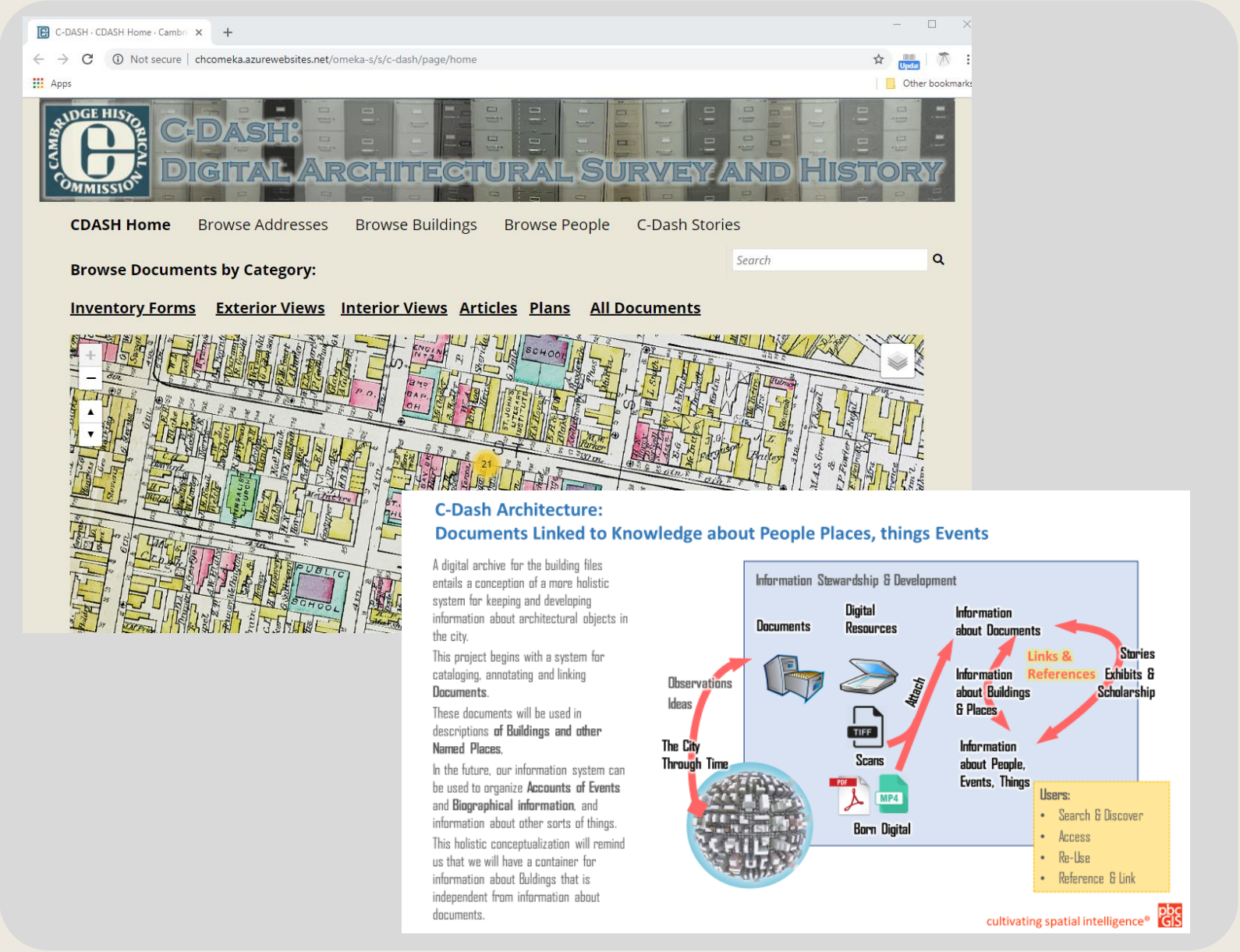
Current work: building Linked Data Infrastructure

- Based on Omeka-S

Links:

