

Curating Architectural 3D CAD Models

FACADE

Future-proofing Architectural Computer-Aided Design

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MIT Libraries' Technology R&D

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Principal Investigator, FACADE Project

Ann Whiteside

Head, Rotch Library of Art and Architecture
MIT Libraries

In conjunction with:



Purpose for Presentation

- Awareness talk:
 - Fairly focussed problem: 3D materials, from field of architecture

- Wider applicability...
 - 3D formats preservation (science, etc.)
 - Ontology approach (large scale, non-organized dataset)

Contents of Talk

- ☐ Project Scope
 - Problem Statement; Project Proposal
 - Data Producers: Architecture Firms Today
 - Data Consumers: Audiences, Future Use Cases
 - Datasets We're Working With
- ☐ 3D CAD
 - Data Formats; Standards; CAD Tools
 - Preservation Strategies
- ☐ Ontology
 - Project Information Model, Workflow
 - Metadata, "Curators Workbench"
 - DSpace Archive
- ☐ User Interface

Project Scope

- Problem Statement; Project Proposal
- Data Producers: Architecture Firms Today
- Data Consumers: Audiences, Future Use Cases
- Datasets We're Working With

Problem Statement

- Current architectural data is being lost.
 - Architectural historians, scholars, teachers concerned
 - Libraries, museums, archives face challenge
 - *(Practitioners less so, but ...)*

Reasons Behind Problem

- CAD (3D) is complex!
 - Highly proprietary, non-standard, backwards incompatibilities, obsolescence of softwares and formats
- 3D digital preservation new territory
 - Lack of tools, standards, approaches

FACADE Project Proposal

- Prof. Bill Mitchell & MIT Libraries
 - Develop optimal long-term archiving strategy for digital architectural data
 - Especially 3D CAD models
 - Demonstrate in DSpace digital archive
 - With SIMILE user interface discovery tools
 - Using Frank Gehry MIT Stata Center dataset
 - Advanced 3D CAD tool CATIA

Data Producers: Architecture Firms

- Technology
 - Design
 - Communications, Management
- 3D CAD increasing in complexity
 - “BIM” recent initiative (Building Information Modelling)
 - Yet standards for use, naming, interoperation lacking

