Activities Bridging the Information Domains of Architecture Engineering Construction and Facilities Management

with

Geospatial Information Infrastructure

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Open Information Models for Campus Modeling

In the future, designers administrators, planners and the public will be able to access up-to-date city models that incorporate building interior spaces and fixtures; each element being served directly from the most authoritative sources.

This information will be accessible through a wide variety of tools: for design, visualization, query, building management, seamless indoor outdoor location-based services, planning analysis, emergency preparedness and response.

This will be made possible in part, by consensus-based open standards for interoperable data exchange

Outline

- An overview of integrating BIM with Geospatial Information Architecture
- Some problems of developing detailed City/Campus models, and why open standards for interoperability are critical.
- How the open standards development process works, and some of the most common exchange standards for building information.
- Why developing applications around open standards is simpler than many people think.
- Two case studies for integration of Building information with Geospatial Information Infrastructure

Integrating Architectural and Building Operation Information models with Geospatial Information Architecture

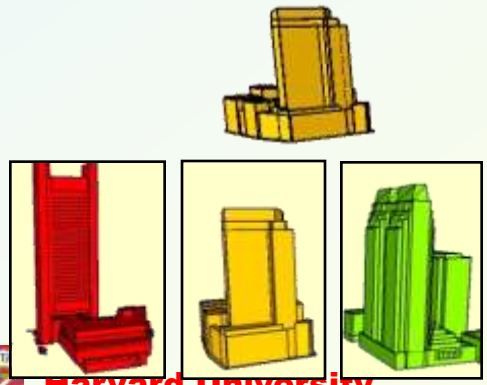
Bridging CAD GIS and BIM Domains

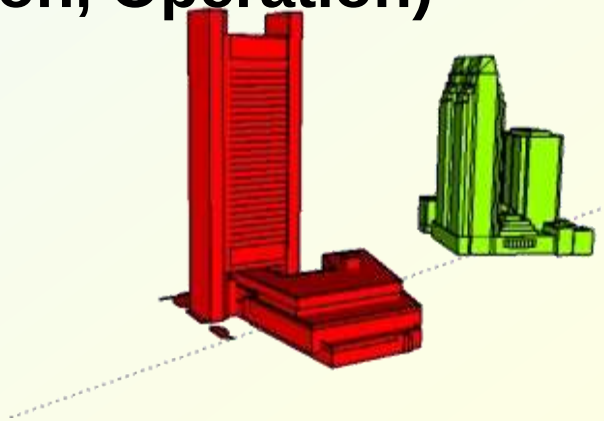
Geospatial Information Infrastructure

Provides Wholesale Context

Building Information Models Should be Georeferenced

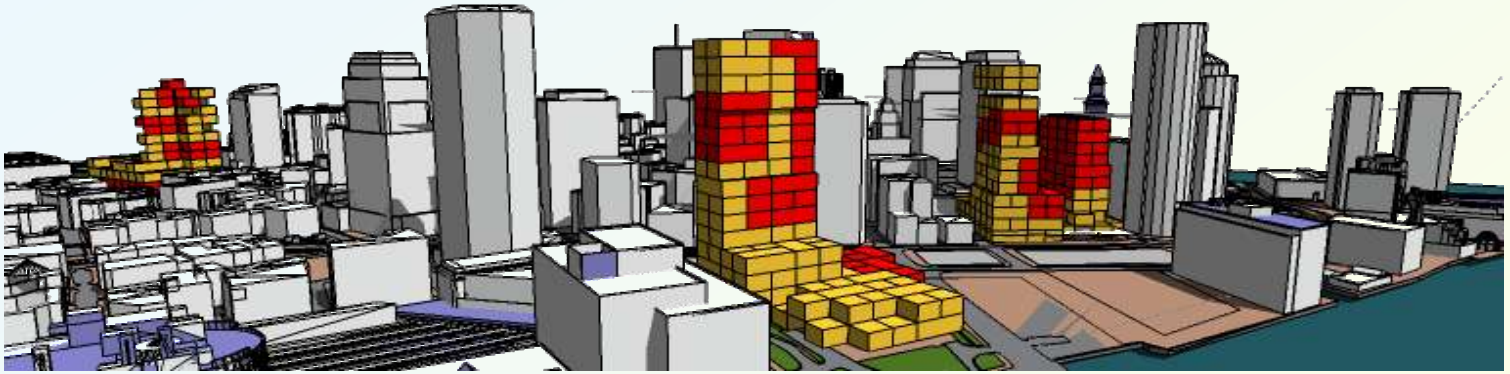
(Design, Construction, Operation)



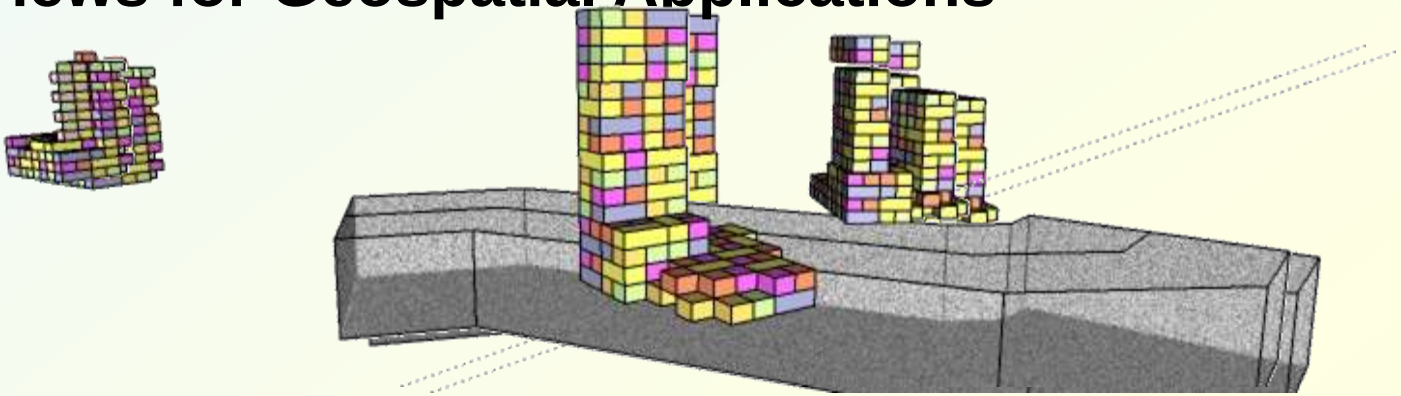


Bridging CAD, GIS, and BIM Domains

Geospatial Information Infrastructure
Will Include Detailed Building Information

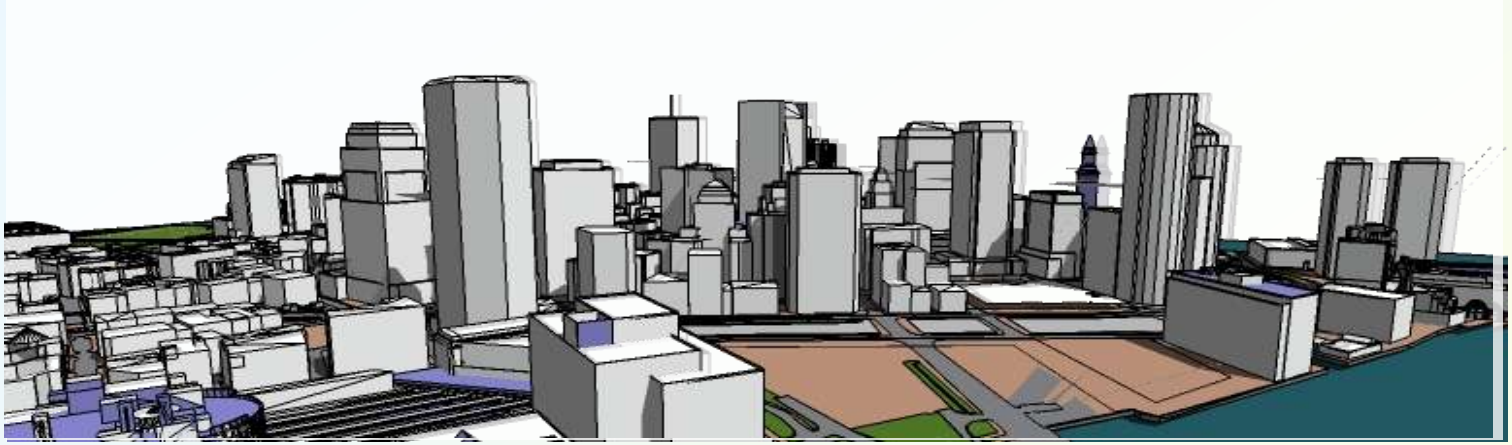


Building Modeling Tools will Create Model Views for Geospatial Applications



Bridging CAD, GIS, and BIM Domains

Geospatial Information Infrastructure

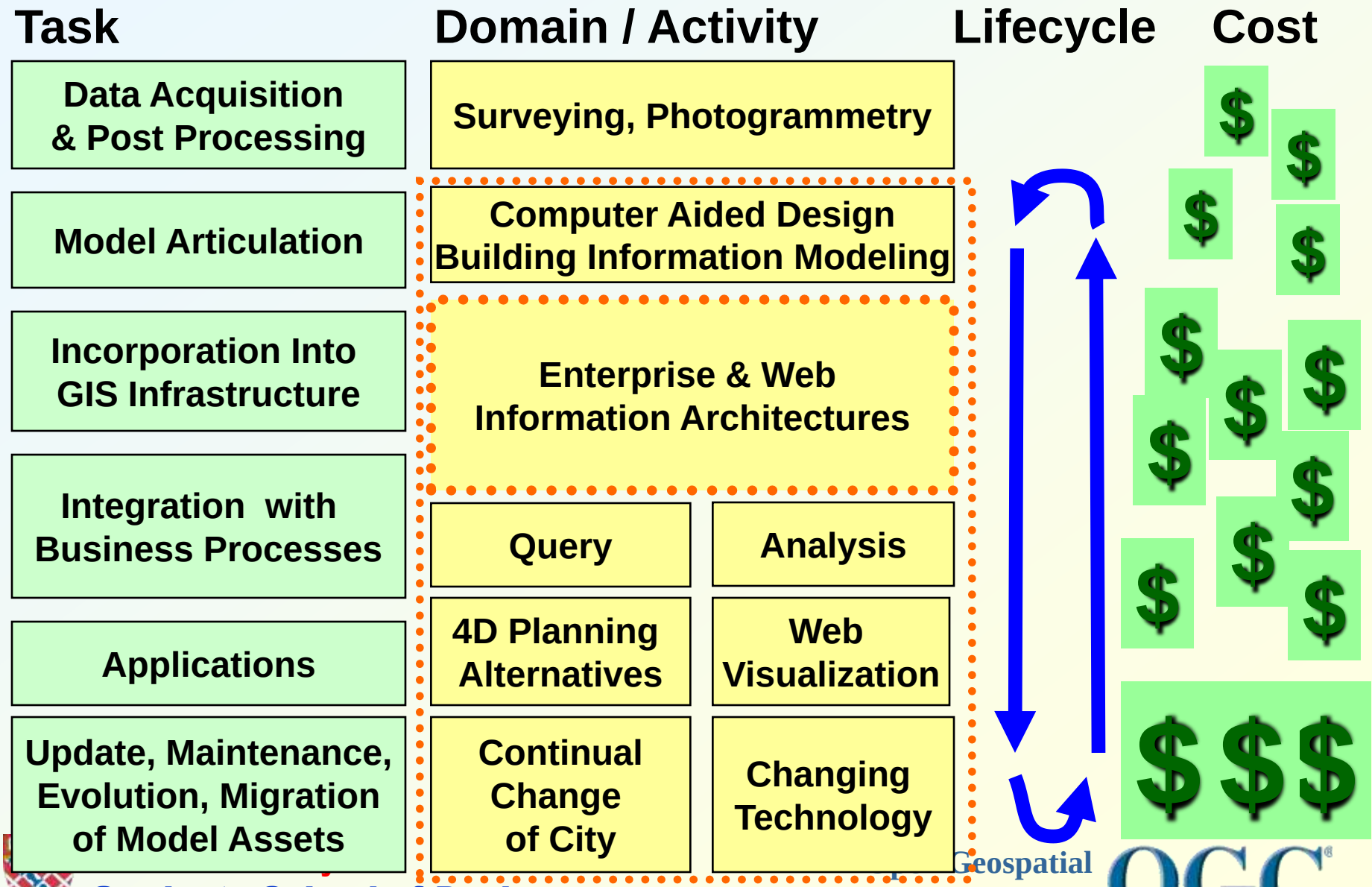


BIM Design and Management Tools

Will be informed by Geospatial Information

Why open standards for interoperability are critical for developing detailed City/Campus models.

Lifecycle Costs of a Campus Data Model



Bridging CAD, GIS and BIM Information Domains

Development and maintenance of city information depends on collaborative effort from a diverse set of actors:

- **Building designers**
- **Photogrammetrists and As-Built modelers**
- **Building operators**
- **Geospatial information managers from different jurisdictions**.

Contributors should not be constrained by single-vendor options

Campus-scale city models will require substantial investments in information assets over long periods of time.

These issues indicate the critical role for stable, non-proprietary specifications for Interoperability in information models and exchange

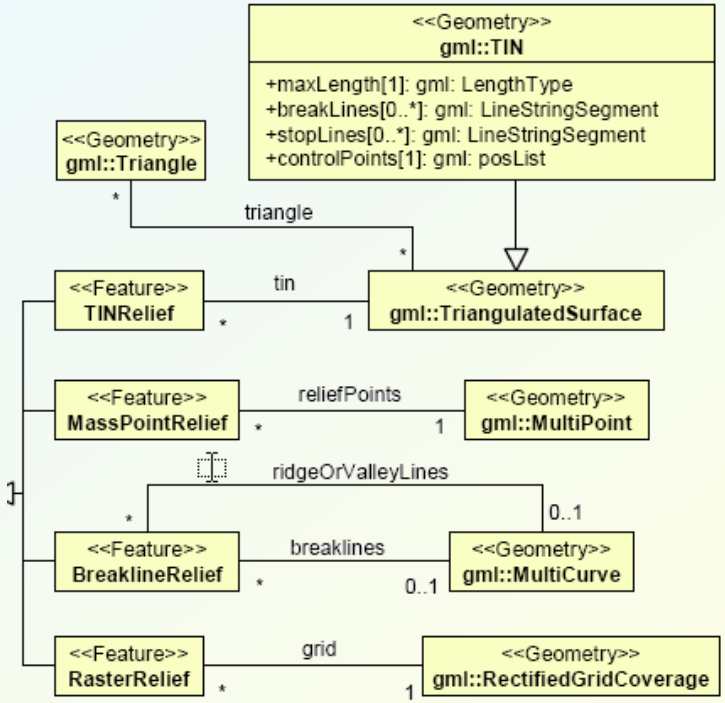
What do we mean by information models and exchange encodings?

Open Information Models

Real World Concepts:

"The building meets the terrain along this line."