[Omeka-S pilot site]

[Project slideshow]



Challenge: Building Identification in 3D Reference Map

Web3d mouse clicks and roll-overs should retrieve information from:

Assessor's database

- Current and historic building ownership and use

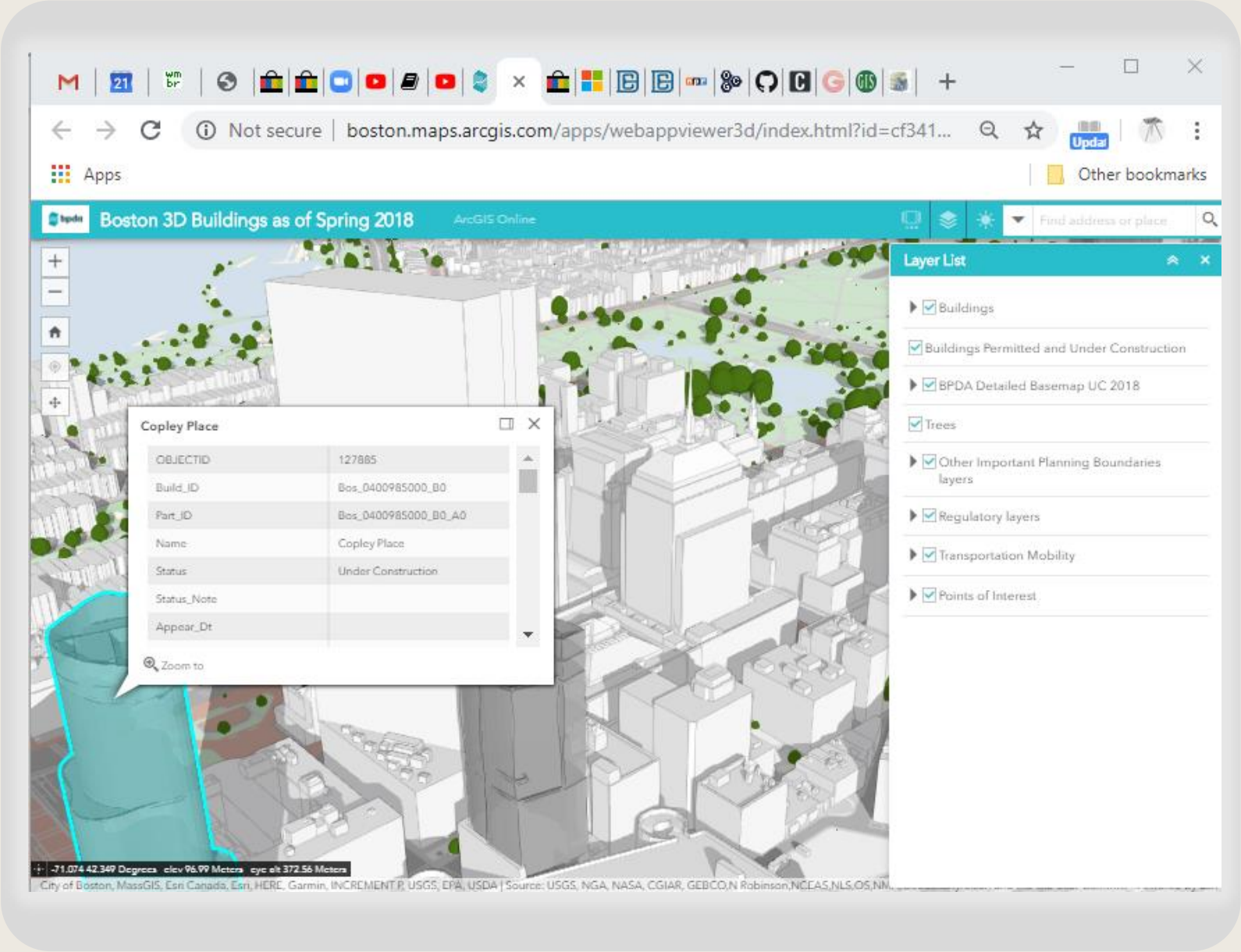
Inspectional services

- Current and future building status

Historical Documents

Architectural Review Status

- Alternative future scenarios



Challenge: Building Identification and Cardinality with Models

What is a Building?