Building Information Modelling

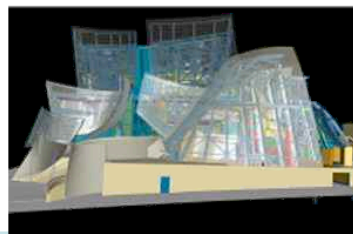
Shared Desktop : Dana K. Smith

Sharing ▾

Building Information Modeling Opportunities



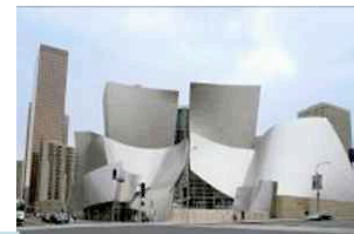
Planning



Design



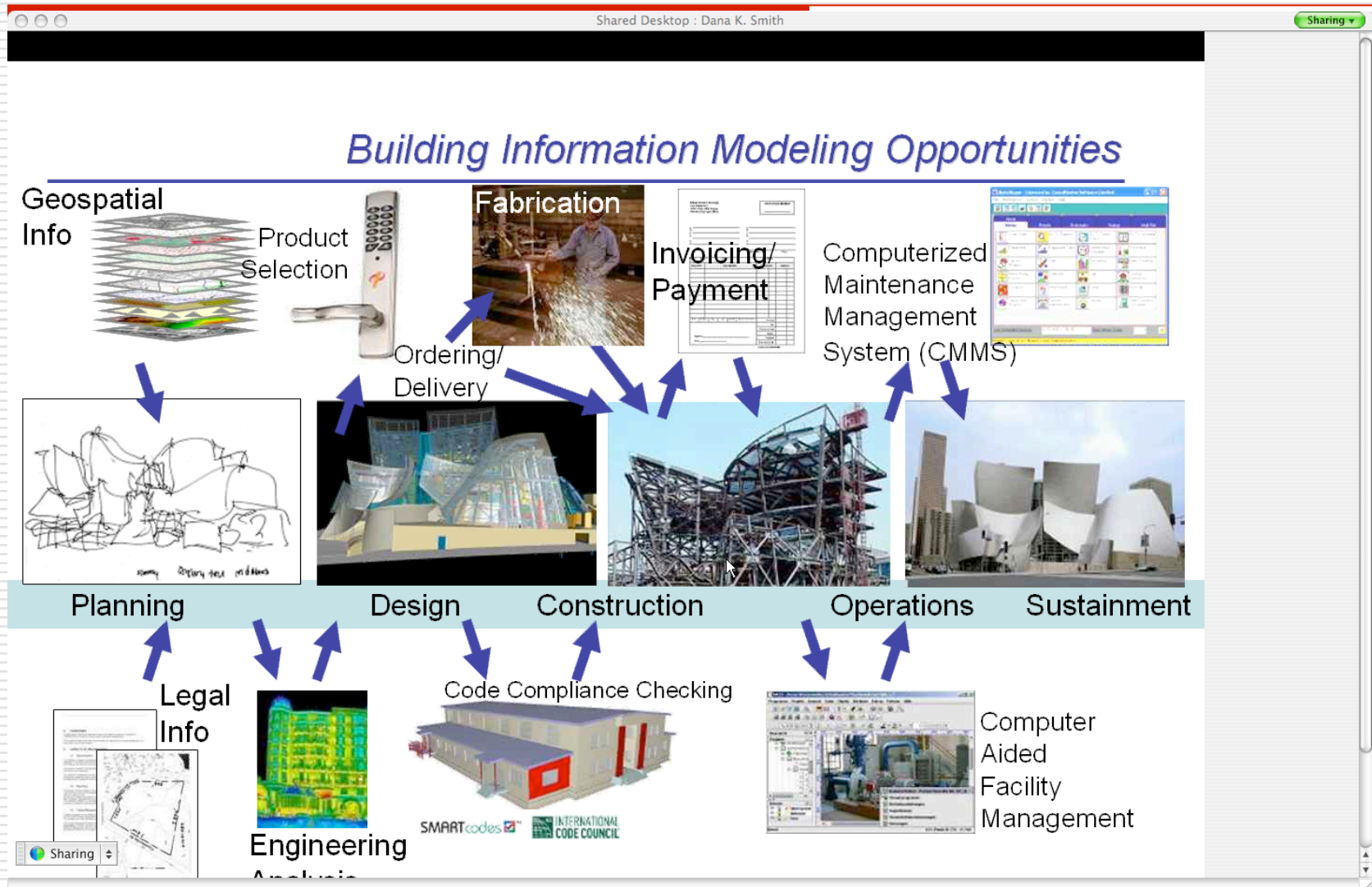
Construction



Operations

Sustainment

Building Information Modelling



What are Firms Doing, re: CAD, digital data?

- Not So Good (status quo):
 - Creating lots more CAD every day, but unorganized
 - Continuing to rely on proprietary formats for current and mid-term purposes
 - Not archiving for long-term
 - Not preparing (don't know how) materials for archive

What are Firms Doing, re: CAD, digital data?

- Good (progress):
 - (Beginning to) recognize the issues
 - Attempting to make data interchange standards work
 - Trying to embrace BIM: richer CAD might aid interchange efforts, heighten need for longer-term archive solution

Data Consumers: Audiences

- ☐ Practice (Architects, Designers, Engineers)
- ☐ Research (Historians, Scholars)
- ☐ Teaching (Instructors, Students)
- ☐ General (Public, Casual)

Audience Use Cases

Blue signifies *future* use cases

- Practice (Architects, Designers, Engineers)
 - (Internal) Perform current work; re-use recent work
 - (External) Data interoperation with partner firms
 - (“Read Only”) Consult own work

Audience Use Cases

Blue signifies *future* use cases

- Research (Historians, Scholars)
 - (Design) Study history of design, “design intent”
 - (Business) Study process, techniques, economics

Audience Use Cases

Blue signifies *future* use cases

- Teaching (Instructors, Students)
 - (Design) Study history of design, “design intent”
 - (Practice) Study models to learn, extend CAD
 - (Computation) Capabilities, constraints, on design

Audience Use Cases

Blue signifies *future* use cases

- General (Public, Casual, Educational)
 - Study architectural history; view buildings, designs