Information Model



Exchange Encoding

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  <xs:complexContent>
    <xs:extension base="_ReliefComponentType">
      <xs:sequence>
        <xs:element name="grid" type="gridPropertyType" />
      </xs:sequence>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
<!-- ========== -->
<xs:element name="RasterRelief" type="RasterReliefType" substit
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    </xs:restriction>
  </xs:complexContent>
</xs:complexType>
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<xs:element name="Elevation" type="gml:LengthType" substitutio
```

e.g. Observations, Prescriptions, Rules

e.g. UML (Unified Modeling Language)

e.g. XML (Extensible Markup Language)

Data Models in Applications

CAD & 3d Modeling

- Largely Geometric & Graphical (little or no semantic structure)
- Semantics in Layers and Objects
- File-Based Storage & Exchange (not scalable as enterprise architecture)
- Project and Domain Specific Scope

Building Information Modeling

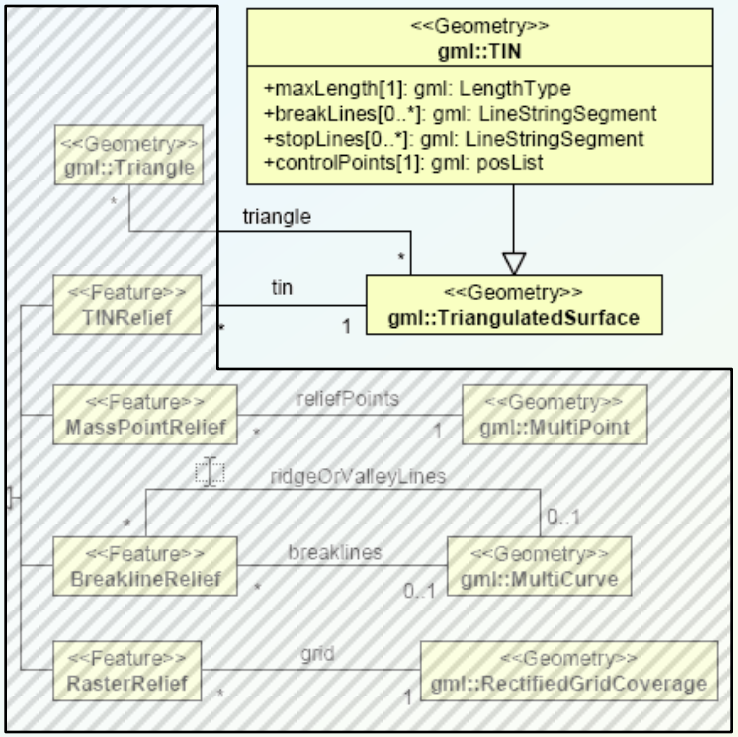
- Geometric & other objects with Semantics
- Complex relationships in Object Model
- File-Based storage and Exchange (not scalable as enterprise architecture)
- Project Specific Scope Spans Domains over lifecycle

Geospatial / Relational Information Infrastructure

- Geometric objects with Semantics
- Relational Database Model (Highly Scalable)
- Enterprise data management – Service Based Exchange
- Global Scope, Broad-scale application domains

Interoperability in Application Data Models

Model View Definition



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    </xs:restriction>
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```
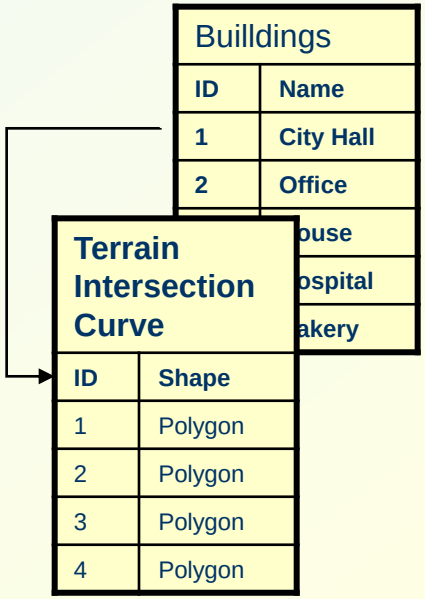

Application Data Model



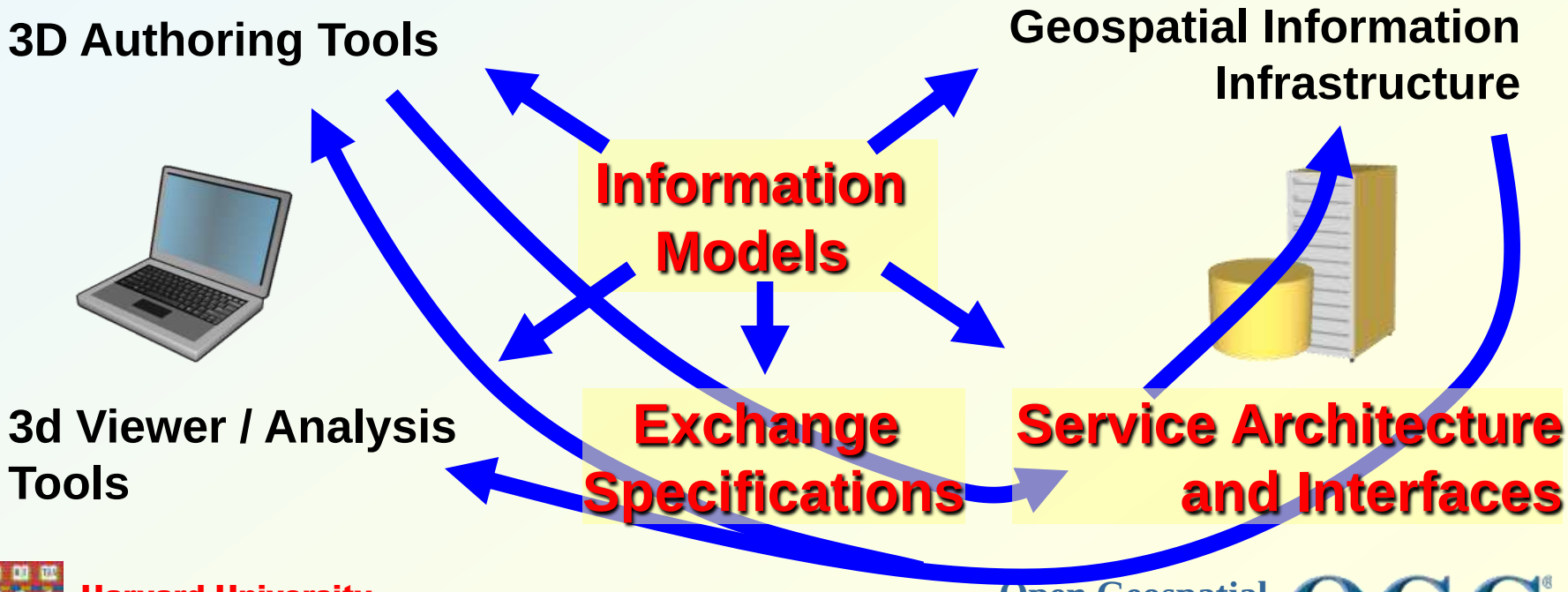
Import

Export

Round Trip = Lossless Exchange

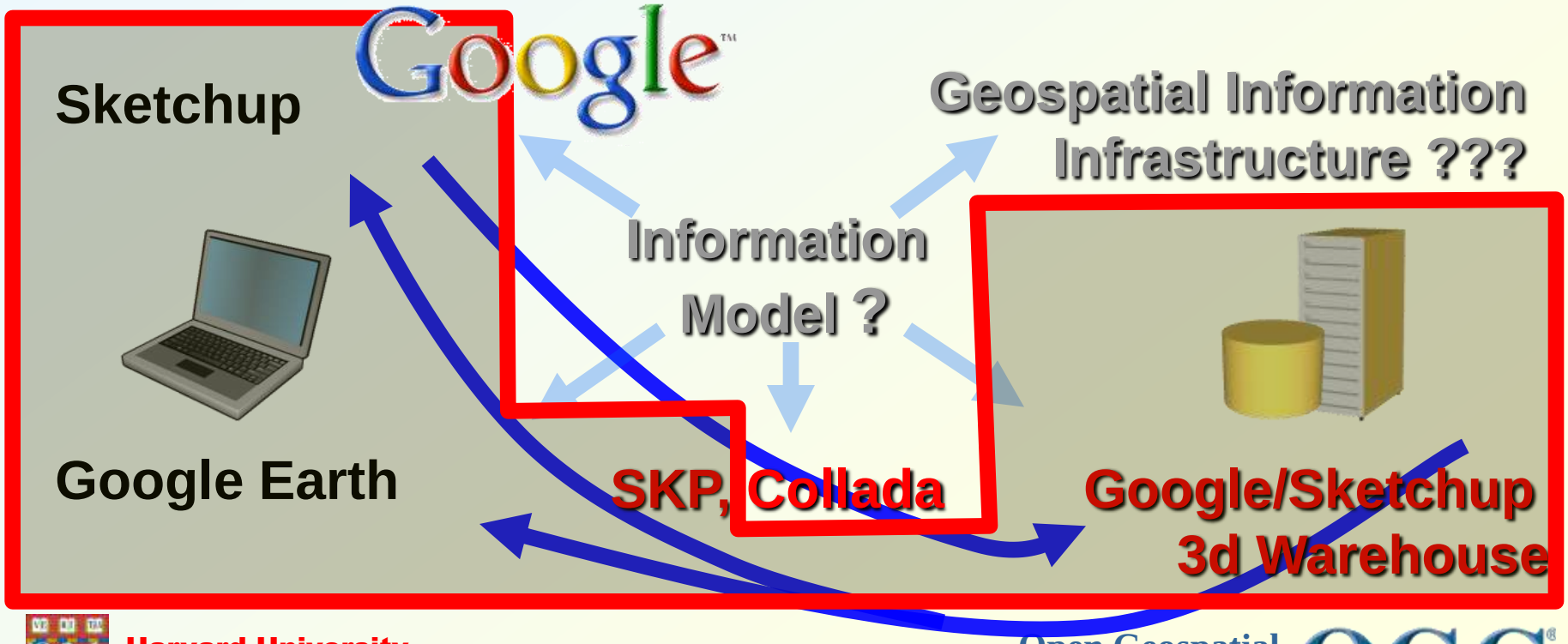
The Road Ahead for Metropolitan 3D

Development and maintenance of detailed 3d models of large urban areas will require collaborative effort across information domains of Architecture, Engineering, Construction and Facilities Management (AEC+FM) and Geospatial Information Systems (GIS), each doamin having their own tools.



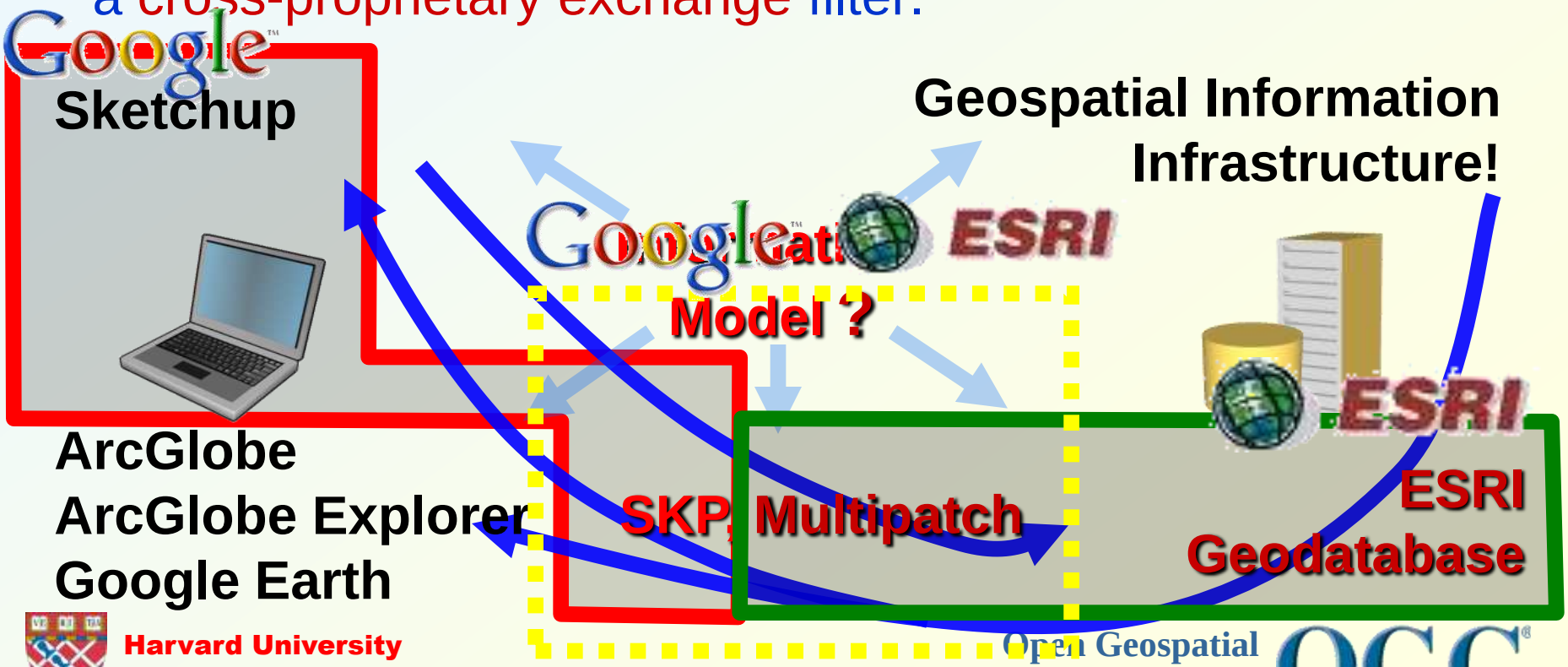
Proprietary Solutions are First on the Market

Applications bridging AEC+FM and GIS domains have emerged first in proprietary commercial systems. The Google Sketchup 3d Warehouse is one example.



Proprietary Solutions are Fast and Easy

The ESRI / Sketchup Collaboration is another example of an early innovation bringing 3d modeling into user-modifiable geospatial infrastructure. The plugin that tranlateses between Sketchup and ESRI Multipatch formats is an interesting case of vendor collaboration on a cross-proprietary exchange filter.



Open Standards Insure Investments in Content and Tools

Communities

- Engineers
- Tool Makers
- Content Creators
- Service Providers
- Users

Industry Consortium

- Understanding
- Consensus
- Application Standards

International Standards Organization

- Foundation Standards
  - Information Structure
  - Service Protocols
- Application Standards

Participation

Assured Stable Environment

Lots of Interoperable Content!

Geospatial Standards

Communities

- Engineers
- Tool Makers
  - ESRI & Others
- Content Creators
  - Federal Govt. Agencies:
  - Local Govt. Agencies
- Service Providers
  - USGS National Map
  - State GIS Agencies
  - Many, Many more!
- Users

Industry Group

Open Geospatial Consortium (OGC)

- Standards
  - Geographic Markup Language (GML)
  - Web Map Service (WMS) – imagery
  - Web Feature Service (WFS) – vector features
  - Catalog Service for the Web (CS/W)
  - CityGML (Draft)
  - KML (future)

A lot of content and services from government

International Standards Organization

- Foundation Standards
  - XML
  - GML
- Service Standards
  - HTTP
  - WMS
  - WFS (draft)
- Application Standards

The Web

Spatial / Semantic Content

Lots of Content!

Architectural Modeling Standards

Communities

- Engineers
- Tool Makers
  - Autodesk
  - Bentley
  - Graphisoft
  - Vectorworks
  - Many more
- Content Creators
  - Architects
  - Building Operators
- Service Providers
  - Very few
- Users
  - U.S. GSA
  - DOD
  - Many in Europe

Industry Group

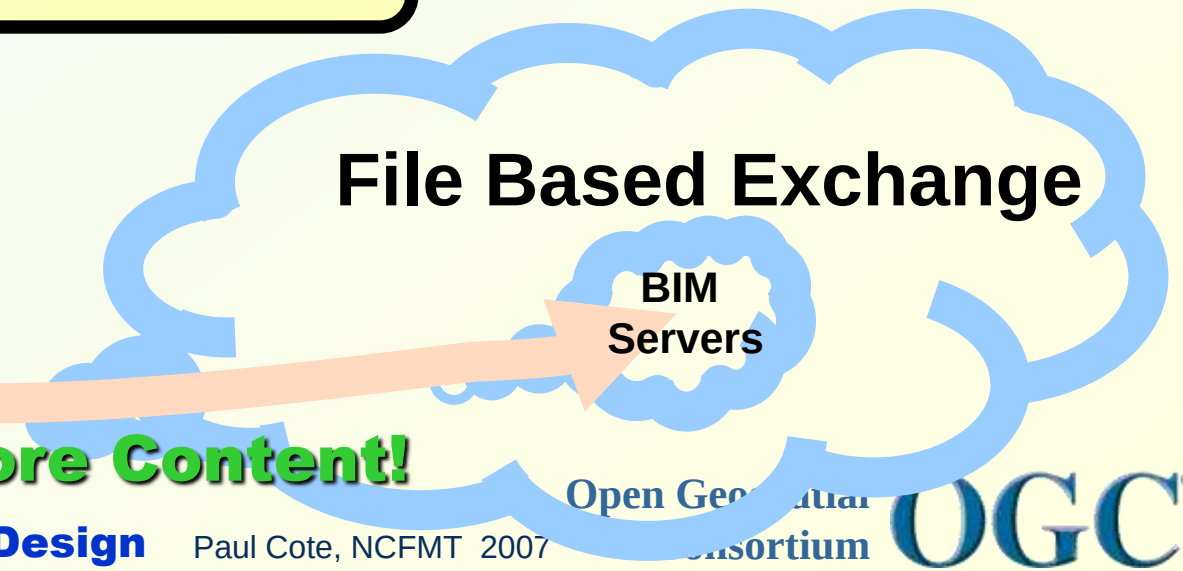
International Alliance for Interoperability

- Application Standards
  - IFC

A lot of buy-in from toolmakers

International Standards Organization

- Foundation Standards
  - XML
  - STEP / Express
- Service Standard
  - None
- Information Model
  - None



Need More Content!

Visualization and Physical Simulation

Communities

- Engineers
- Tool Makers
  - Lots
- Content Creators
  - Gaming industry
  - Sketchup users
- Service Providers
  - Google Earth
- Users
  - Lots

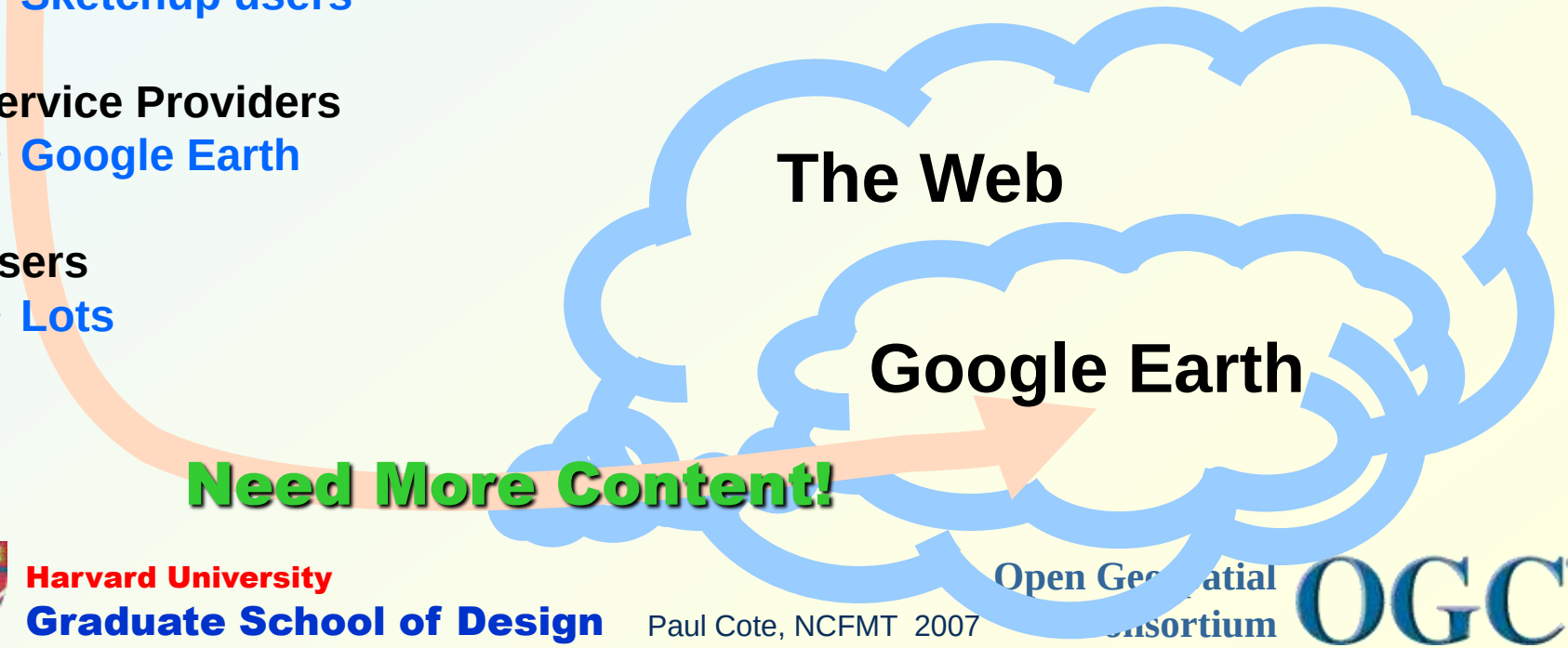
Industry Group

Khronos Consortium

- Application Standards
  - Collada

International Standards Organization

- Foundation Standards
  - XML
- Service Standard
  - None
- Information Model
  - None



Emerging Open Specifications for City Modeling

Open Information Models / Exchange Standards for 3D:

- **GML:** defines **geospatial primitives and means of relating them**
- **CityGML:** spatial model for city representation **with coherent semantic rules***
- **IFC:** spatial / semantic model for building representation **with coherent semantic rules***
- **Collada:** encapsualted 3d geometry for interactive visualization
- **X3D / VRML:** encapsulated 3d geometry for interactive visualization

*Coherent Semantic Models ensure consistency between geometric and semantic relationships (Stadler, Kolbe)
http://www.igg.tu-berlin.de/uploads/tx_ikgpublication/SDQ2007_Stadler_Kolbe_final.pdf)

Fundamental Open Standards for Data and Geometry:

- SQL
- GML Simple Features
- GML 3

Stability assured by the International Standards Organization

Foundation Data Primitives

International Standards define the most basic forms of data. These provide a stable open foundation for basic databases and applications that use data

ISO SQL Standard

Structured query language provides a set of logical rules and interfaces for creating and accessing data. These are adhered to by almost every commercial database provider

Numbers:
- Integer
- Double-Precision
- Floating Point

Temporal:
- Dates
- Times

Character:
- Strings
- Text

Try to imagine the world of databases today if the SQL standard did not exist,or was controlled by IBM!

Foundation Data Primitives

International Standards define the most basic forms of data. These provide a stable open foundation for basic databases and applications that use data

ISO 19125 (OGC) simple feature access

Having both spatial and non spatial attributes. These simple features extend the power of SQL to spatial queries and operations

Points: **Linestrings:** **Polygons:**

Aggregate Features:

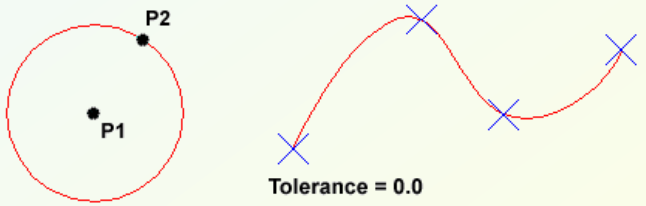
- MultiPoint
- MultiLine
- MultiPolygon

Most geospatial data can be exchanged through GML, though much of the logic of relationships does not make the round trip.

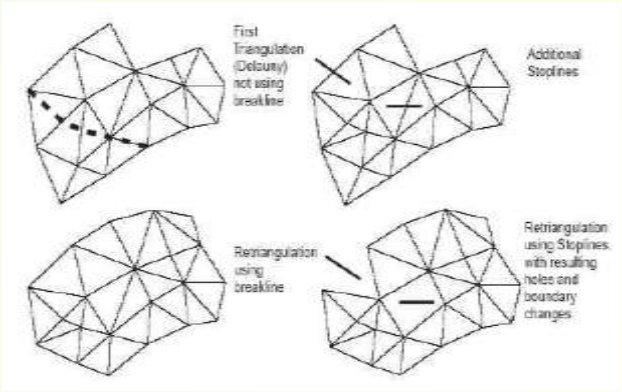
Parametric Geometries Supported in GML3

ISO 19107 (OGC) Geographic Markup Language includes a richer set of 3d geometry.

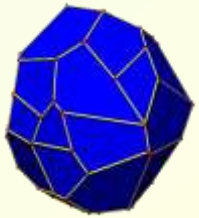
Parametric Linear Shapes:
Circles and Arcs
Splines:
Segmemted Curves with control points



Surfaces:
Patches, edges have any linear shape (above)
Cones
Cylinders
Polyhedrons
Triangulated Irregular Networks (TIN)



Solids:
Composite Surfaces e.g. Shells
AKA Boundary Representation (B-REP)



Open Information Models for Applications:

Collada Concepts

COLLADA

COLLAborative Design Activity

Standards Consortium:

- Khronos Group

Communities:

- Visualization
- Gaming

Capabilities:

- Very rich visual and physical simulation: photorealistic shaders, cameras, movement
- No semantic model
- No georeferencing

Modeling / Encoding

- UML / XML

Adoption:

- Many 3d authoring tools, 3d Studio, Sketchup …
- The vehicle for textured models in Google Earth

Collada Concepts

Cameras,

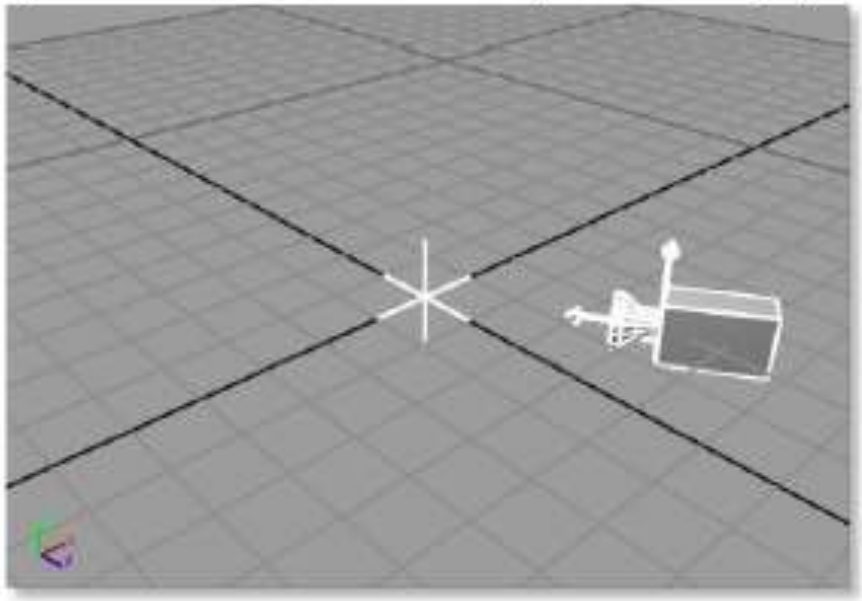
Prescribed and dynamic views

Example

Here is an example of a <lookat> element indicating a position of [10,20,30], centered on the local origin, with the y axis rotated up:

```
<node id="Camera">
  <instance_camera url="#camera1"/>
  <lookat>
    2.0  0.0  3.0  <!-- eye position (X,Y,Z)         -->
    0.0  0.0  0.0  <!-- interest position (X,Y,Z)    -->
    0.0  1.0  0.0  <!-- up-vector position (X,Y,Z)   -->
  </lookat>
  ...
```

Figure 4-1: <lookat> element; the 3-D "cross-hair" represents the interest-point position



Collada Concepts

Lighting Model,
Sophisticated Shaders with reflectance, etc

Collada Concepts

Motion, Physics

CityGML Concepts

CityGML

City Geographic Markup Language

Standards Consortium:

- Open Geospatial Consortium (Best Practice Specification)

Communities:

- Photogrammetry
- Municipal Geospatial Infrastructure

Capabilities:

- Very rich semantic model for city objects and relationships
- 5 predefined levels of detail
- Image textures supported

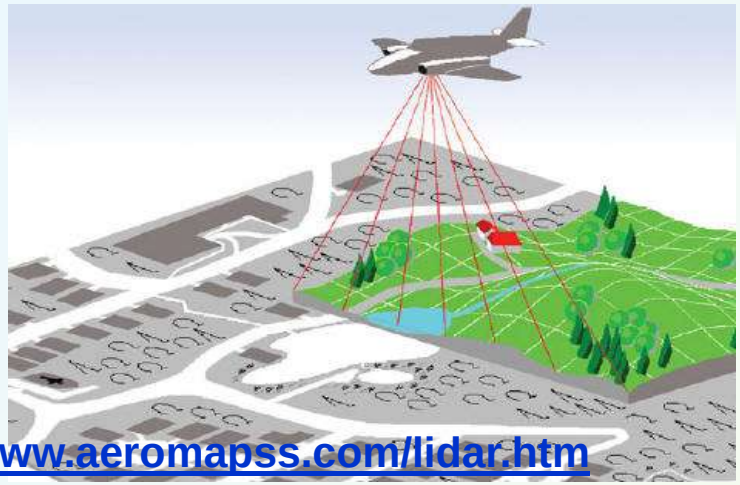
Modeling / Encoding

- UML / XML / GML3 Profile

Adoption:

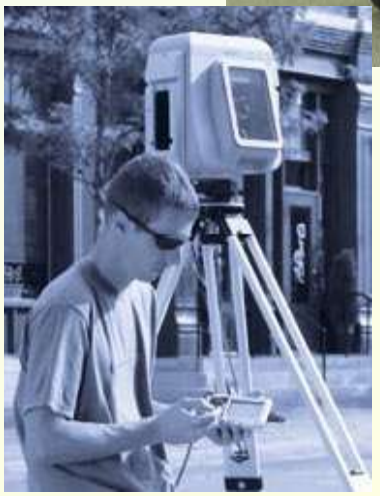
- Berlin, Bonn and many other German cities
- Compatible with OGC Web Feature Services

CityGML is Adapted for Modeling Semantics of Observable Objects



www.aeromapss.com/lidar.htm

Robot:
Mobilerobots.com
Photo:
DirectionsMagazine



CityGML: Objects May Honor Specific Levels of Detail

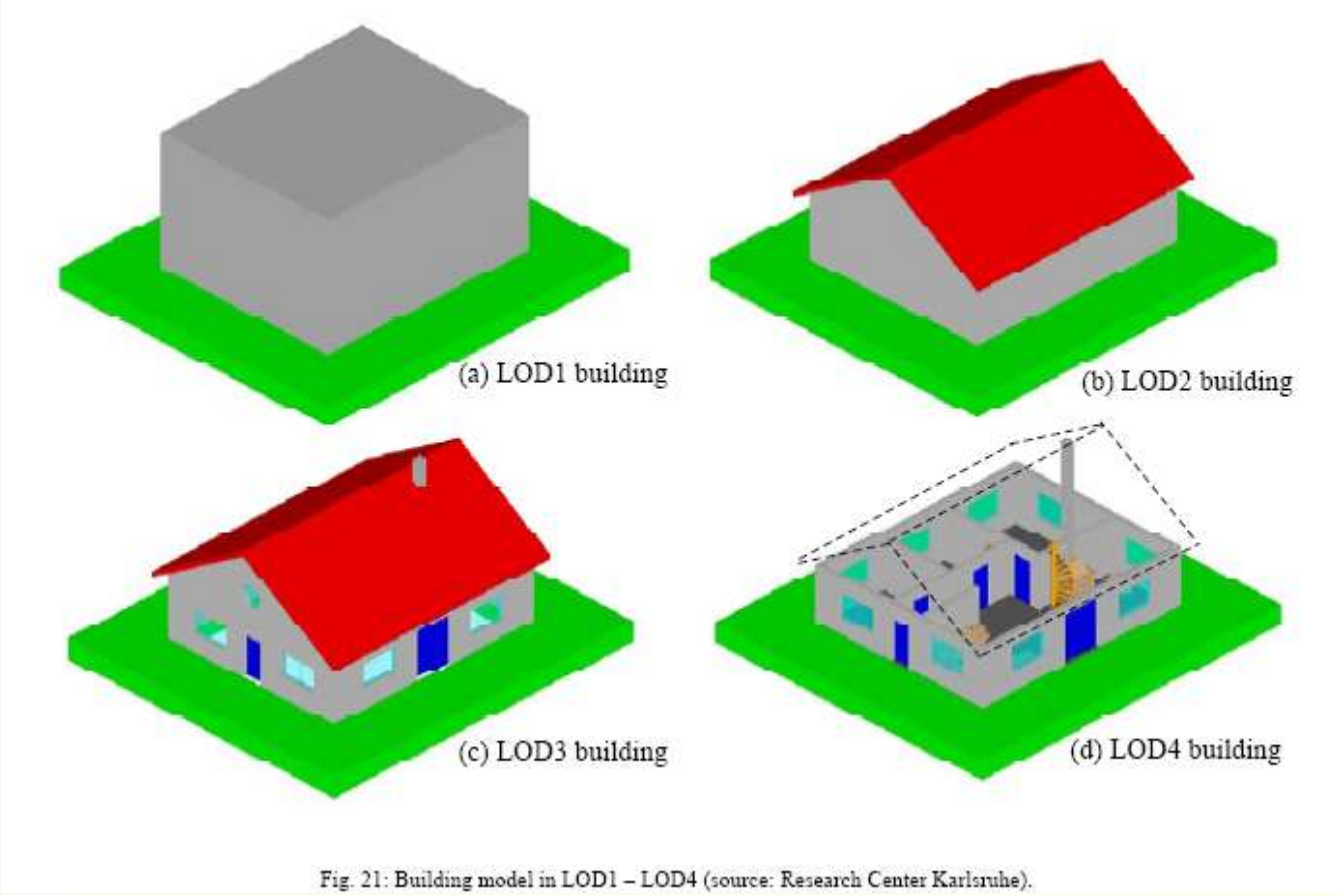


Fig. 21: Building model in LOD1 – LOD4 (source: Research Center Karlsruhe).

Image from OGC CityGML Discussion paper, Kolbe, Groeger, Czerwinski

CityGML can provide a Spatially Exhaustive Semantically Rich model of the city

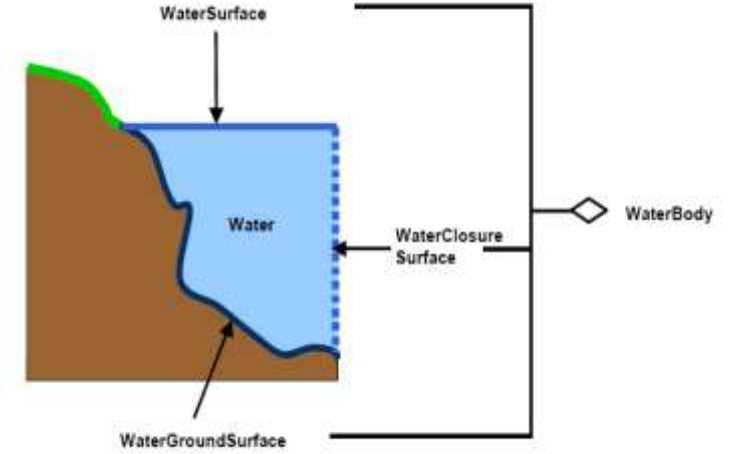


Fig. 24: Illustration of a water body defined in CityGML (graphic: IKG Uni Bonn).

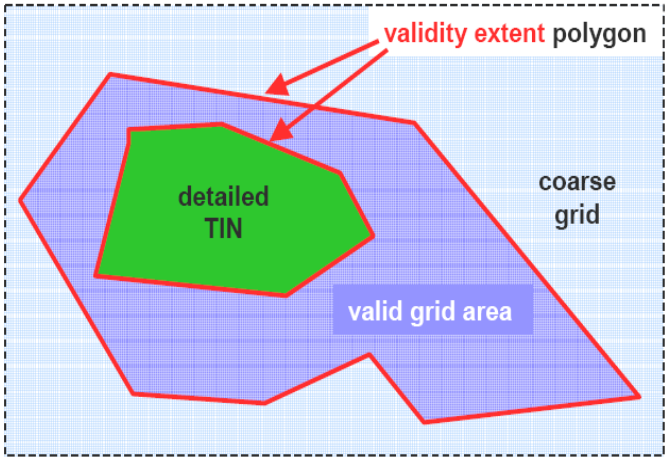


Fig. 16: Nested DTMs in CityGML using validity extent polygons (graphic: IKG Uni Bonn).

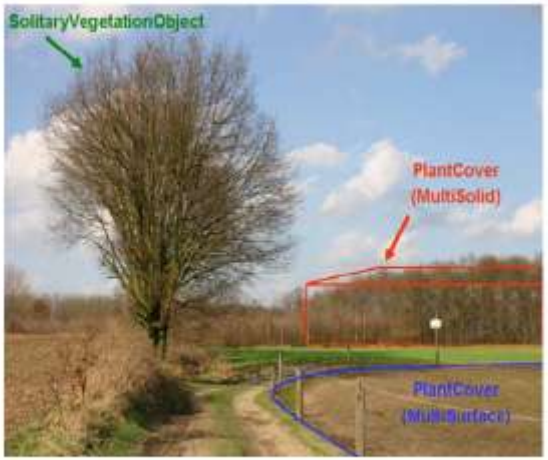


Fig. 32: Example for vegetation objects of the classes *SolitaryVegetationObject* and *PlantCover* (graphic: District of Recklinghausen).

Fig. 27: Example for the representation of a *TransportationComplex* in LOD2 in CityGML: a road, which is the aggregation of *TrafficAreas* and *AuxiliaryTrafficAreas* (source: City of Solingen, IKG Uni Bonn).

Image from OGC CityGML Discussion paper, Kolbe, Groeger, Czerwinski

CityGML: Transportation Objects

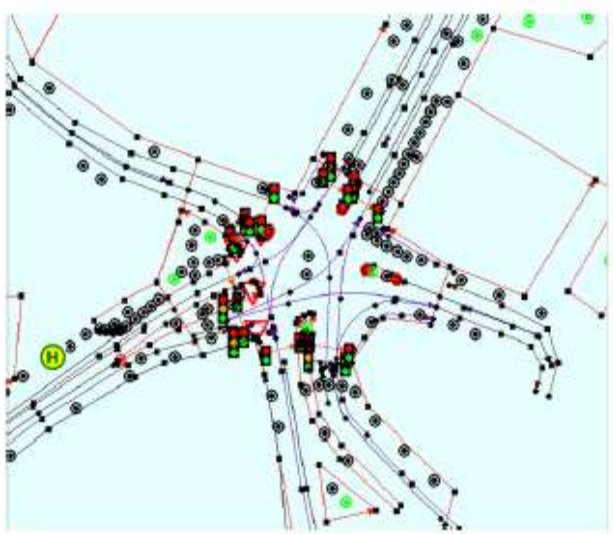


Fig. 31: Complex urban intersection (left: linear transportation network with surface descriptions and external references, right: generated scene) (source: Rheinmetall Defence Electronics).

9.5.1 Transportation complex

_TransportationObjectType, _TransportationObject