- There are many agencies in the city with concern for managing building information.
- The tax assessor, for one, jas records rerlated to the taxation of property, and keeps information associated with individual buildings

Limitations of Photogrammetry

- Photogrammetric techniques are not capable of “seeing” the distinctions that are considered by the tax assessor
- Especially where buildings are touching eachother.

Buildings have Parts

- Ehen it comes to representing buildings in three dimensions and in terms of changes over time, it is very useful to have a data model that allows for the possibilitiy that a building can have parts
  - Parts that have different uses
  - Parts that have different heights
  - Parts that have different built and demolition dates

Modes of geometric representation have different degrees of Chunkiness, and different technical ease or difficulty with regard to splitting.

- True 3d Models are very difficult to split
- Polygon footprints are relatively easy to split, even with automated GIS techniques.

Address	BldgNur	PropertyClass	Zoning	GISID	Owner_Name	Condition_YearBuilt	PID	PropertyTaxAmount
219-221 Monsignor...	1	HOTEL	SD-1	7-115	MONSIGNOR HOTEL,...	2014	3	389041.82
225 Monsignor Obrie...	1	MANUFACTURING	SD-1	7-29	EASTMAN BROOK LL...	1920	5	82651.97
187-197 Monsignor...	1	HOTEL	SD-1	7-31	NATRAJ HOSPITALIT...	2002	6	357127.68
199 Monsignor Obrie...	1	WAREHOUSE	SD-1	7-34	FAHIMIAN, EDWARD...	1870	7	31630.3
263 Monsignor Obrie...	1	WAREHOUSE	SD-1	7-35	PREVITE, ANTHONY...	1983	8	26766.93
241 Monsignor Obrie...	1	GAS-STATION	SD-1	7-37	PECTEN PROPERTIES,...	1956	9	45942.23