Audiences Consulted

- Advisory Board
 - Architectural historian
 - 3D engineer
 - World cultural heritage
 - Architecture faculty
 - Practicing architects
 - CAD researcher
 - Architecture CAD platform CIO
 - Architecture IT consultant

Audiences Consulted

- ☐ MIT School of Architecture Faculty
- ☐ MIT architecture advanced grad. students
- ☐ Architecture firm visits
- ☐ Architecture firm libraries
- ☐ DCC 3D preservation seminars
- ☐ AIA Congress workshops
- ☐ CAD vendors discussions

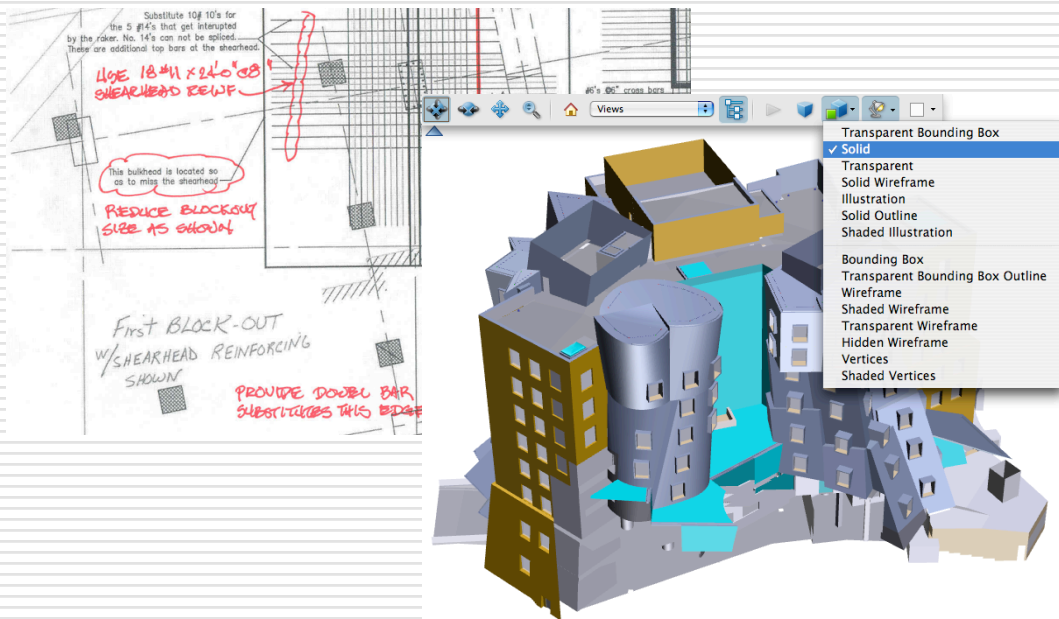
Datasets We're Working With

- Frank Gehry, MIT Stata Center
 - Cambridge, Mass. (2004)
 - CATIA
- Moshe Safdie, U.S. Institute of Peace
 - Washington, D.C. (2009)
 - Revit
- Thom Mayne, Caltrans
 - Los Angeles, Calif. (2004)
 - Microstation

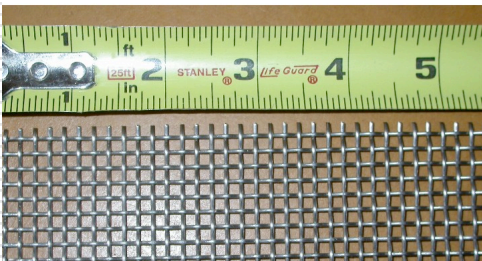


Data

- Design data
 - 3D Models
 - 2D Drawings

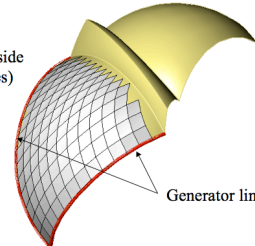


Data and "Meta" Data



Option 1: 'Draped net'

Every tile has same side length (angle changes)