```
<xs:complexType name="_TransportationObjectType" abstract="true">
  <xs:complexContent>
    <xs:extension base="_CityObjectType" />
  </xs:complexContent>
</xs:complexType>
<!-- ========== -->
<xs:element name="_TransportationObject" type="_CityObjectType" substitutionGroup="_CityObject" />
```

Image from OGC CityGML Discussion paper, Kolbe, Groeger, Czerwinski

CityGML: Engineered objects relate to various terrain surfaces

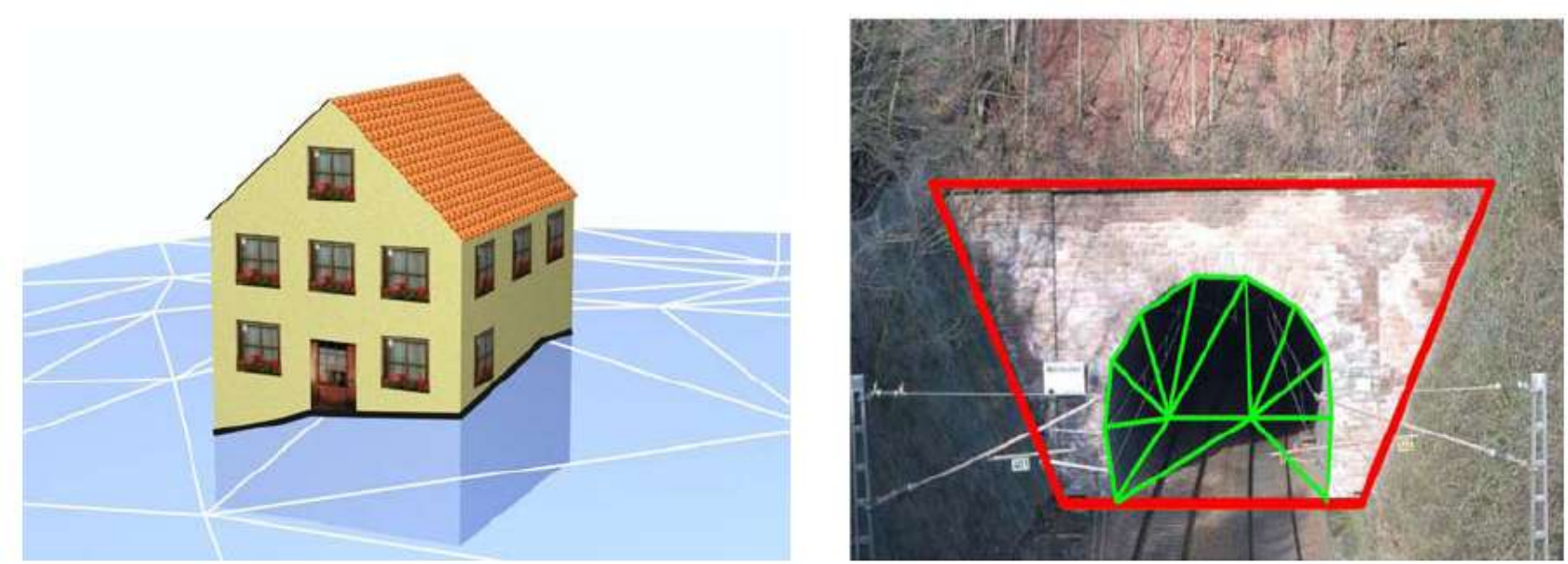


Fig. 5: *TerrainIntersectionCurve* for a building (left, black) and a tunnel object (right, white). The tunnel's hollow space is sealed by a triangulated *ClosureSurface* (graphic: IKG Uni Bonn).

Image from OGC CityGML Discussion paper, Kolbe, Groeger, Czerwinski

IFC Concepts

IFC

Industry Foundation Classes

Standards Consortium:

- International Alliance for Interoperability (IAI BuildingSmart)

Communities:

- Architecture Engineering and Construction
- Facilities Management

Capabilities:

- Very rich semantic model for building systems and relationships

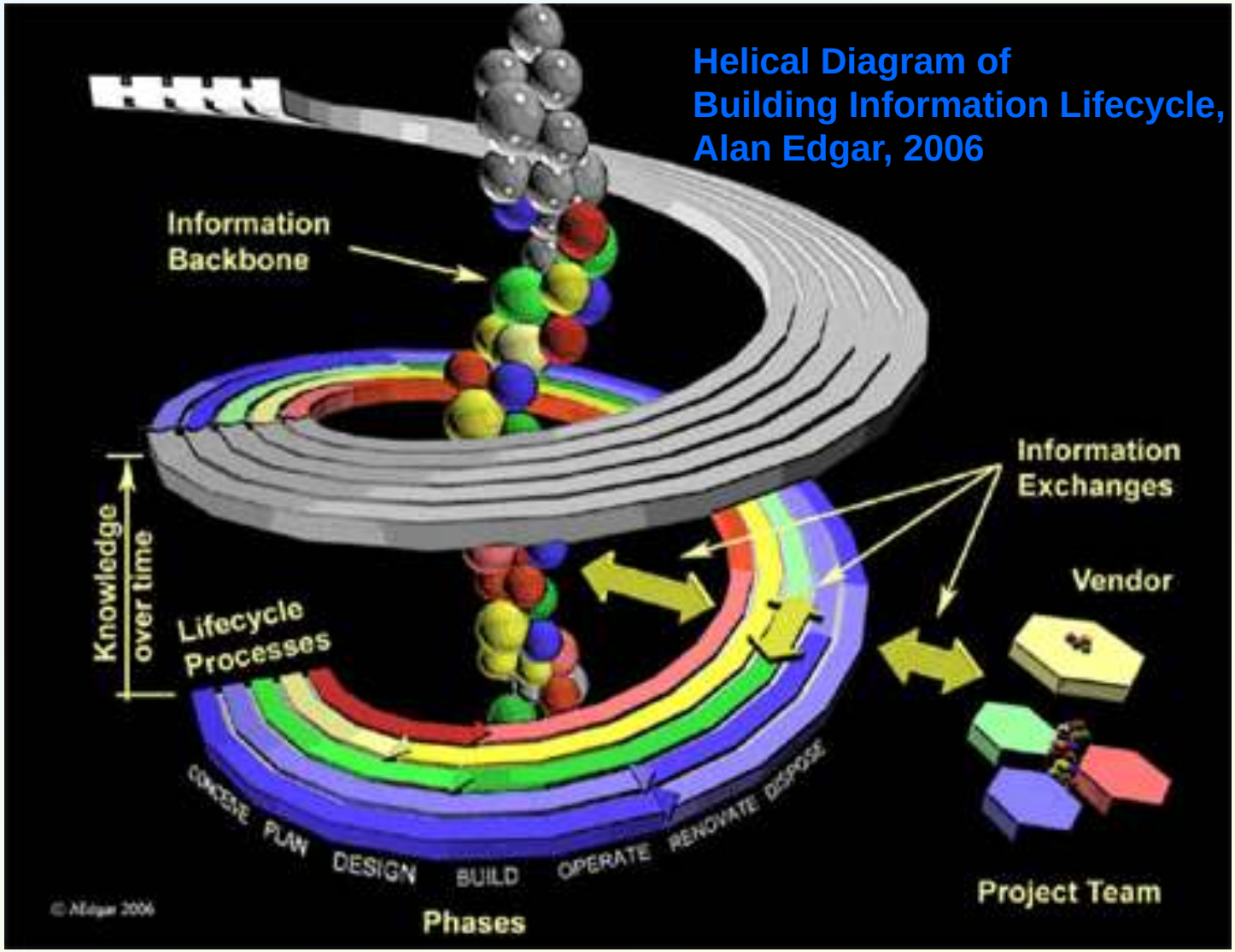
Modeling / Encoding

- EXPRESS / STEP, XML

Adoption:

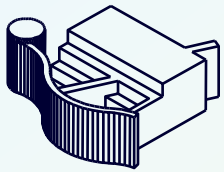
- Very broad adoption in authoring tools for Building Information Modeling (BIM)
- Requirement for many big building customers e.g. U.S. General Services Administration

IFC: Information Model for Building Lifecycle

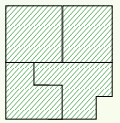


IFC Concepts

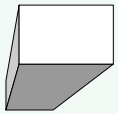
Shape (explicit)



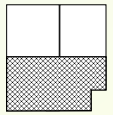
Spaces, Space Structure
space, storey, part, building, site



Shape (extrusions)
beams, pipes, ducts, walls etc.

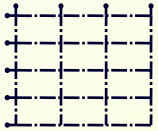


Compartmentation
fire, workstation



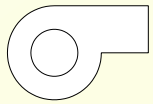
Shape (topology)
line representations for pipe, duct, etc.

Grids



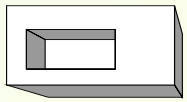
Building Elements
wall, door, window, roof, stairs, etc.

Equipment
chillers, fans, pumps, etc.

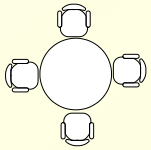


Relations Between Elements

holes, chases, voids, zones



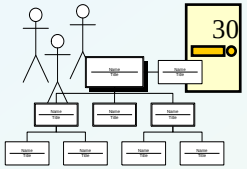
Furniture
inc. system furniture



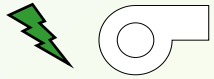
Slide taken from IAI North America, Images, Jeffrey Wix

IFC Concepts

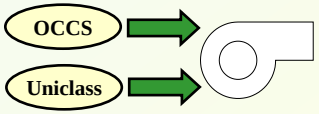
Actors
people, organizations, addresses



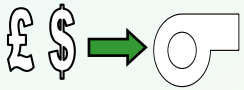
External Data



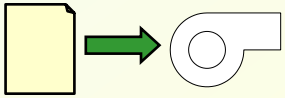
Classification



Costing
cost planning, estimates, budgets

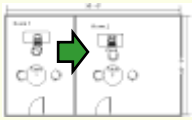


Associated Documents

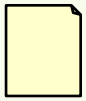


Work Plans and Schedules
inc. nested schedules, resource allocation

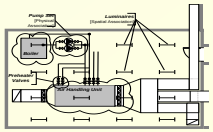
Move Management



Orders
work orders, change orders, purchase orders



Asset Identification
Maintenance History, Inventories



Slide taken from IAI North America, Images, Jeffrey Wix

Why developing applications around open standards is simpler than many people think

Application-Specific Model Views

People often find general domain information models dauntingly deep and complex.

- **Specific applications require small subsets of concepts from the entire model**
- **Implementation data models are generally more constrained in implementation than UML (e.g. Relational Database Management Systems**
- **A subset of concepts from a General Domain Information Model is known as a Model View Definition.**

Application Model Views allow developers and users to be develop stable interoperable systems without implementing the entire domain information model.

IFC Model Views may be Very Simple

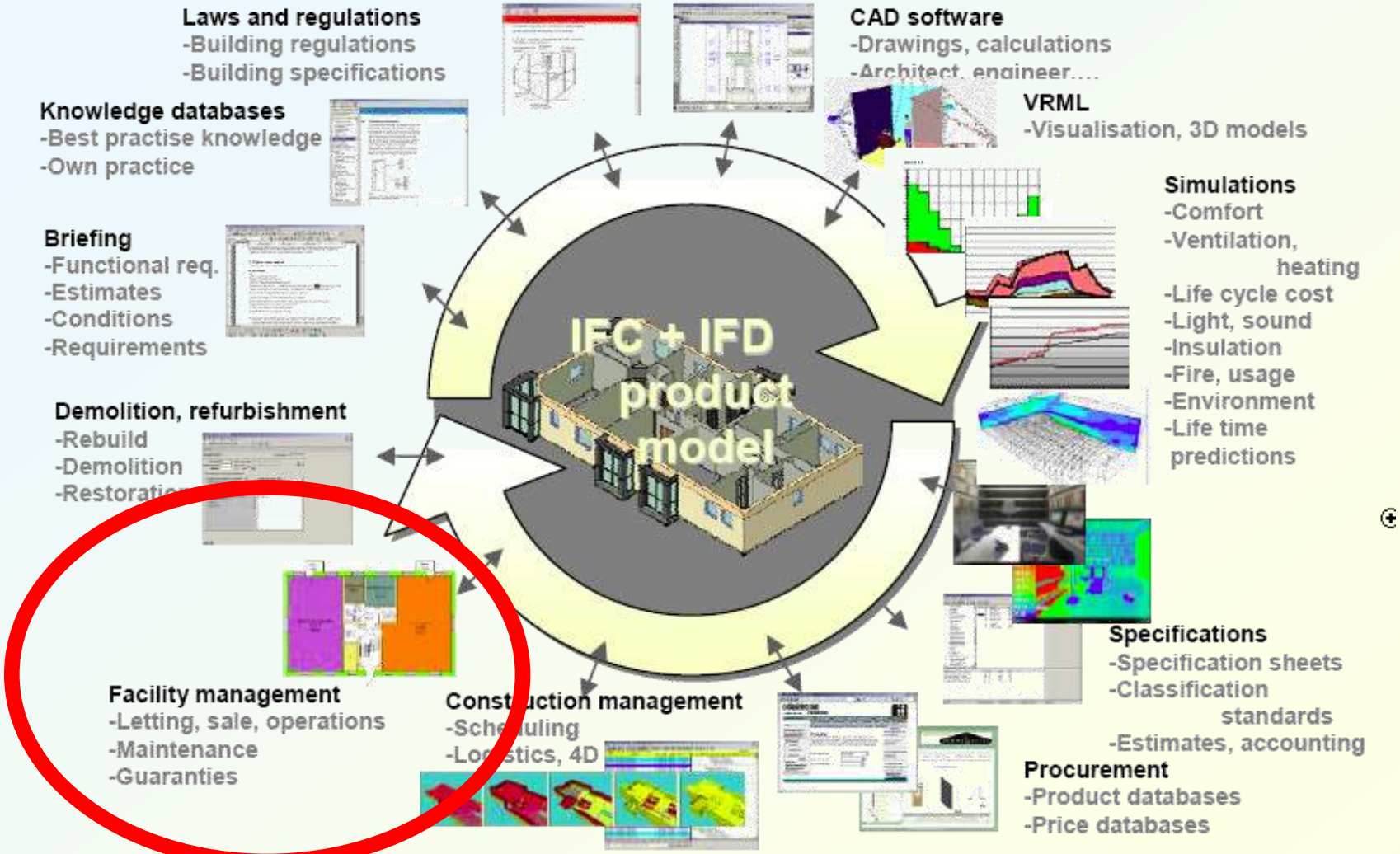


Figure 3.2-4 - BIM Relationships (drawing courtesy IAI International and AEC Infosystems, Inc)

Slide taken from NBIMS V1

NBIMS Model View Development Process

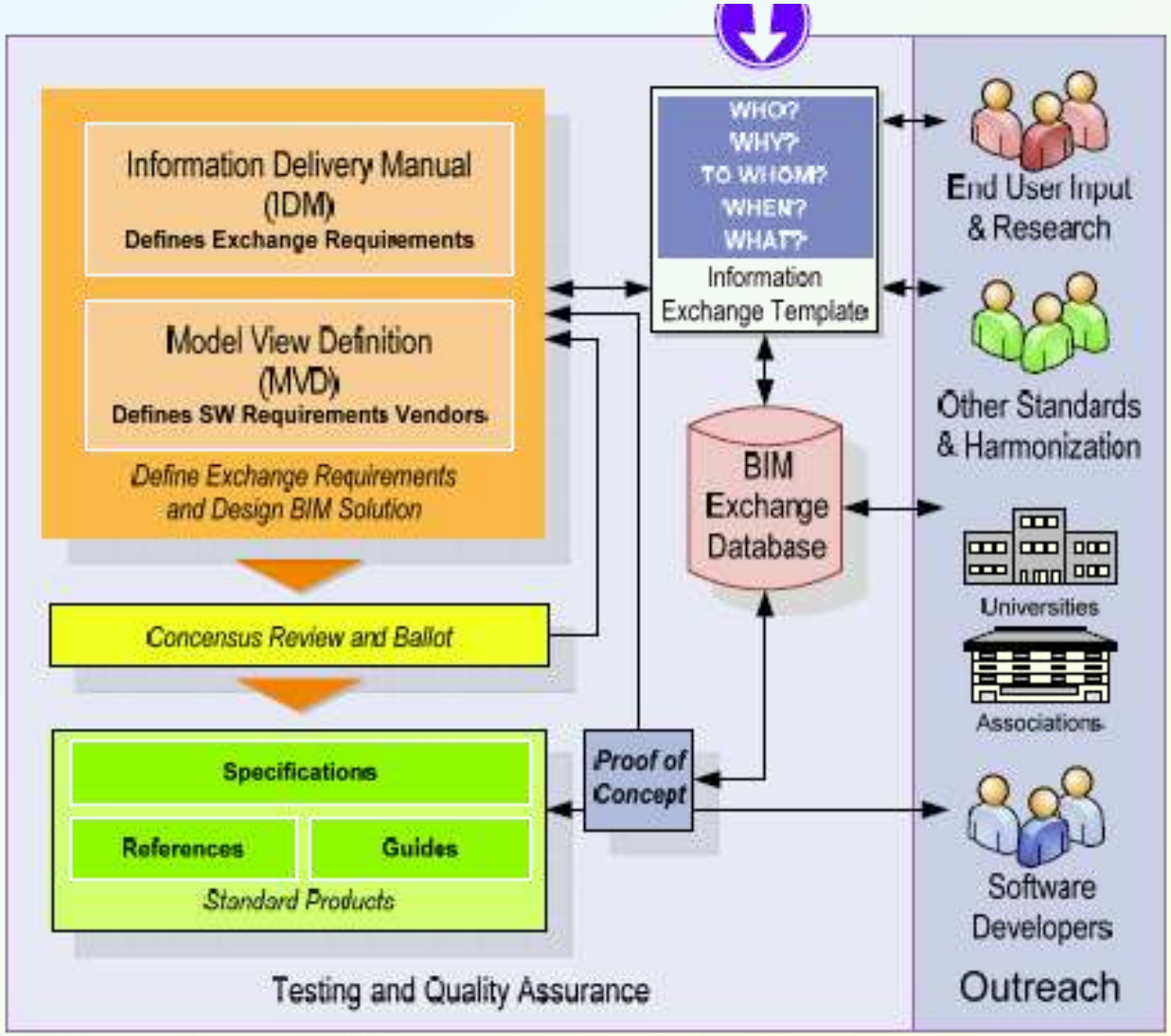


Figure 5.1-1 - NBIM Standard Concept Diagram

http://www.facilityinformationcouncil.org/bim/pdfs/NBIMS_Initiative.jpg

GSA Model View Implementation

United States General Services Administration requirements for space planning and assessment

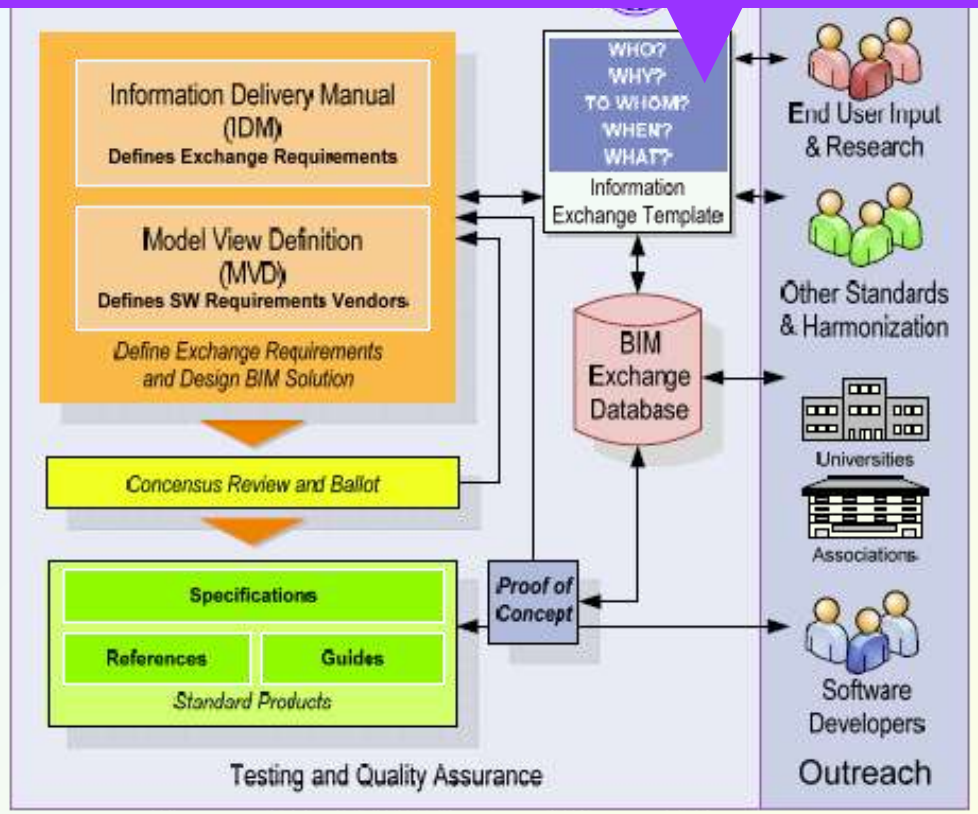


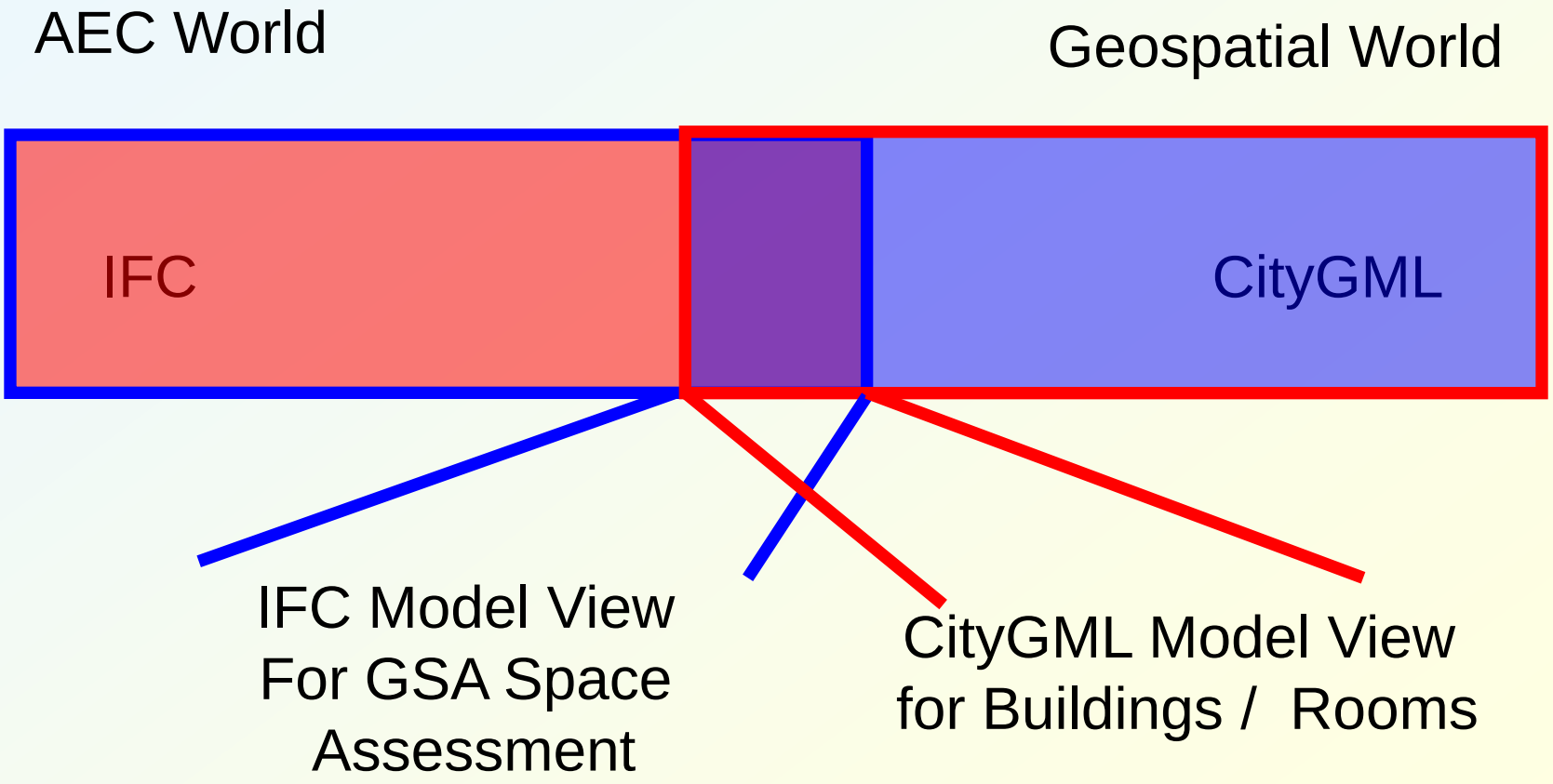
Figure 5.1-1 - NBIM Standard Concept Diagram
http://www.facilityinformationcouncil.org/bim/pdfs/NBIMS_Initiative.jpg

Model View Import/Export Supported in many authoring tools

Autodesk, Onuma, Bentley, Graphisoft, Others

Bridging AEC and Geospatial Information Models

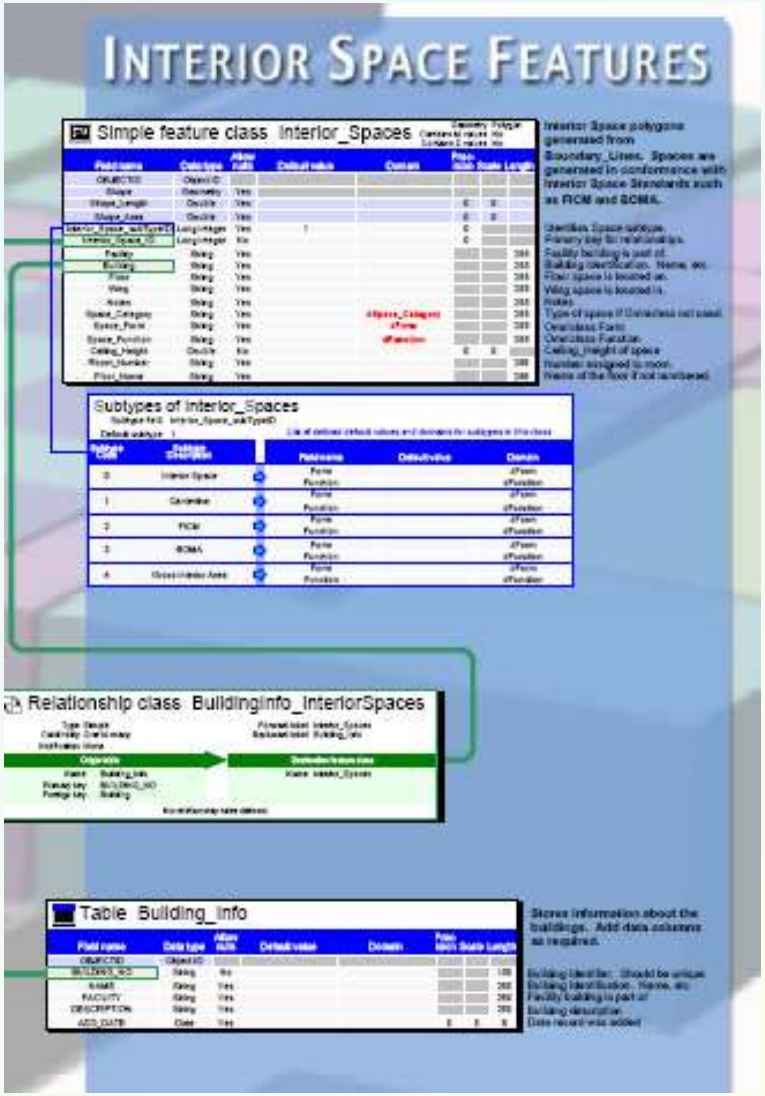
The OGC Testbed, Phase 4 developed a mapping between the GSA model view and concepts from CityGML



Case 1:

Interoperability Between BIM Authoring Tools and a GIS/Relational Model for Interior Spaces

A Relational / GIS Data Model for Space Planning



Application Data Model

→ ESRI Geodatabase

→ Any ISO Compliant Spatial Database

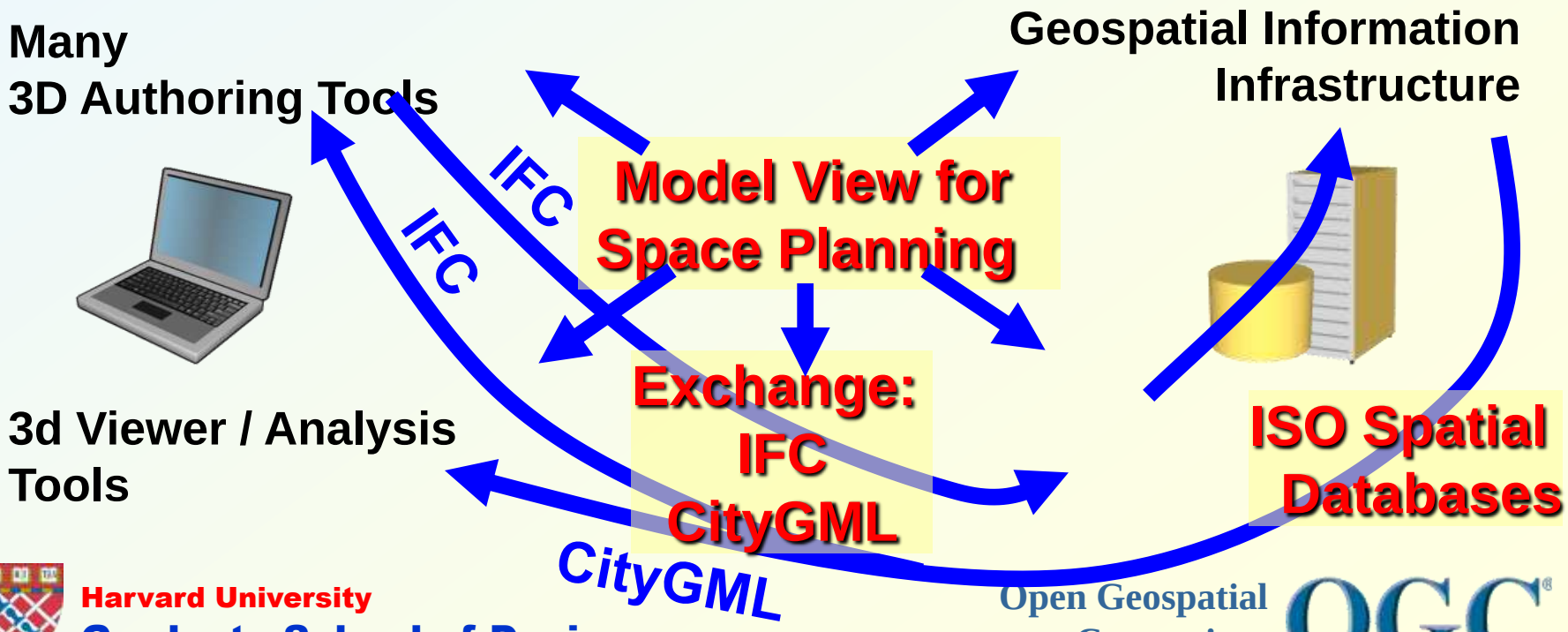
Exchange (potential)

→ IFC Model View

→ CityGML

The Road Ahead for Metropolitan 3D

Development and maintenance of detailed 3d models of large urban areas will require collaborative effort across information domains of Architecture, Engineering, Construction and Facilities Management (AEC+FM) and Geospatial Information Systems (GIS)



Case 2:

Evolution of a Sustainable Metropolitan-Scale 3d City Model from Local Municipal GIS Infrastructures

Intro and Acknowledgements

This project documents work sponsored by the Town of Brookline, Massachusetts GIS Department Feng Yang, Director.

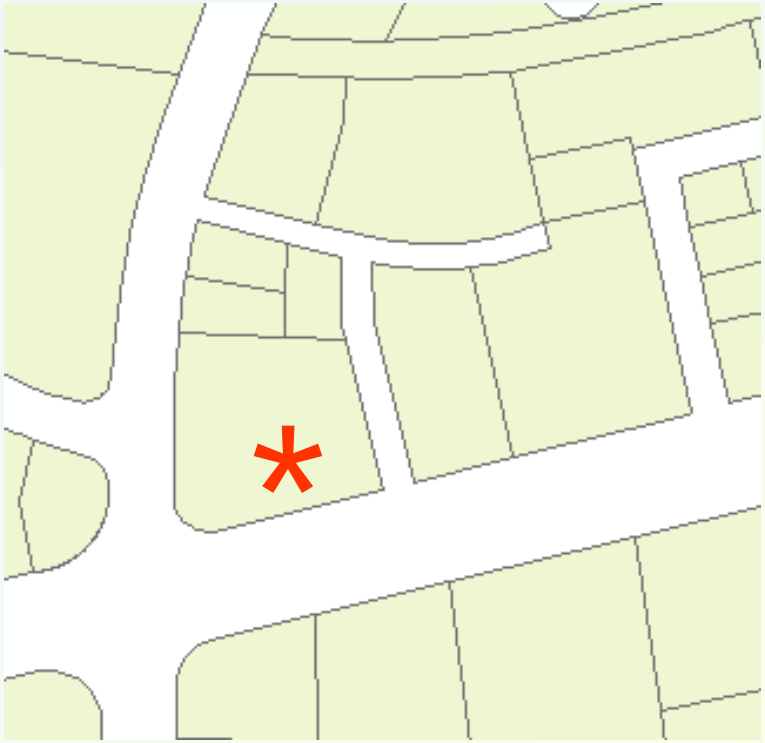
3D Applications with Existing Resources

Difficulties:

- How to organize lots of 3d of buildings models?
- How to integrate representations of buildings with town's GIS?
- How to keep many broad-scale models made for specific purposes/locations in sync with continually improving model repository?
- How to evolve model management system to deal with interior spaces and emergency preparedness detail?
- How to ensure that model assets will continue to be moved from one system to another as technology changes?

Existing GIS Layers: Parcels

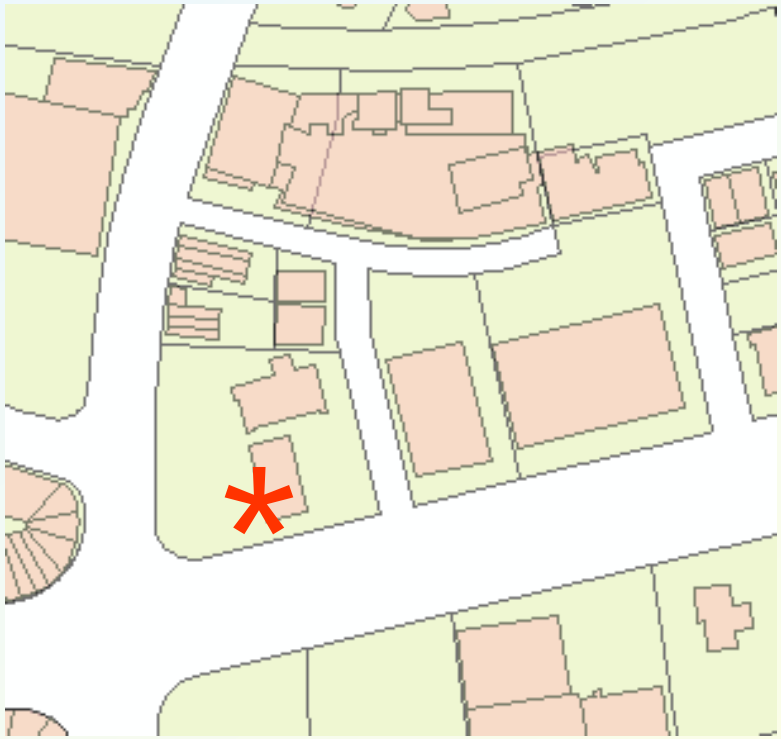
Each town in the metro area has a parcels layer that forms a decent source of information about buildings. We alter the parcel ID by appending a 3 character territory code and an _P so that the parcel IDs are assured to be unique within a multi_town schema.



Parcel Attributes	
Shape	Polygon
Territory	Brookline
Parcel_ID	Brk_P189-24-29
Owner	Mobil Oil Co
Year Built	1971
Address	333 Boylston St
Stories	1

Existing Layers: Building Footprints

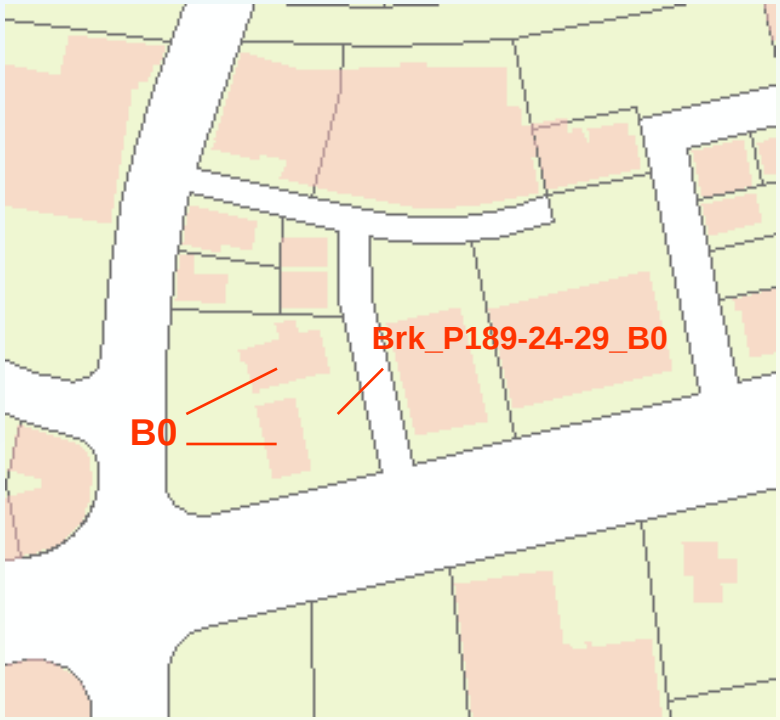
Each town has a building footprints layer established from a photogrammetric survey



Footprint Attributes	
Shape	Polygon
Unique ID	9498754

New Table: Abstract Buildings

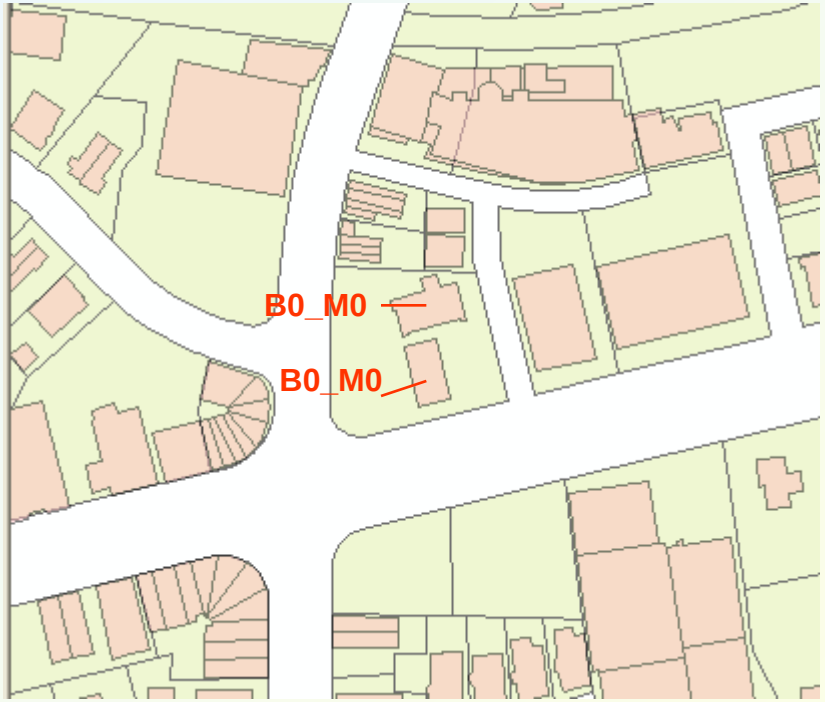
The Parcels table can form a table of information about buildings. Unique Building IDs are created from Parcel IDs. This table has no geometry associated with it. Any building associated with a parcel are designated Building 0. This lumping is inaccurate, but sufficient for an initial buildings table.



Abstract Buildings	
Territory	Brk
Bld_id	Brk_P189-24-29_B0
Owner	Mobil Oil Co
Const_dt	1971
Demo_dt	Null
Address	333 Boylston St
Built	Yes
Priv	Public
Stories	2

New Layer: Building Massing Parts

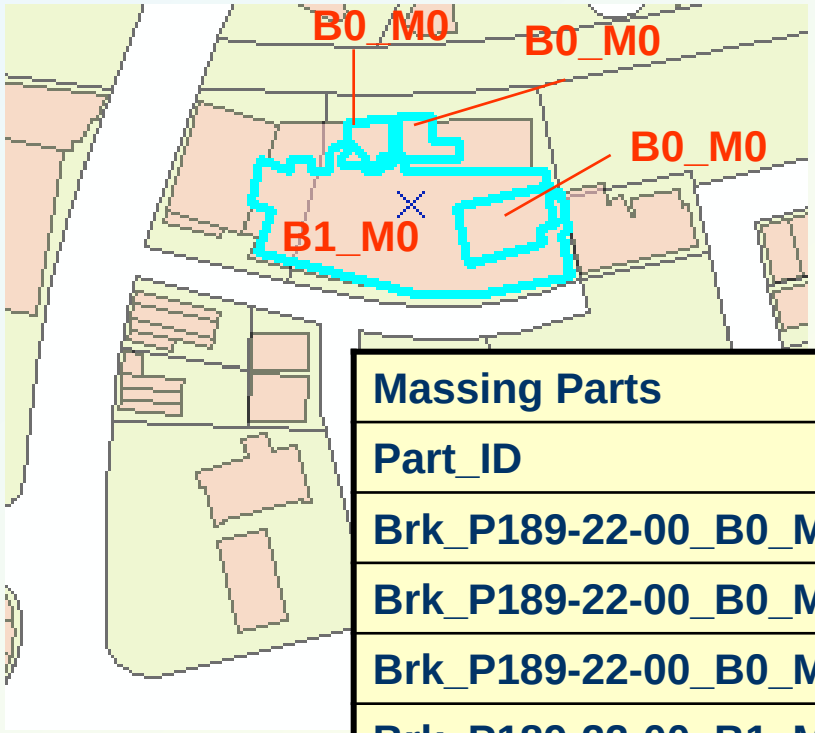
Building footprints are associated with information from the Abstract Buildings Table through a spatial join with the parcels table. Each polugon is given a Massing Part ID, formed by appending a _M0 to the Building ID. Initially, all building parts associated with a parcel have the same ID, which works fine until you have reason to distinguish building parts.



Building Massing Parts	
Shape	Polygon
Bld_id	Brk_P189-24-29_B0
Pt_ID	Brk_P189-24-29_B0_M0
Const_dt	1971
Demo_dt	Null
Built	Yes
Priv	Public
Height	35
Deprec	No

New Layer: Building Massing Parts

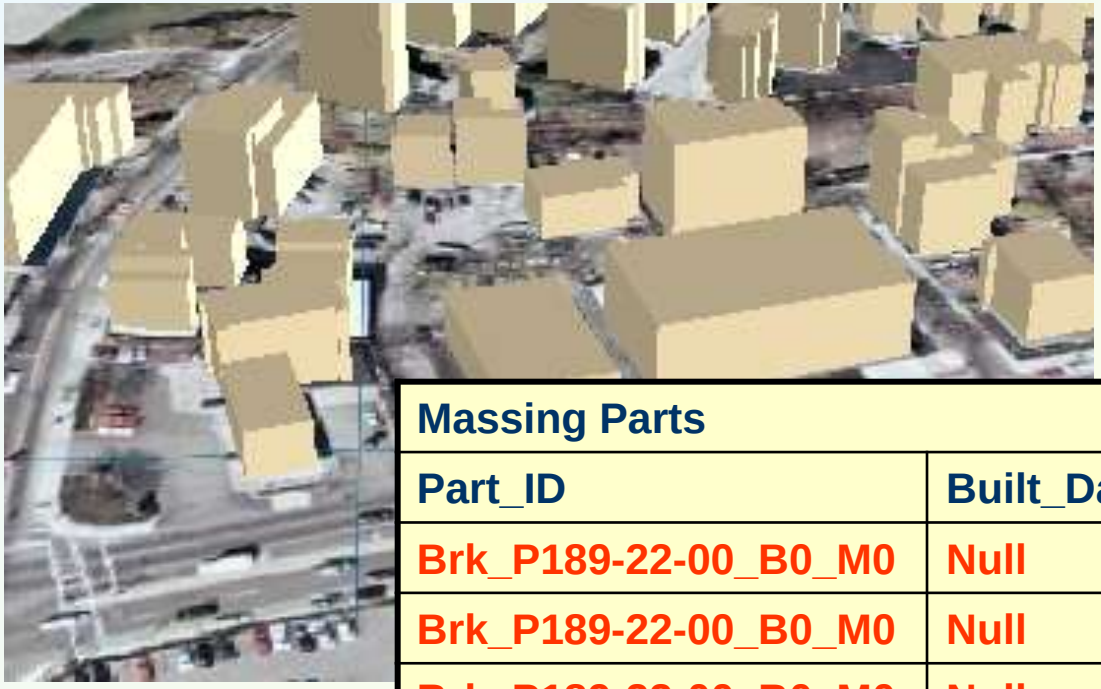
Where individual building parts vary in terms of their attributes, they may be distinguished with Part IDs and individual built and demolished dates, Heights, etc. This example shows three building parts that were demolished in 2002 and replaced with a larger taller building.



Massing Parts			
Part_ID	Built_Date	Demo_Date	Height
Brk_P189-22-00_B0_M0	Null	2002	35
Brk_P189-22-00_B0_M0	Null	2002	42
Brk_P189-22-00_B0_M0	Null	2002	37
Brk_P189-22-00_B1_M0	2002	Null	60

Date-Specific Building Massing Views

The Massing Parts Layer forms a complete model of every building in the metro area at a low level of detail (CityGML LOD2). A simple SQL Query can create a view of this model at any period in time (assuming the data are correct.)

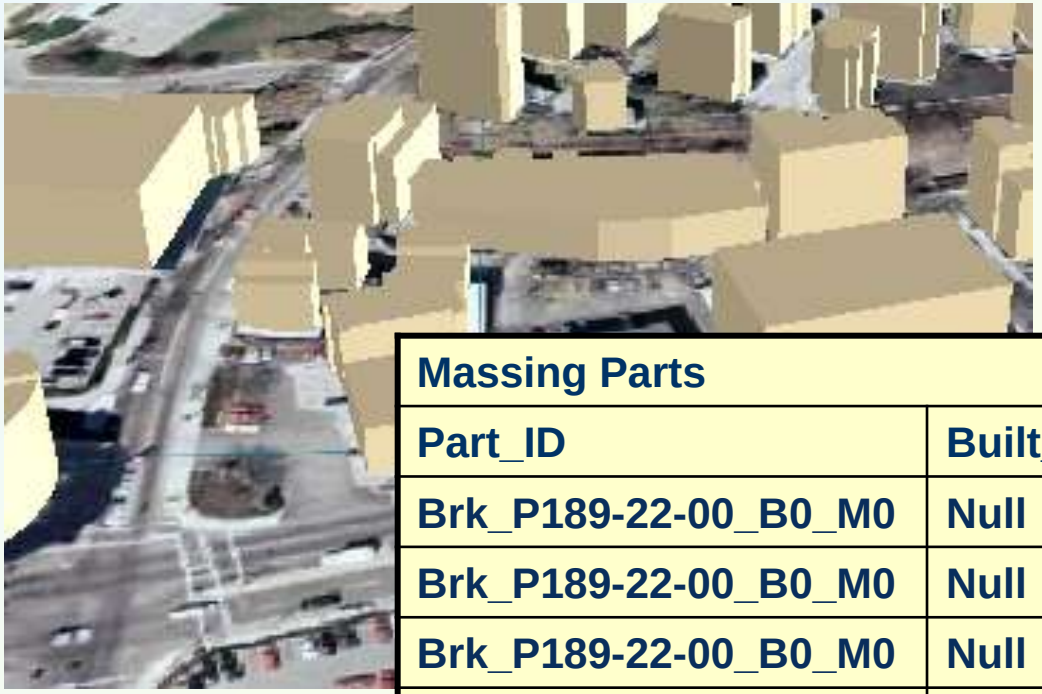