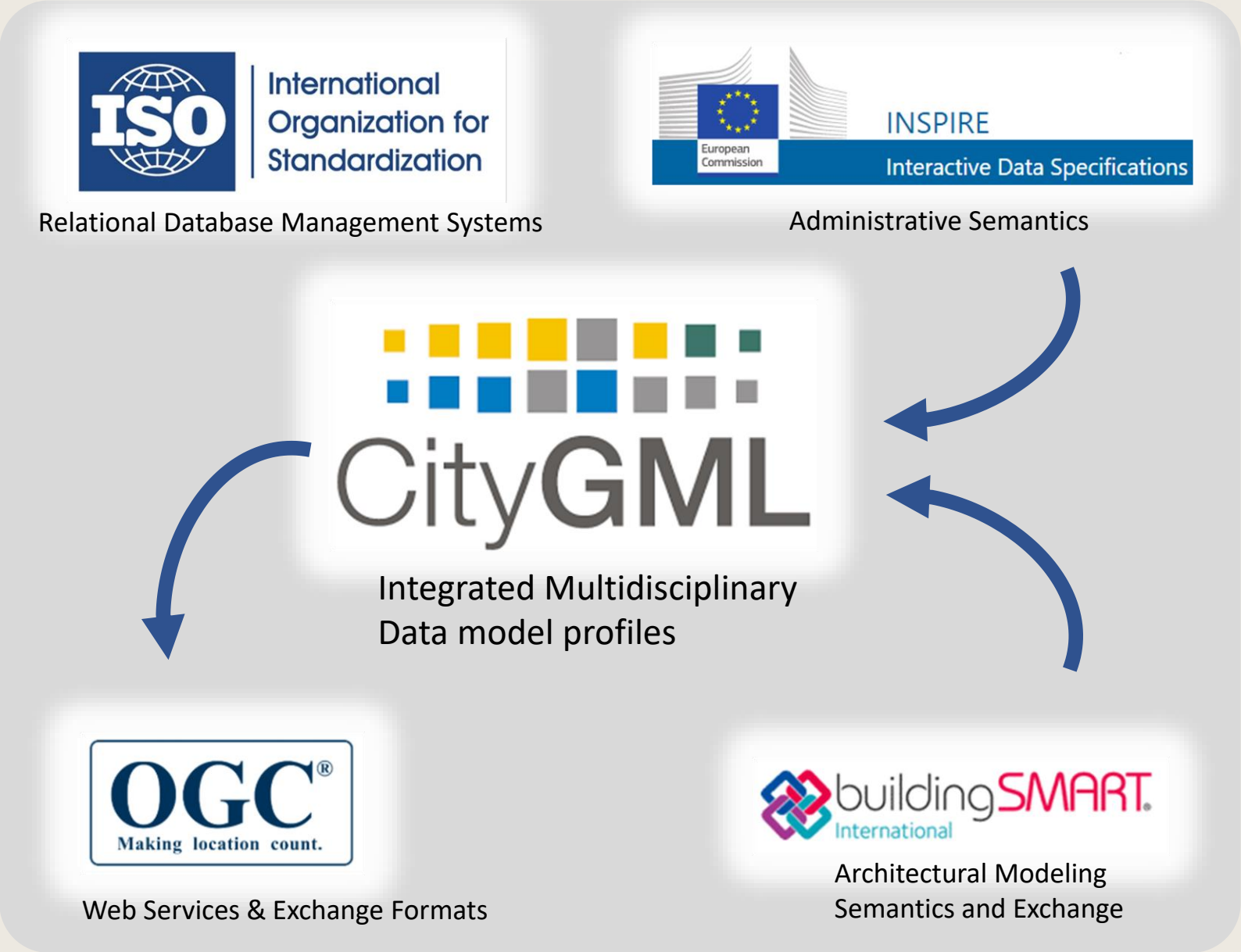
Applicable Semantic and Service Standards

Standards for Database Design

- Standards organizations convene system engineers, subject matter experts and users to formulate recommendations for robust and efficient system design
- Many standards are interdisciplinary and build on eachother
- Following standards provides safety against re-inventing the wheel and learning form expensive experience lessons that have already been learned.

CityGML Caveats:

- CityGML is an object model has a potential to be deeply hierarchal.
- GIS adminstrators in the USA are very much oriented toward very simple relational models with straight-forward layer-style feature classes.
- Nobody implements standards for the virtue of them alone.
- Specific concepts are pulled from standards to solve practical problems.



Relational database design concepts

Information about Buildings Stored in a Buildings Table

- A table about buildings should contain one row per building
- This building table can include polygons representing the extent of buildings.
- Given that buildings may be connected underground, theoretically , these polygons may not always look like building footprints
- This table should probably match with the tax assessor's concept of buildings.

Building Parts should be represented in a separate table or tables.

- There may be different types of building parts.
- A rough massing model can be represented by polygons with heights that can be exteruded.
- Buildnig skins can be represented with true 3d geometry (e.g. multipatch objects.)
- Each of these building parts tables can use building identifiers to relate back to the buildings table.

Address	BldgNur	PropertyClass	Zoning	GISID	Owner_Name	Condition_YearBuilt	PID	PropertyTaxAmount
219-221 Monsignor...	1	HOTEL	SD-1	7-115	MONSIGNOR HOTEL,...	2014	3	389041.82
225 Monsignor Obrie...	1	MANUFACTURING	SD-1	7-29	EASTMAN BROOK LL...	1920	5	82651.97
187-197 Monsignor...	1	HOTEL	SD-1	7-31	NATRAJ HOSPITALIT...	2002	6	357127.68
199 Monsignor Obrie...	1	WAREHOUSE	SD-1	7-34	FAHIMIAN, EDWARD...	1870	7	31630.3
263 Monsignor Obrie...	1	WAREHOUSE	SD-1	7-35	PREVITE, ANTHONY...	1983	8	26766.93
241 Monsignor Obrie...	1	GAS-STATION	SD-1	7-37	PECTEN PROPERTIES,...	1956	9	45942.23

Challenge: Building Identification and Cardinality with Models

What is a Building?