Every tile is different



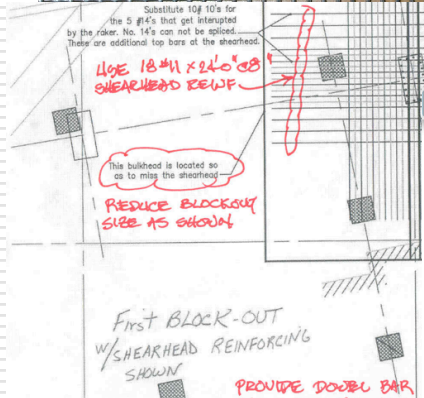
REQUEST FOR INFORMATION

REF CODE:
This RFI form is prepared by the Contractor Documents, or to notify the architect of conditions

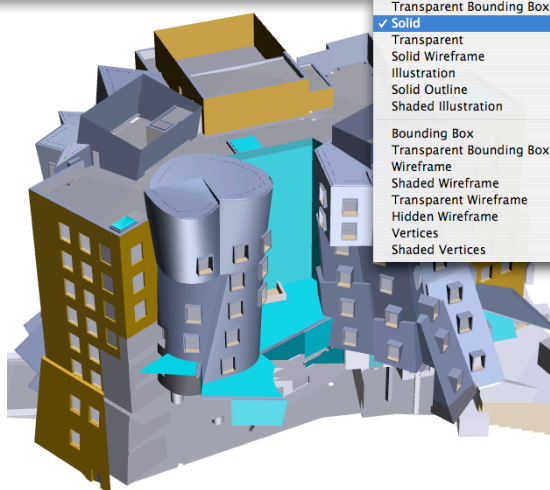
AREA REF:
RFI #: 7 REV #:
SUBS RFI #:
SUB:
FOR: Leblanc, Claude

Massachusetts Institute of Technology
Frank O. Gehry and Associates
CANNON
Beacon Skanska Construction Company





Electronic Transmittal -
Volume in drive F is acad-
Volume Serial Number is 01AF-0203
Directory of F:\9801\transfer\out\01060401-jama-
06/04/01 09:29a <DIR>
06/04/01 09:27a <DIR>
06/04/01 10:00a 883 etransmt.txt
06/01/01 07:20p 82,433 s2_3-1-2b.dwg
06/01/01 07:19p 100,329 s2_3-1-2t.dwg
06/01/01 09:51p 341,764 s4_13.dwg
06/01/01 07:11p 339,014 x_2bot.dwg
06/01/01 07:16p 63,655 x_2t_pts.dwg
06/01/01 07:11p 36,641 x8998.dwg
06/01/01 07:11p 29,590 xfp_m1.dwg
06/01/01 07:17p 520,153 xfp02.dwg
06/01/01 07:12p 152,113 xfp02.dwg
06/01/01 07:16p 974,465 xsp_02.dwg
13 File(s) 2,641,040 bytes
524,288 bytes free



- Transparent Bounding Box
- ☒ Solid
- Transparent
- Solid Wireframe
- Illustration
- Solid Outline
- Shaded Illustration
- Bounding Box
- Transparent Bounding Box
- Wireframe
- Shaded Wireframe
- Transparent Wireframe
- Hidden Wireframe
- Vertices
- Shaded Vertices

current_master_model_list.xls

	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
ISSUE DATES																				
S.I. 201	11.12.02																			
S.I. 186	9.17.02																			
S.I. 176	9.17.02																			
S.I. 175	8.13.02																			
S.I. 122																				
S.I. 89 & Issue #10																				
Addendum 1 3.18.02																				
Structure Refresh																				
3.15.02																				
Issue #10	01.21.02																			
S.I. 41	01.21.02																			
PR 12	12.19.01																			
S.I. 41	12.05.01																			
S.I. 37	10.25.01																			
S.I. 24	10.18.01																			
Addendum #3																				
(To Issue #6) 08.27.01																				
S.I. 18	01.18.21																			
Addendum #2																				
(To Issue #6) 07.30.01																				
Addendum #1																				
(To Issue #6) 07.02.01																				
Issue 6 Shell																				
& Core (Part 1-4)																				
Construction & Permit																				
Set 04-50-01																				
Issue #8																				
Shell & Core (Part 4)																				
For construction																				
ISSUE #6.1 Construction																				
Set - Part 2 03-05-01																				



navigation

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- [Community portal](#)
- [Current events](#)
- [Recent changes](#)
- [Random page](#)
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[page](#) [discussion](#) [edit](#) [history](#) [delete](#) [move](#) [protect](#) [watch](#)