```
Select Massing Parts
Where
Built_Date < 2001
AND
Demo_Date >= 2001
```

Massing Parts			
Part_ID	Built_Date	Demo_Date	Height
Brk_P189-22-00_B0_M0	Null	2002	35
Brk_P189-22-00_B0_M0	Null	2002	42
Brk_P189-22-00_B0_M0	Null	2002	37
Brk_P189-22-00_B1_M0	2002	Null	60

3d Building Massing Parts Model

The Massing Parts Layer forms a complete model of every building in the metro area at a low level of detail (CityGML LOD2). A simple SQL Query can create a view of this model at any period in time (assuming the data are correct.)

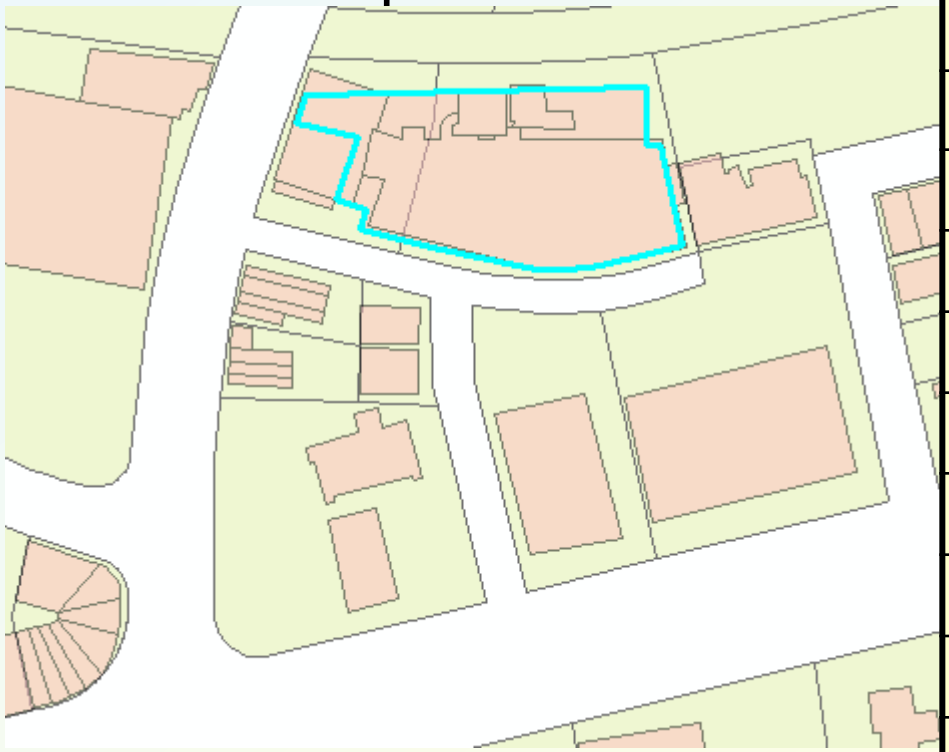