- There are many agencies in the city with concern for managing building information.
- The tax assessor, for one, jas records rerlated to the taxation of property, and keeps information associated with individual buildings

Limitations of Photogrammetry

- Photogrammetric techniques are not capable of “seeing” the distinctions that are considered by the tax assessor
- Especially where buildings are touching eachother.

Buildings have Parts

- Ehen it comes to representing buildings in three dimensions and in terms of changes over time, it is very useful to have a data model that allows for the possibilitiy that a building can have parts
  - Parts that have different uses
  - Parts that have different heights
  - Parts that have different built and demolition dates

Modes of geometric representation have different degrees of Chunkiness, and different technical ease or difficulty with regard to splitting.

- True 3d Models are very difficult to split
- Polygon footprints are relatively easy to split, even with automated GIS techniques.

Address	BldgNur	PropertyClass	Zoning	GISID	Owner_Name	Condition_YearBuilt	PID	PropertyTaxAmount
219-221 Monsignor...	1	HOTEL	SD-1	7-115	MONSIGNOR HOTEL,...	2014	3	389041.82
225 Monsignor Obrie...	1	MANUFACTURING	SD-1	7-29	EASTMAN BROOK LL...	1920	5	82651.97
187-197 Monsignor...	1	HOTEL	SD-1	7-31	NATRAJ HOSPITALIT...	2002	6	357127.68
199 Monsignor Obrie...	1	WAREHOUSE	SD-1	7-34	FAHIMIAN, EDWARD...	1870	7	31630.3
263 Monsignor Obrie...	1	WAREHOUSE	SD-1	7-35	PREVITE, ANTHONY...	1983	8	26766.93
241 Monsignor Obrie...	1	GAS-STATION	SD-1	7-37	PECTEN PROPERTIES,...	1956	9	45942.23

Integration of CityGML/Inspire Concepts for 3d Reference Service

Abstract Building Table (CityGML / Inspire)

- Each building identified by assessor
- Non-Spatial
- Unique building ID (Map, Lot and Building)
- Classes of buildings tagged with special information

2.5 Dimensional Building Parts (CityGML LOD1)

- Tagged with Map, Lot and Building
- Linked to assessing and special information
- Invisible, but used in scene-graph to catch clicks and mouse-over events
- Easy to split and keep synced with assessing information.

3D Building Parts (CityGML LOD2+ Appearance)

- Compiled through photogrammetry or hand-made.
- Great for reference – easily recognizable, More accurate sight-lines, potentially textured
- Very lumpy
- Very difficult to split

Address	BldgNur	PropertyClass	Zoning	GISID	Owner_Name	Condition_YearBuilt	PID	PropertyTaxAmount
219-221 Monsignor...	1	HOTEL	SD-1	7-115	MONSIGNOR HOTEL,...	2014	3	389041.82
225 Monsignor Obrie...	1	MANUFACTURING	SD-1	7-29	EASTMAN BROOK LL...	1920	5	82651.97
187-197 Monsignor...	1	HOTEL	SD-1	7-31	NATRAJ HOSPITALIT...	2002	6	357127.68
199 Monsignor Obrie...	1	WAREHOUSE	SD-1	7-34	FAHIMIAN, EDWARD...	1870	7	31630.3
263 Monsignor Obrie...	1	WAREHOUSE	SD-1	7-35	PREVITE, ANTHONY...	1983	8	26766.93
241 Monsignor Obrie...	1	GAS-STATION	SD-1	7-37	PECTEN PROPERTIES,...	1956	9	45942.23