ConcordFormats

- [Concordance "How To" Page](#)

Merged Format Concordance for FOG/A

[\[edit\]](#)

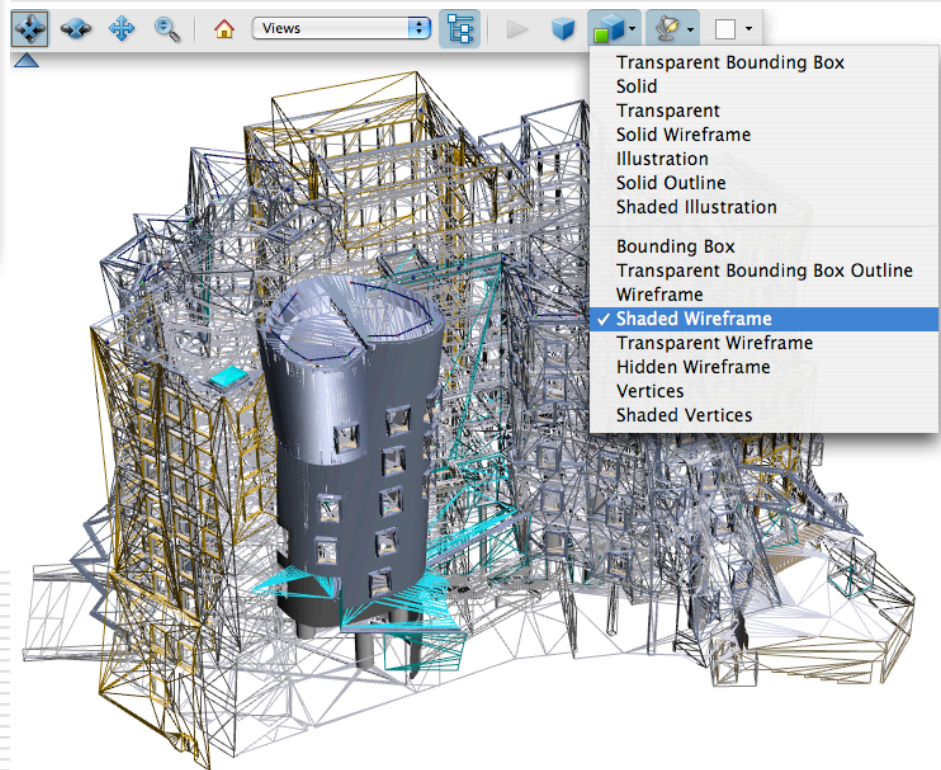
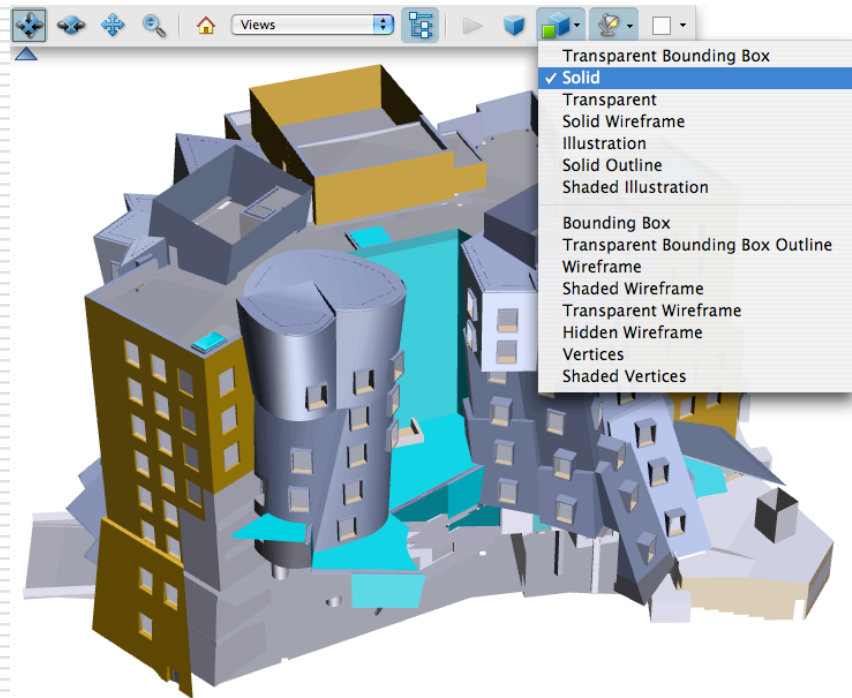
Frank O. Gehry's Stata Center