```
Select Massing Parts
Where
Built_Date < 2003
AND
Demo_Date >= 2003
```

Massing Parts			
Part_ID	Built_Date	Demo_Date	Height
Brk_P189-22-00_B0_M0	Null	2002	35
Brk_P189-22-00_B0_M0	Null	2002	42
Brk_P189-22-00_B0_M0	Null	2002	37
Brk_P189-22-00_B1_M0	2002	Null	60

Deprecated Building Parts

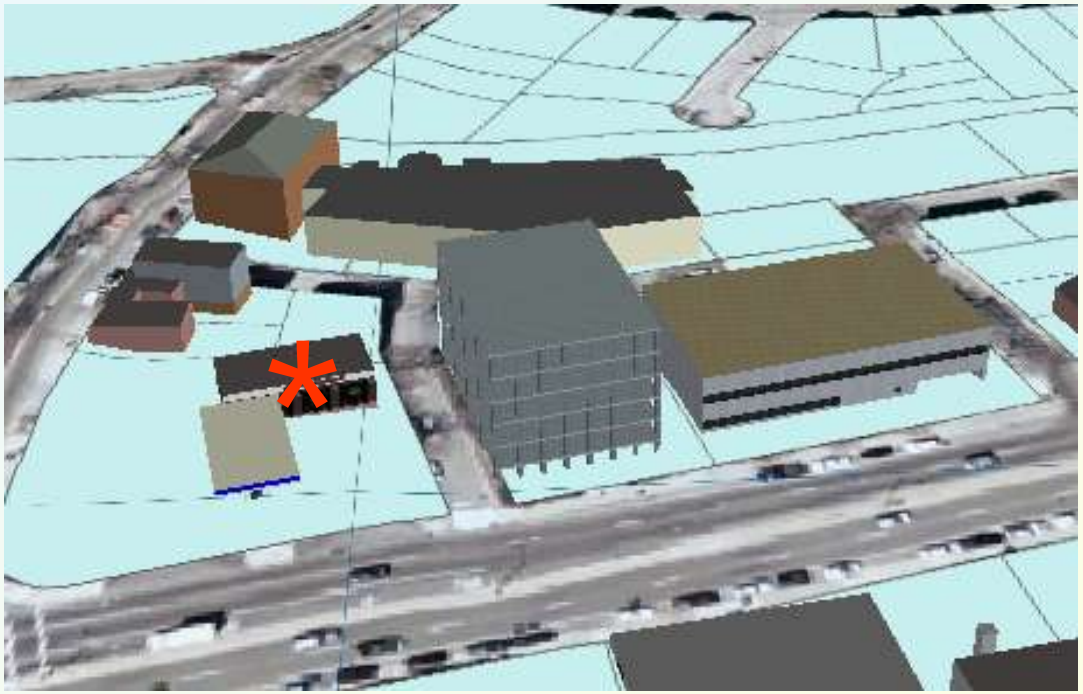
Older versions of building parts may be deprecated so that they do not render in any date scenario. It may be useful to preserve these old versions in the database. A notes field allows information about newer and older versions to be preserved.



Building Massing Parts	
Shape	Polygon
Bld_id	Brk_P189-24-29_B0
Pt_ID	Brk_P189-24-29_B0_M0
Const_dt	1971
Demo_dt	Null
Built	Yes
Priv	Public
Height	35
Deprec	1

3d Building Skin Models

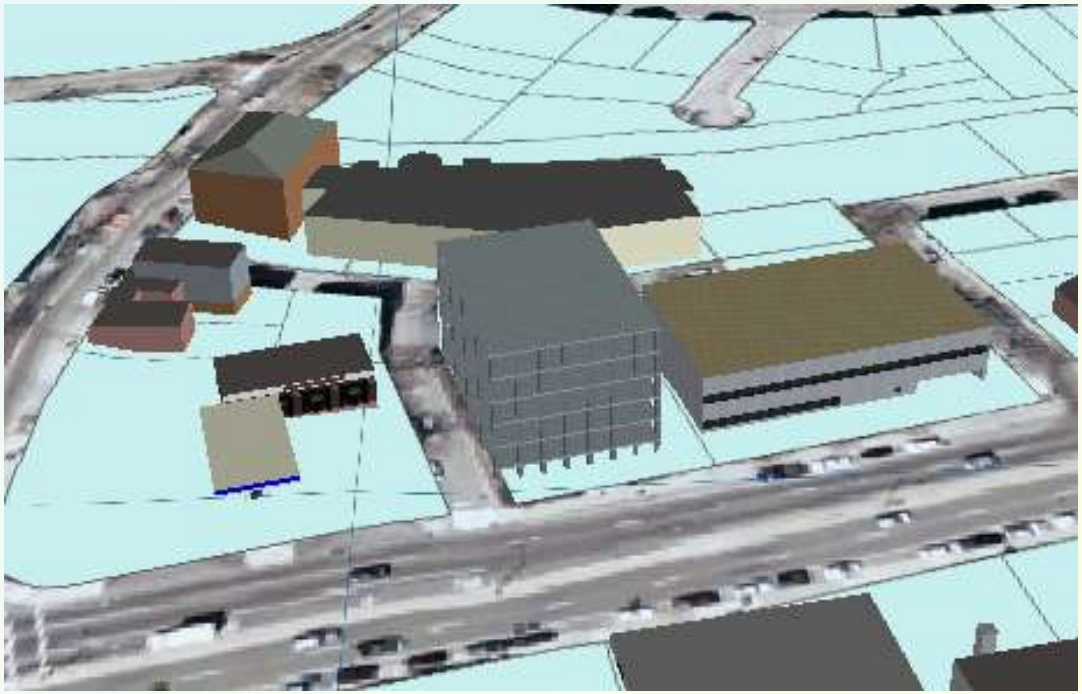
Using a 3D authoring tool, models of building exterior skins can be encapsulated as sketchup or collada models and placed into relational tables as georeferenced objects. Like Massing Parts, Skin Parts carry the forign ID of their parent abstract buildings and may have more specific attributes.



Building Skin Parts	
Shape	Multipatch or other
Model	Sketchup or Collada Blob
Bld_ID	Brk_P189-24-29_B0
Part_ID	Brk_P189-24-29_B0_S0
Owner	Null
Built	1971
Demo	Null
Built	Built
Priv	Public

Date-Specific Skin Model Views

Building Skin parts may be selected based on the Built and demolition dates (either of themselves or their parents in the Abstract Buildings Table. A query such as this generates a date specific view of the collection. The query is actually a bit more complicated than shown below. The real SQL is given in the full documentation.



```
Select Skin Parts
Where
Built_Date < 2001
AND
Demo_Date >= 2001
```

Date-Specific Skin Model Views

Building Skin parts may be selected based on the Built and demolition dates (either of themselves or their parents in the Abstract Buildings Table. A query such as this generates a date specific view of the collection. The query is actually a bit more complicated than shown below. The real SQL is given in a later slide.