Integration of CityGML/Inspire Concepts for 3d Reference Service

Abstract Building Table (CityGML / Inspire)

- Each building identified by assessor
- Non-Spatial
- Unique building ID (Map, Lot and Building)
- Classes of buildings tagged with special information

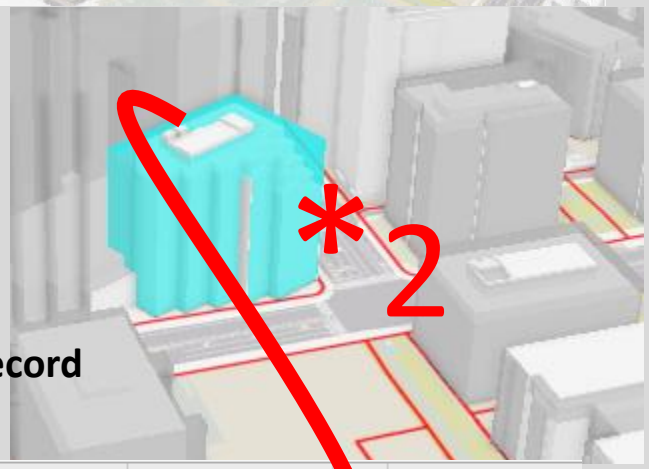
2.5 Dimensional Building Parts (CityGML LOD1)

- Tagged with Map, Lot and Building
- Linked to assessing and special information
- Invisible, but used in scene-graph to catch clicks and mouse-over events
- Easy to split and keep synced with assessing information.

3D Building Parts (CityGML LOD2+ Appearance)

- Compiled through photogrammetry or hand-made.
- Great for reference – easily recognizable, More accurate sight-lines, potentially textured
- Very lumpy
- Very difficult to split

1. **User sees 3D Appearance Parts**
2. **Mouse events captured by extruded LOD1 polygon (Invisible!)**
3. **Mouse events retrieve abstract building record**



*3

Address	BldgNur	PropertyClass	Zoning	GISID	Owner_Name	Condition_YearBuilt	ID	PropertyTaxAmount
219-221 Monsignor...	1	HOTEL	SD-1	7-115	MONSIGNOR HOTEL,...	2014	[illegible]	389041.82
225 Monsignor Obri...	1	MANUFACTURNG	SD-1	7-29	EASTMAN BROOK LL...	1920	[illegible]	82651.97
197 Monsignor...	[illegible]	[illegible]	SD-1	7-31	NATRAJ HOSPITALIT...	2002	[illegible]	357127.68
199 Monsignor Obrie...	1	WAREHOUSE	[illegible]	[illegible]	FAHIMIAN, EDWARD...	1870	7	31630.3
263 Monsignor Obrie...	1	WAREHOUSE	SD-1	7-35	PREVITE, ANTHONY...	1983	8	26766.93
241 Monsignor Obrie...	1	GAS-STATION	SD-1	7-37	PECTEN PROPERTIES,...	1956	9	45942.23

Recommendations for ISO City-Modeling Initiative

Very Simple Relational Profile of CityGML

- The people involved with managing GIS in the expect to understand data in terms of intuitively accessible relational feature classes.
- A simple-relational profile for CityGML.
  - Abstract Building, LOD1 Parts, LOD3 Appearance
- Must have very flat relational schema with max. 4 or 5 tables.

Support for invisible click-catcher layers in 3D Web Services

- Currently not an option in ESRI ArcGIS On-Line
- Why not a CSS-Like styling capability for 3D?

Need: GIS-Oriented Standard Support in BIM (Building Information Modeling) Tools

- Builldingsmart IFC Profile for GIS
- KMZ Export for georeferenced LOD1 and Textured LOD2 building shells.
- GIS Profile should be standard option in every Autodesk Revit model.

CityGML

A simple-relational profile for CityGML

OGC® Making location count.

CSS-Like styling capability for 3D

buildingSMART International

Builldingsmart IFC Profile for GIS