```
Select Skin Parts
Where
Built_Date > 2001
AND
Demo_Date >= 2001
```

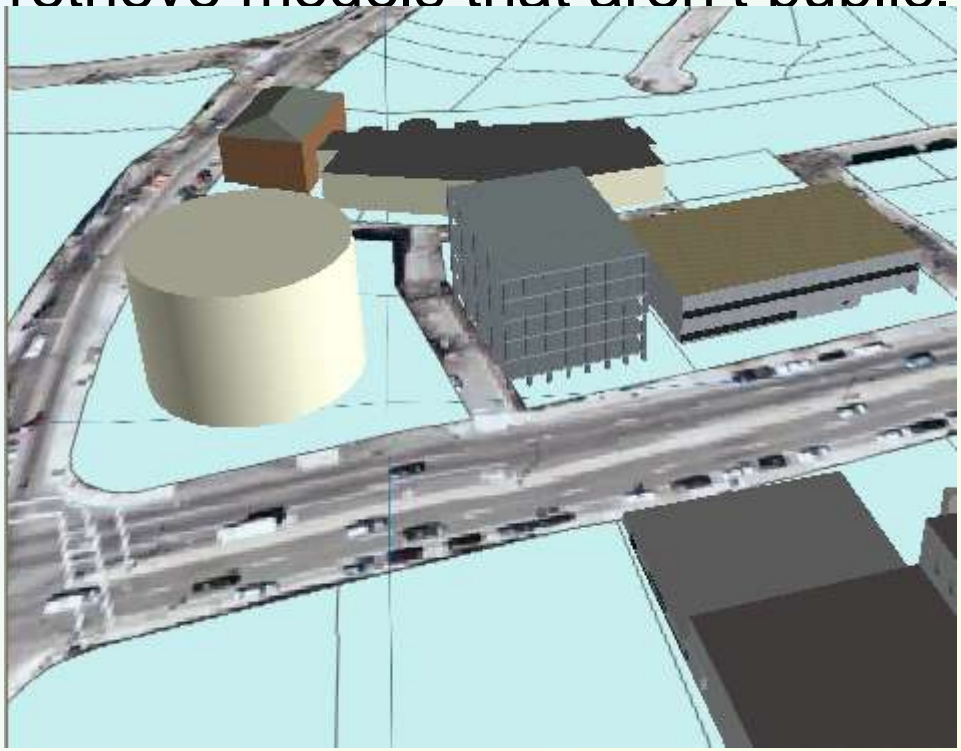
3d Building Skin Parts

Buildings that have never been built may be added to the repository. The "Built" attribute in this case would be set to "Unbuilt." The example below shows a scenario where the gas station would be replaced with an Ice Cream Parlor.

Building Skin Parts	
Shape	Multipatch or other
Model	Sketchup or Collada Blob
Bld_ID	Brk_P189-24-29_B0
Part_ID	Brk_P189-24-29_B0_S1
Owner	Null
Built	1971
Demo	Null
Built	Unbuilt
Priv	Public

3d Building Skin Parts

Another scenario investigates the visual impact of a large gas storage tank on the site. This scenario is for in-house viewing only, so the Privileges attribute is flipped from "Public" to "Private." A password must be entered to retrieve models that aren't public.



Building Skin Parts	
Shape	Multipatch or other
Model	Sketchup or Collada Blob
Bld_ID	Brk_P189-24-29_B0
Part_ID	Brk_P189-24-29_B0_S1
Owner	Null
Built	1971
Demo	Null
Built	Unbuilt
Priv	Private

Design Scenario Tables

In order to create custom scenarios you must be able to turn on unbuilt buildings and to turn off other buildings that would otherwise render. This is accomplished by creating Schemes and entering part-specific rendering instructions in the Scheme_Parts table. Because the Part IDs are distinct for Massing and Skin part models, the Scheme Parts table can refer to either type of part.

Scheme Parts

Pt_ID	Render	Sc_ID
Brk_P189-24-29_B0_S1	Yes	1
Brk_P189-24-29_B0_M0	No	1

Schemes

ID	Name
1	Ice Cream
2	Tank

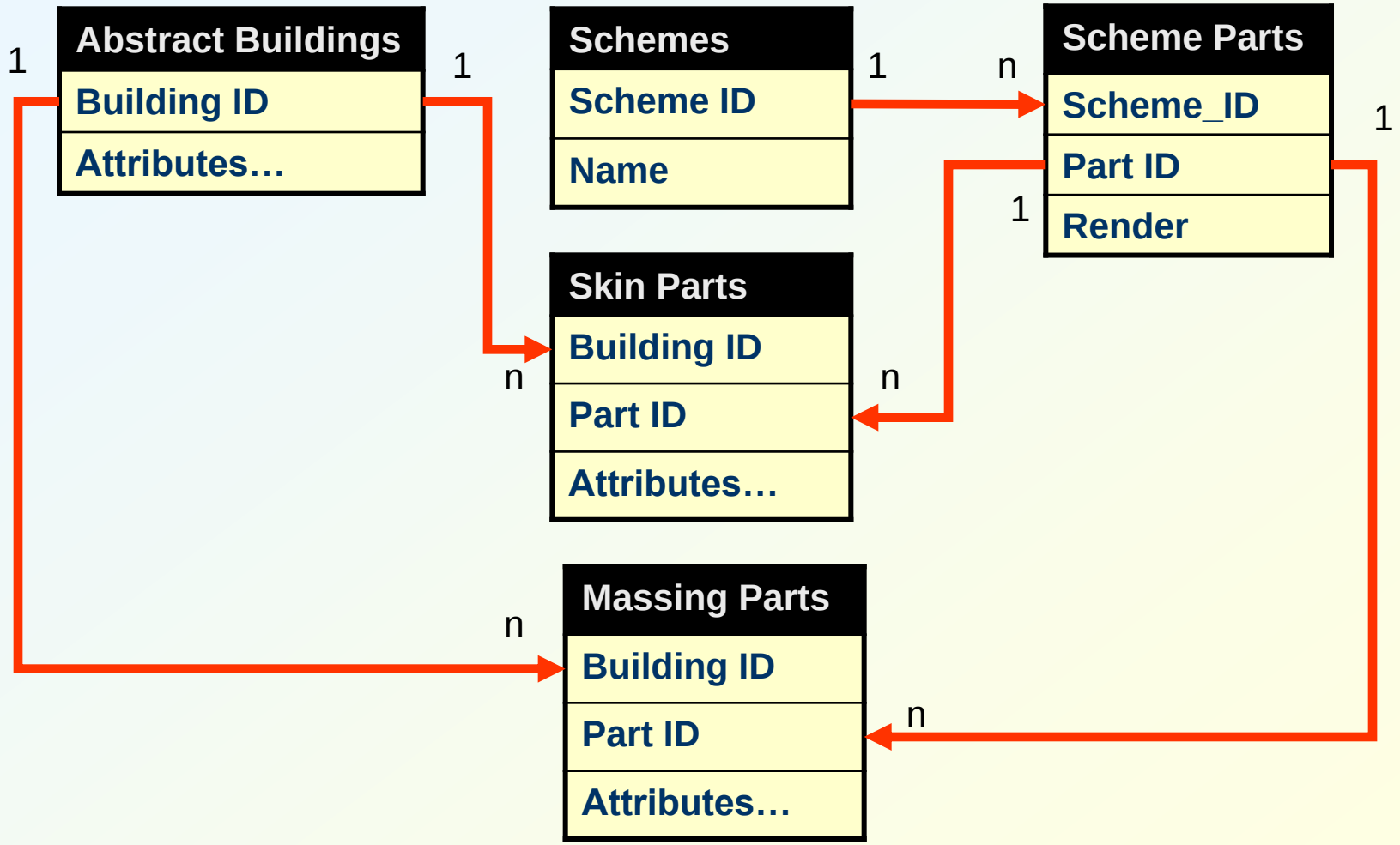
Building Skin Parts

Part_ID	Name	Built
Brk_P189-24-29_B0_S1	Ice Cream	Unbuilt
Brk_P189-24-29_B0_S2	Tank	Unbuilt
…	…	

Building Massing Parts

Part_ID	Name
Brk_P189-24-29_B0_M0	Gas Station
Brk_P189-24-29_B0_M1	…
…	…

Building Model Management Schema



Mixing Massing and Skin Models

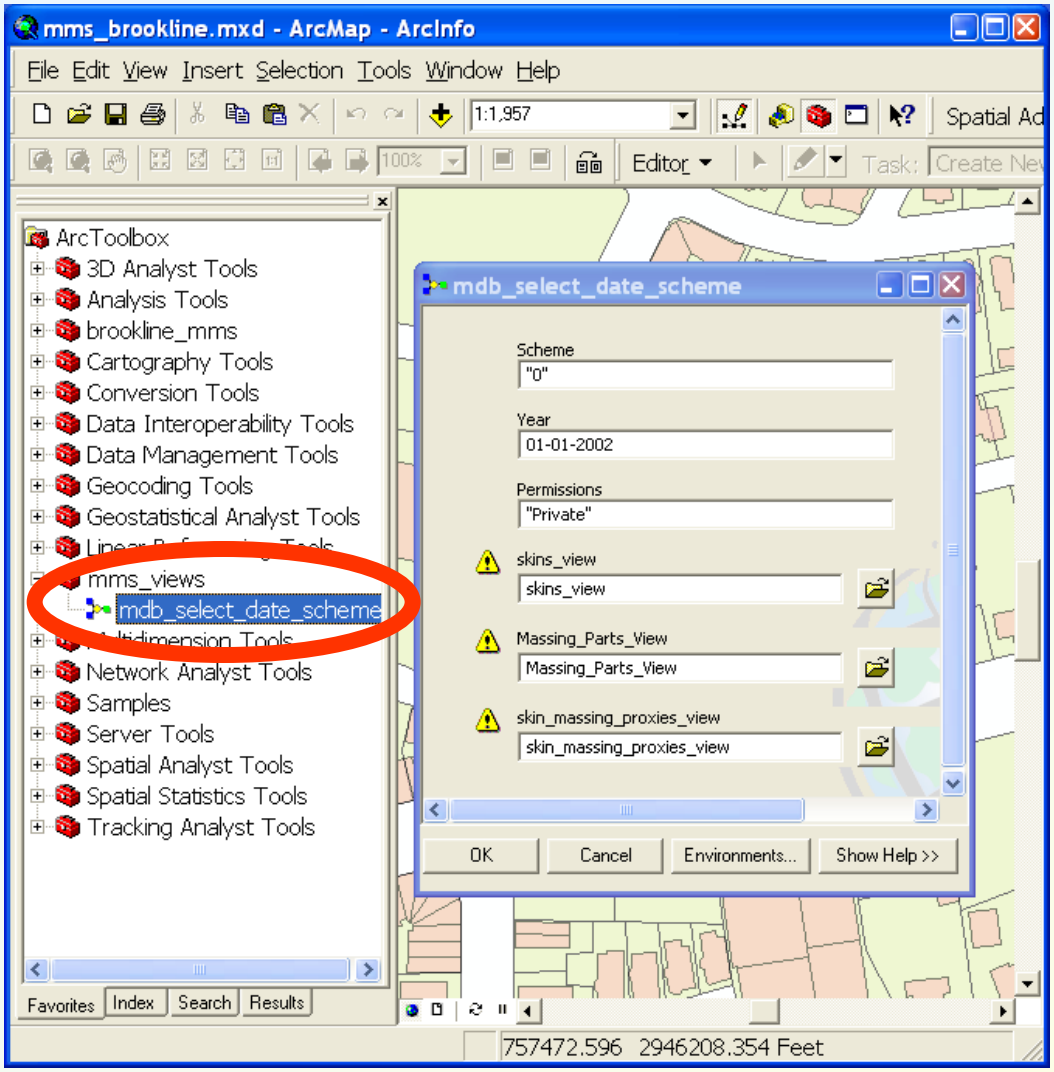
Through the elegant logic of relational databases and Structured query language (SQL) nested sub queries (to be shown below) the appropriate Skin Models may be selected to a Skins View and then the Massing models corresponding to Buildings not represented by Skins may also be selected and written to a Massing View to fill in the model.

Levels of Detail

A good 3d rendering tool will allow layers to be swapped in and out depending on the distance of their features form the viewer. So in addition to the Massing and Skins Views discussed in the previous slide, The Skin Proxies View is also created, which contains the Massing Models corresponding to the buildngs in the Skins View. When a skin model is further than a given distance from the viewppoint, the Massing Proxy is rendered instead.

This view is captured just at the view-swapping threshold.

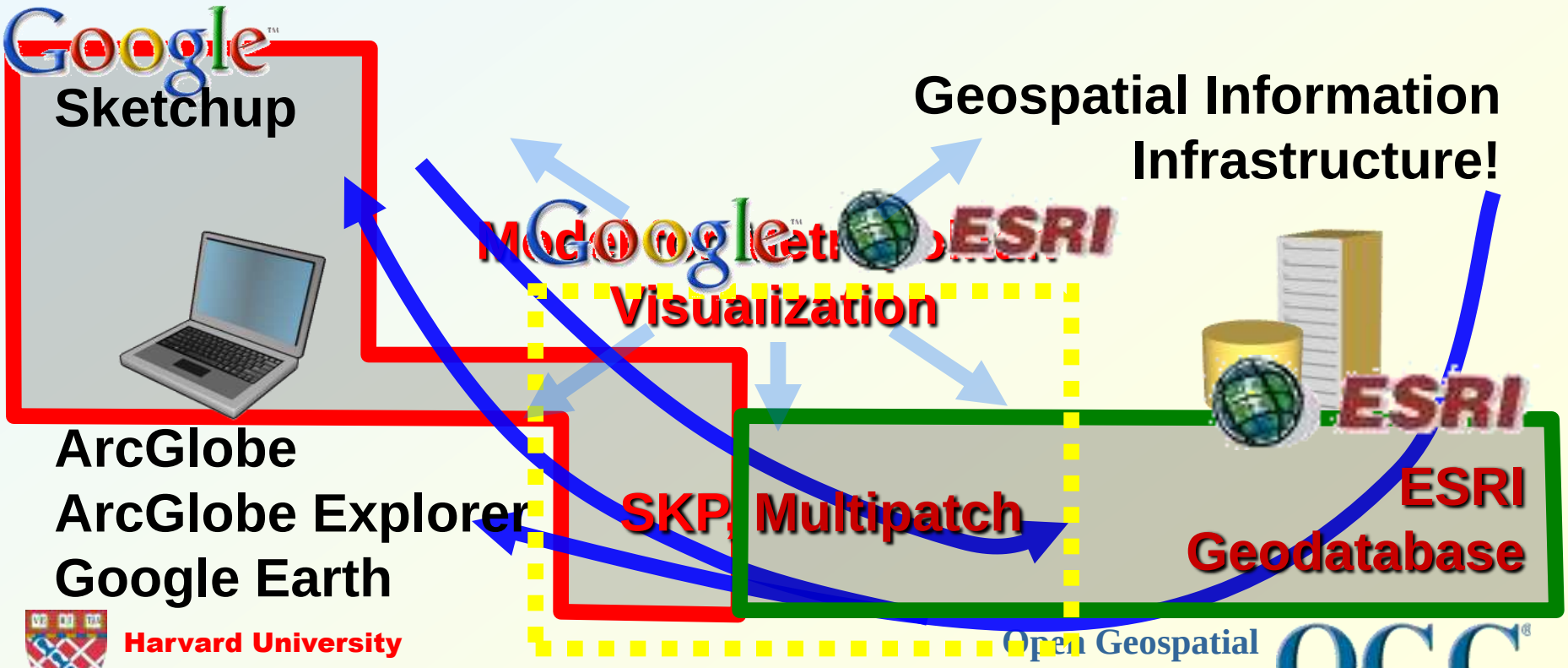
The Scheme View Tool



A tool has been created with all of the SQL to create the three views necessary to portray a Date and Scheme Specific Scenario based on the user's privileges. One needs only to double-click on the tool and fill in the blanks.

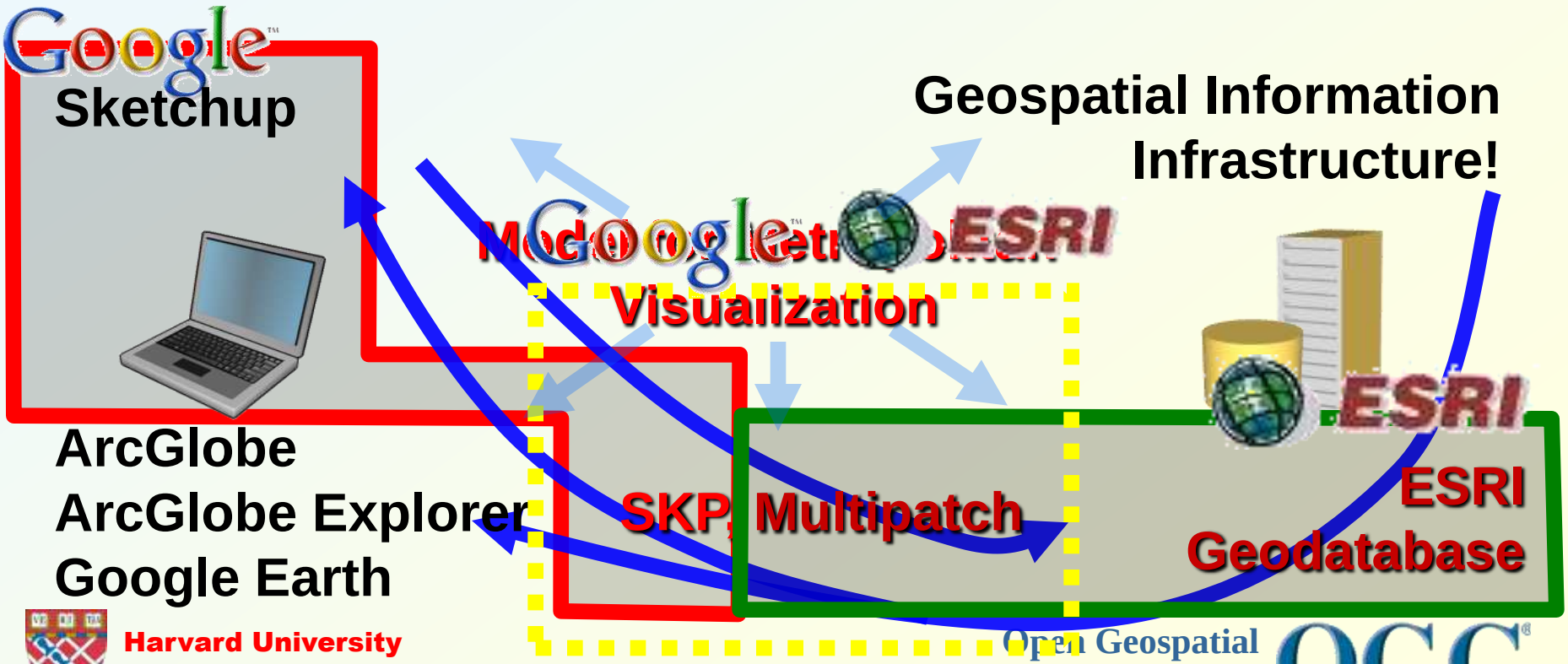
Proprietary Solutions are Fast and Easy

The plugin that tranlateses between Sketchup and ESRI Multipatch formats is an interesting case of vendor collaboration on a cross-proprietary exchange filter.



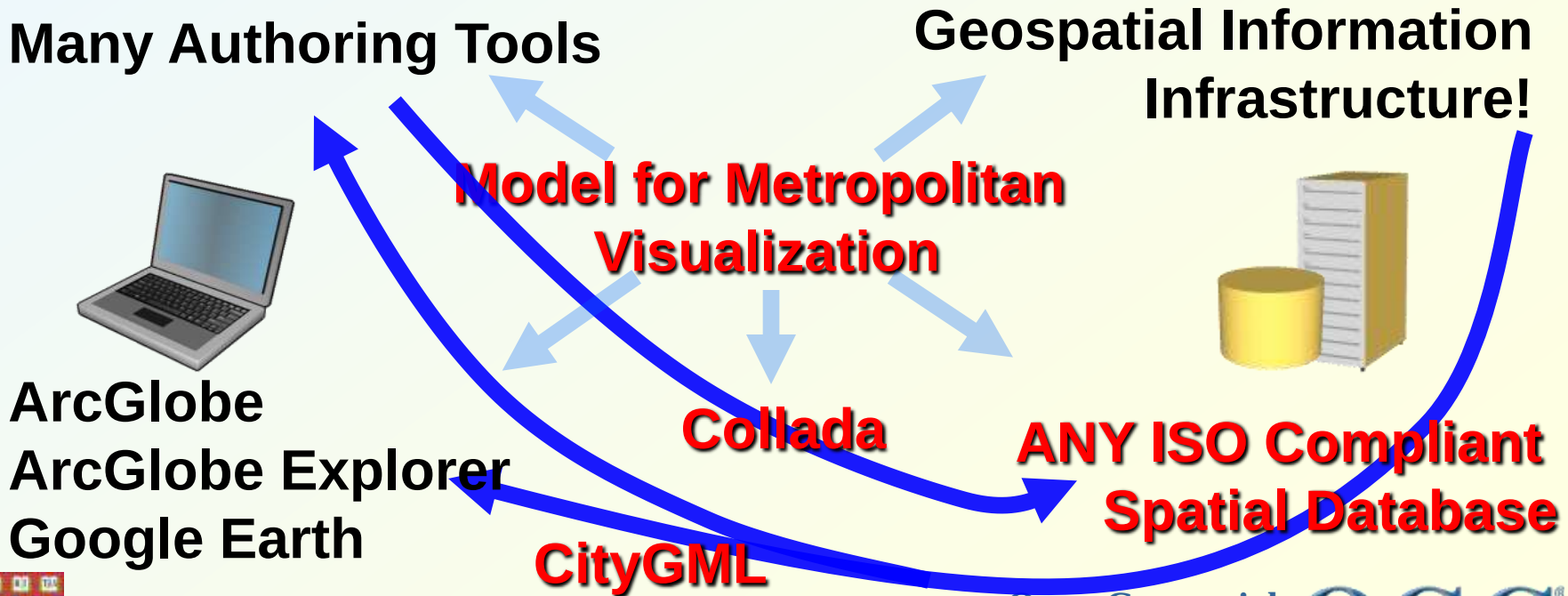
This model requires a proprietary exchange

The plugin that tranlateses between Sketchup and ESRI Multipatch formats is an interesting case of vendor collaboration on a cross-proprietary exchange filter.



Using Collada would make it much more versatile

The plugin that tranlateses between Sketchup and ESRI Multipatch formats is an interesting case of vendor collaboration on a cross-proprietary exchange filter.



Mapping of Building Schema to CityGML

Proposals to extend municipal GIS infrastructure should consider long-term costs of maintenance and upgrade in light of changes in technology and data exchange standards.

- The Abstract Buildings and Massing Parts tables can be mapped directly to CityGML LOD2 buildings
- If Building Skins are stored as Collada models, they may be exchanged as CityGML Generic City Objects
- This Data Model could be seen as fulfilling a very narrow Application Profile for Simple Temporal Building Visualizations

Service Architectures

File-Based Information Exchange

Content Requirements:
Concepts, Relationships

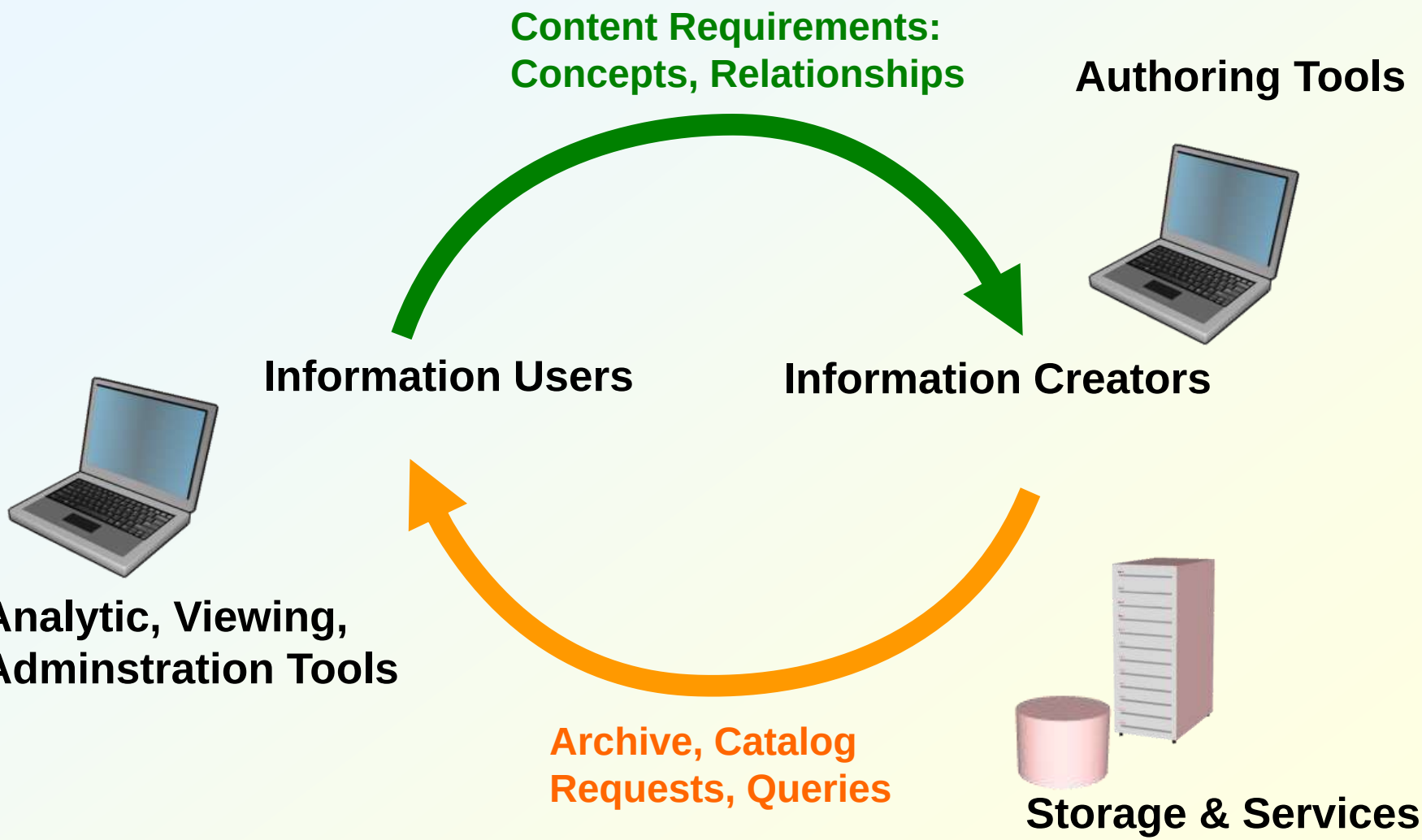
Information Users ← **Information Creators**

Email Attachments

FTP Exchange

Sneaker-Net

Service-Based Information Exchange

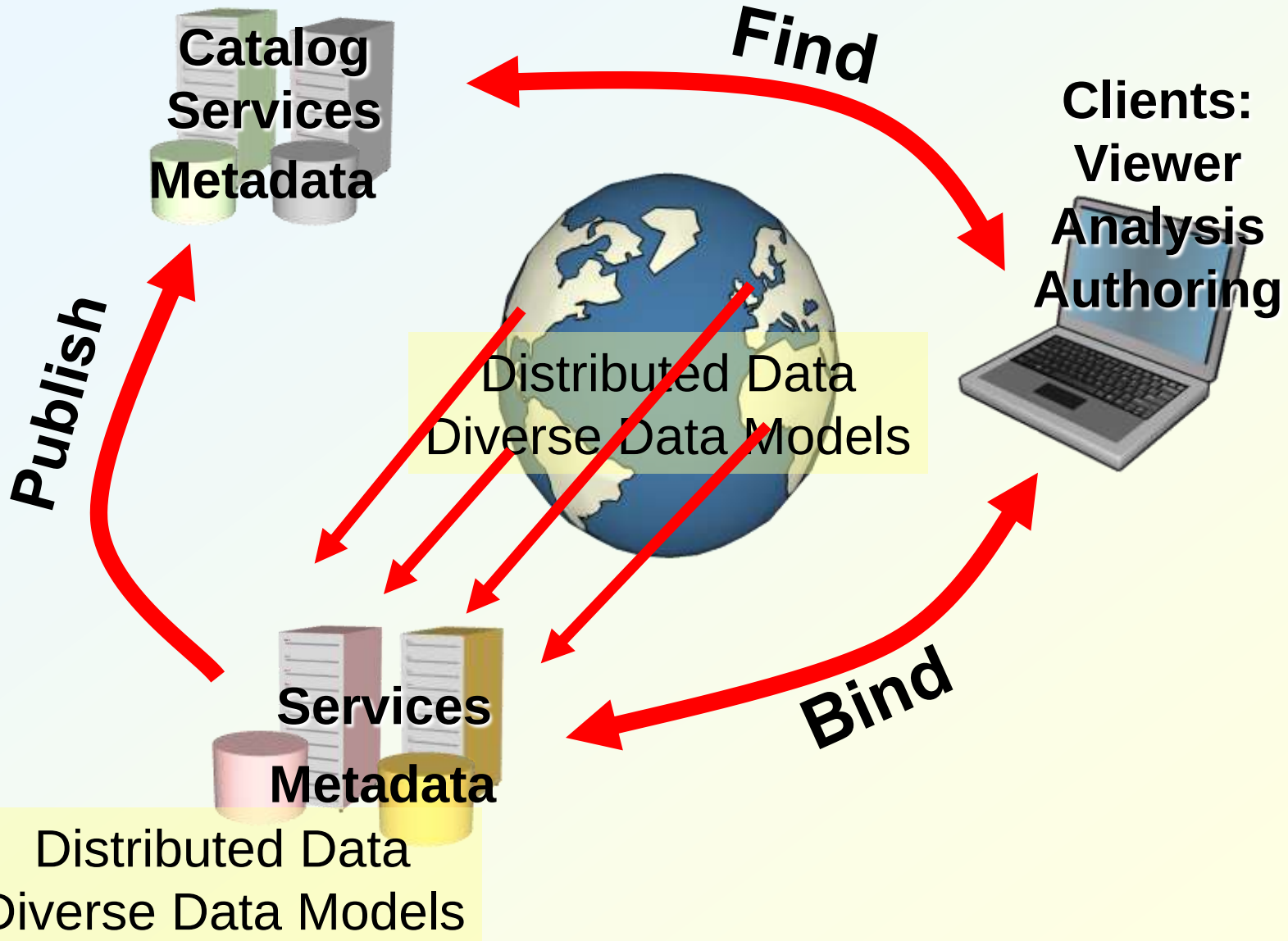


Open Geospatial Consortium

Industry Consortium for Geospatial Service and Exchange Specifications

- ~400 members from government & other large users, software companies, academia
- Specification process governed by member participation and consensus
- Several exchange and service standards have been adopted by the International Standards Organization (ISO)
  - GML: Geographic Markup Language (Exchange Standard)
  - WMS: Web Map Service (Service interface for imagery)
  - WFS: Web Feature Service (Service Interface for Features)
- Many more specifications and best practices in process!

OGC Web Services Architecture



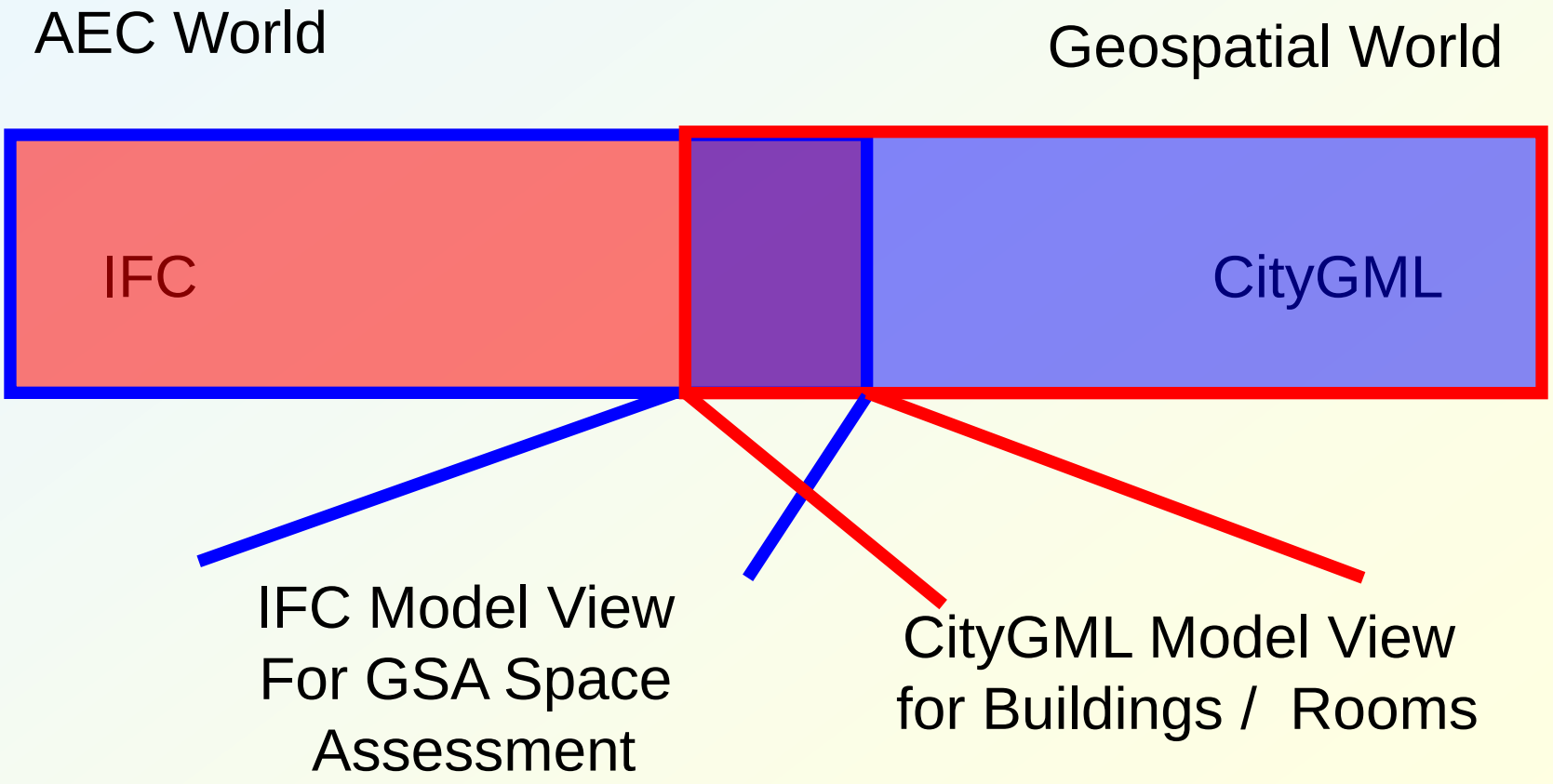
OGC Web Services Testbed 4 (OWS-4)

OWS-4 was a six month rapid prototyping testbed initiated to extend the OGC Service Architecture to integrate City Models with Building Information Models

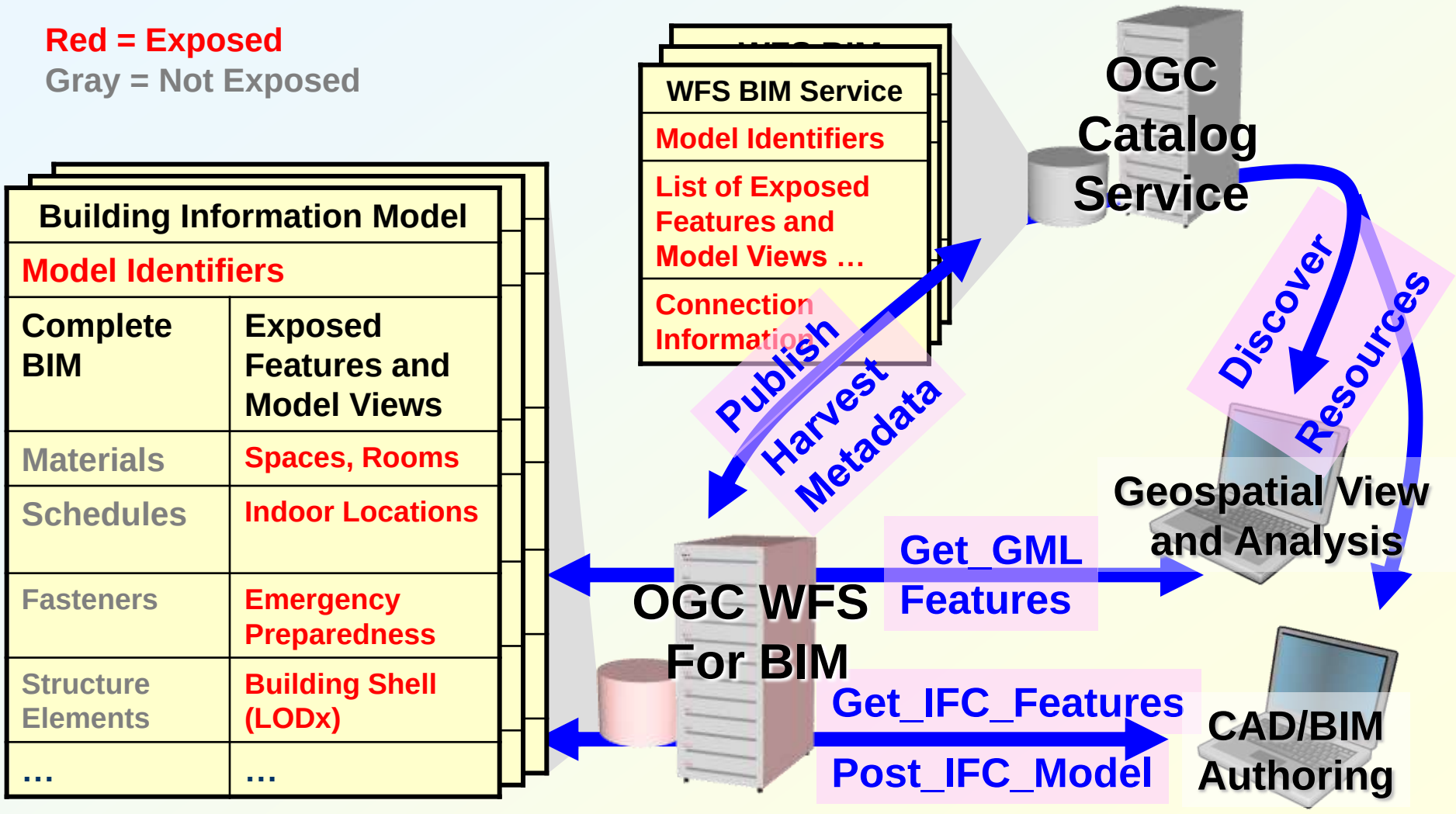
- **Developed bridge between CityGML and IFC information models (focus on GSA Model View for interior spaces). Research Center of Karlsruhe, University of Bonn, IAI.**
- **Adapted OGC Web Feature Service with interfaces for exchange of 3d models through CityGML. Snowflake Software**
- **Prototyped new WFS interfaces for Building Information Models: WFS for BIM. Onuma Inc.**
- **Adapted BIM authoring clients to interface with Geospatial web services: WMS, WFS and WFS for BIM. Bentley Systems**
- **Developed tool to retrieve and analyze models combining wholesale CityGML city models combined with information from building information models from WFS. Hasso Plattner Institute**

Bridging AEC and Geospatial Information Models

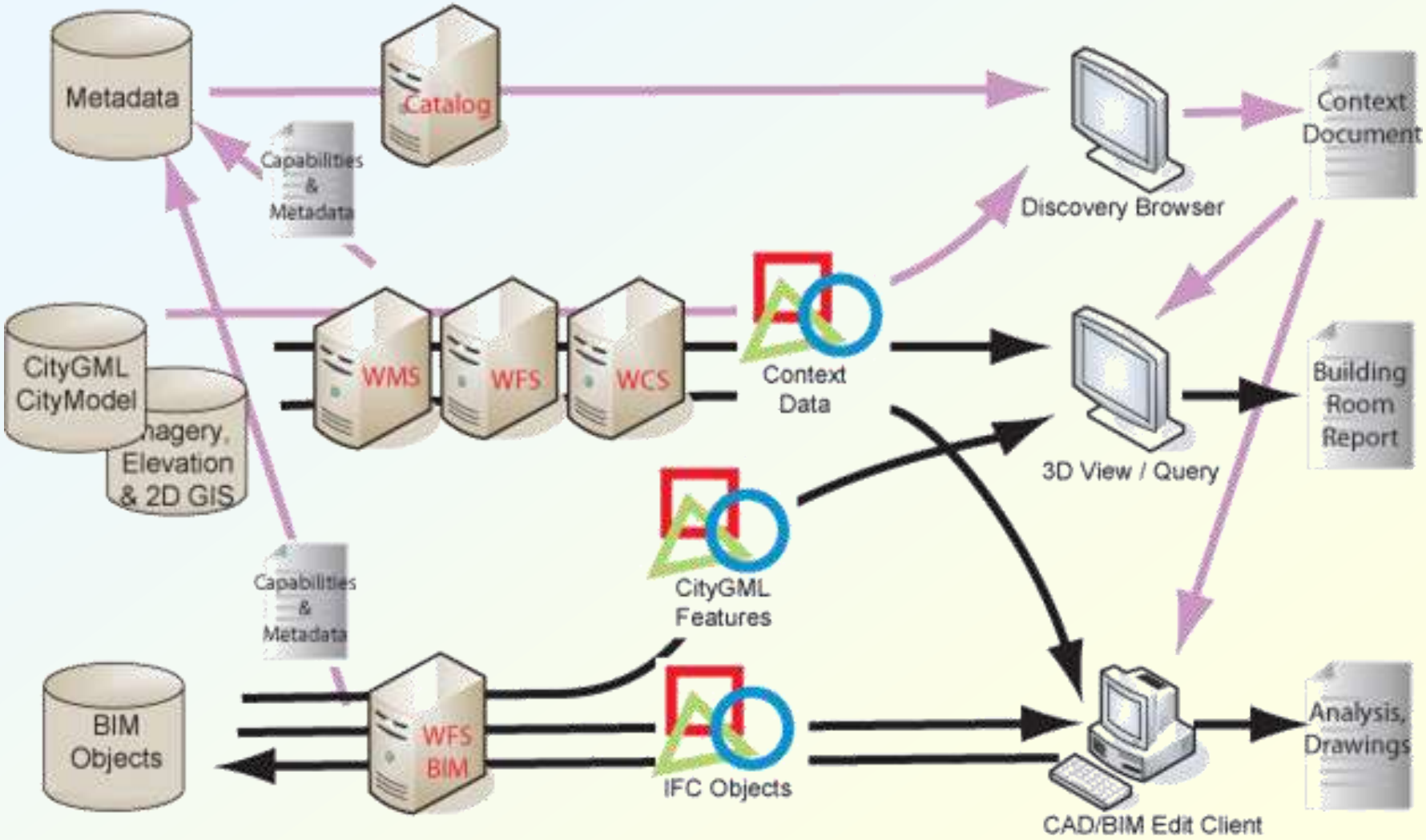
The OGC Testbed, Phase 4 developed a mapping between the GSA model view and concepts from CityGML



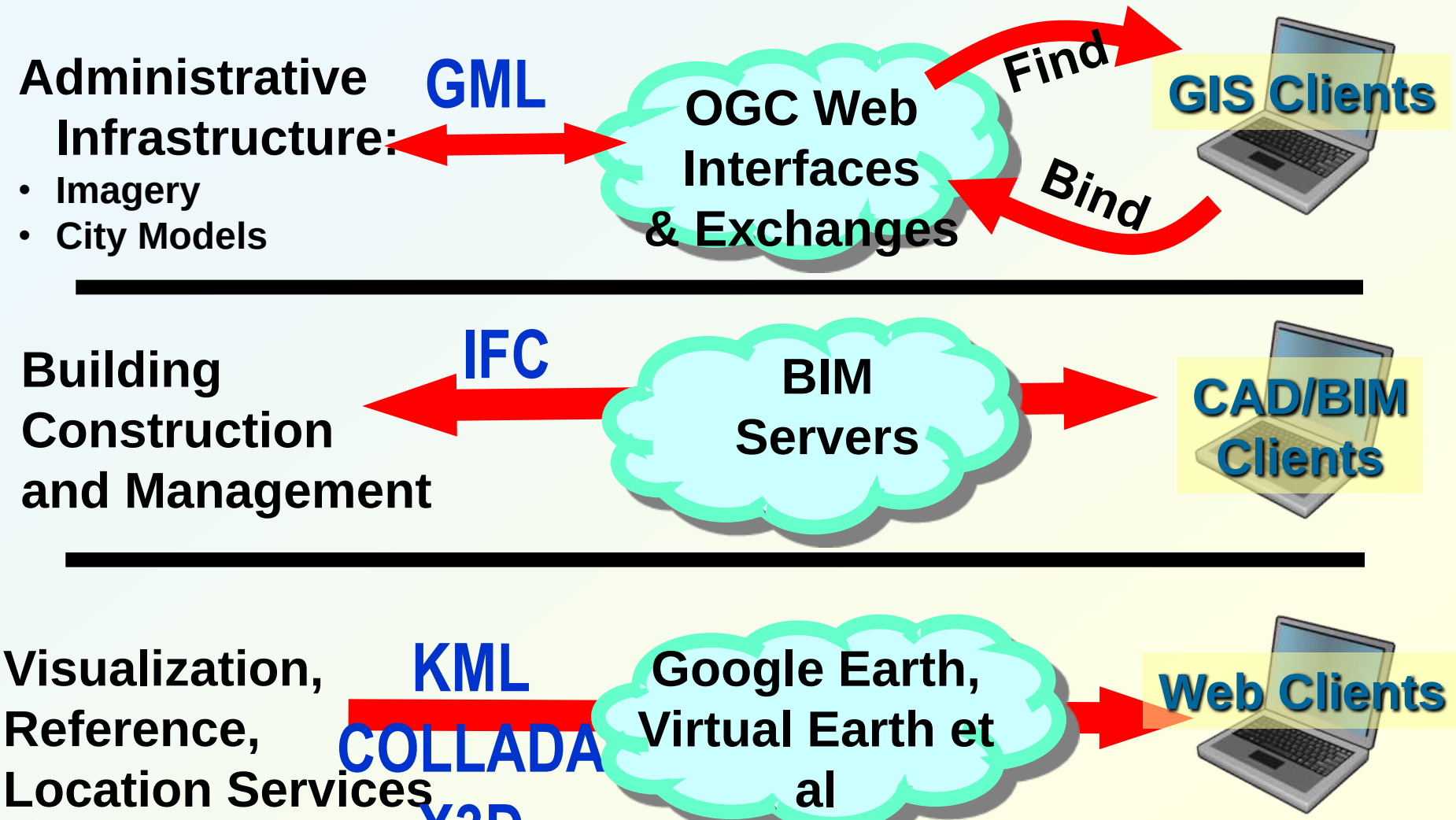
OGC Web Feature Service for Building Information Models



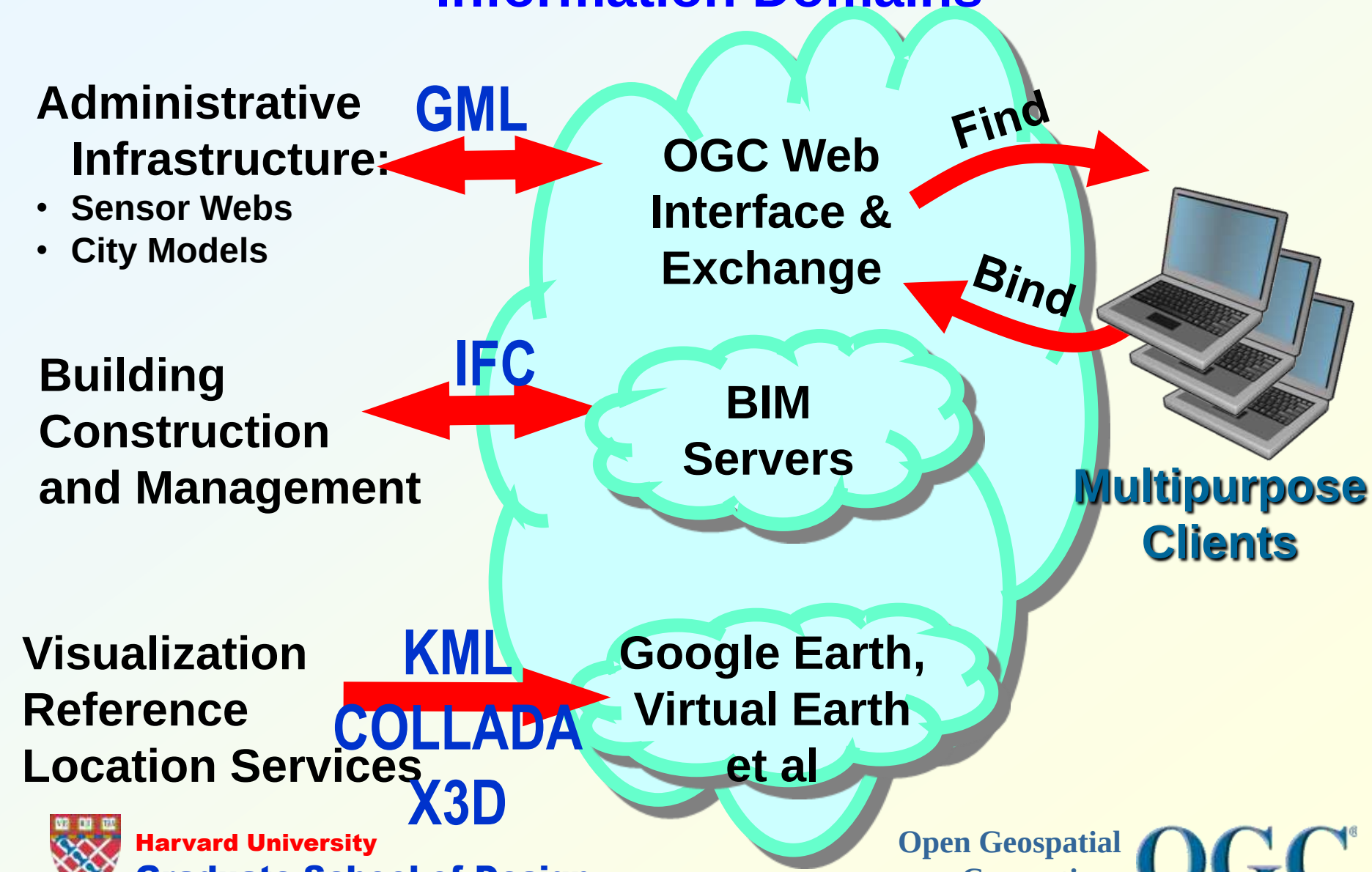
OWS-4-CGB Service Architecture



OpenGeospatial Web Services: Bridging Information Domains



OpenGeospatial Web Services Bridging Information Domains



Parting Thoughts

- Campus modeling is a collaborative effort
- That requires sharing data among many specialized tools
- Tools, information models and data models are evolving
- Open standards for interoperability are the best way to insure investments in enterprise data infrastructure

Thank You!

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Architect, Open Geospatial Consortium
Web Services Testbed for CAD GIS and BIM (phase 4)

Principal, PlaneTable Technology Co.