ID	Format Description	File ext	Format type	File count	Status
1	JPEG image data	jpg	JPEG image data	671	keep
2	AutoCAD DWG	dwg	AutoCAD DWG	18683	keep
3	AutoCAD shape or font file	shx	data	1047	maybe
4	TrueType font data	ttf	TrueType font data	59	keep
5	AutoCAD plotter configuration files (compressed)	pc3	PC pointer image data	74	trash
6	AutoCAD plotter configuration files (compressed)	ctb	PC pointer image data	78	trash
7	AutoCAD font map	fmp	ASCII text	86	trash
10	CATIA model	model	data	107	keep
11	Excel Spreadsheet	xls	Microsoft Office Document	94	keep
12	Unknown .project -- maybe related to FOGA stuff?	project	data	8	maybe
15	TAR archive	tar	tar archive	3	keep
17	PDF	pdf	PDF document	1338	keep
18	SDNF (Steel Detailing Neutral File)	sdnf	ISO-8859 text; with CRLF line terminators	69	keep
19	MS Word	doc	Microsoft Office Document	121	keep
21	ASCII text	txt	ASCII text	1191	keep
24	Empty	sdnf	empty	16	trash

3D CAD

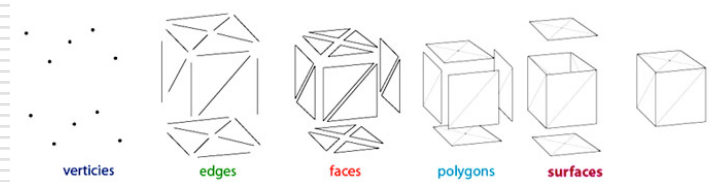
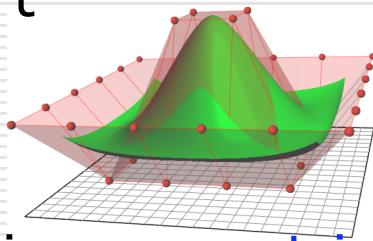
- Data Formats; Standards; CAD Tools
- Preservation Strategies

3D PDF: Quick Look

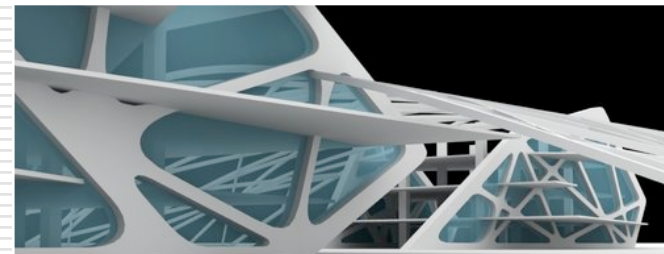
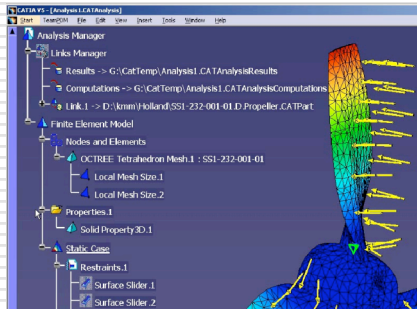


3D CAD Modelling Tools

- Vary in complex (**NURBS**) v. simple geometry (**Mesh**) support



- Vary in **parametric** modeling v. **inert geometry** support



How CAD products encode geometric and parametric models is unique and proprietary

Data Exchange Formats

- Open, Standards-Based

- Model Information

- **STEP (ISO 10303)**

- **IFC (ISO 16739)**

- Geometry Information

- **IGES**

- VRML

- STL

- Display formats (generally available)

- **3D PDF**

- Flash

Blue signifies formats under study

- *Various Industry Data Exchange Solutions*

- *Navisworks*

- *Collada*

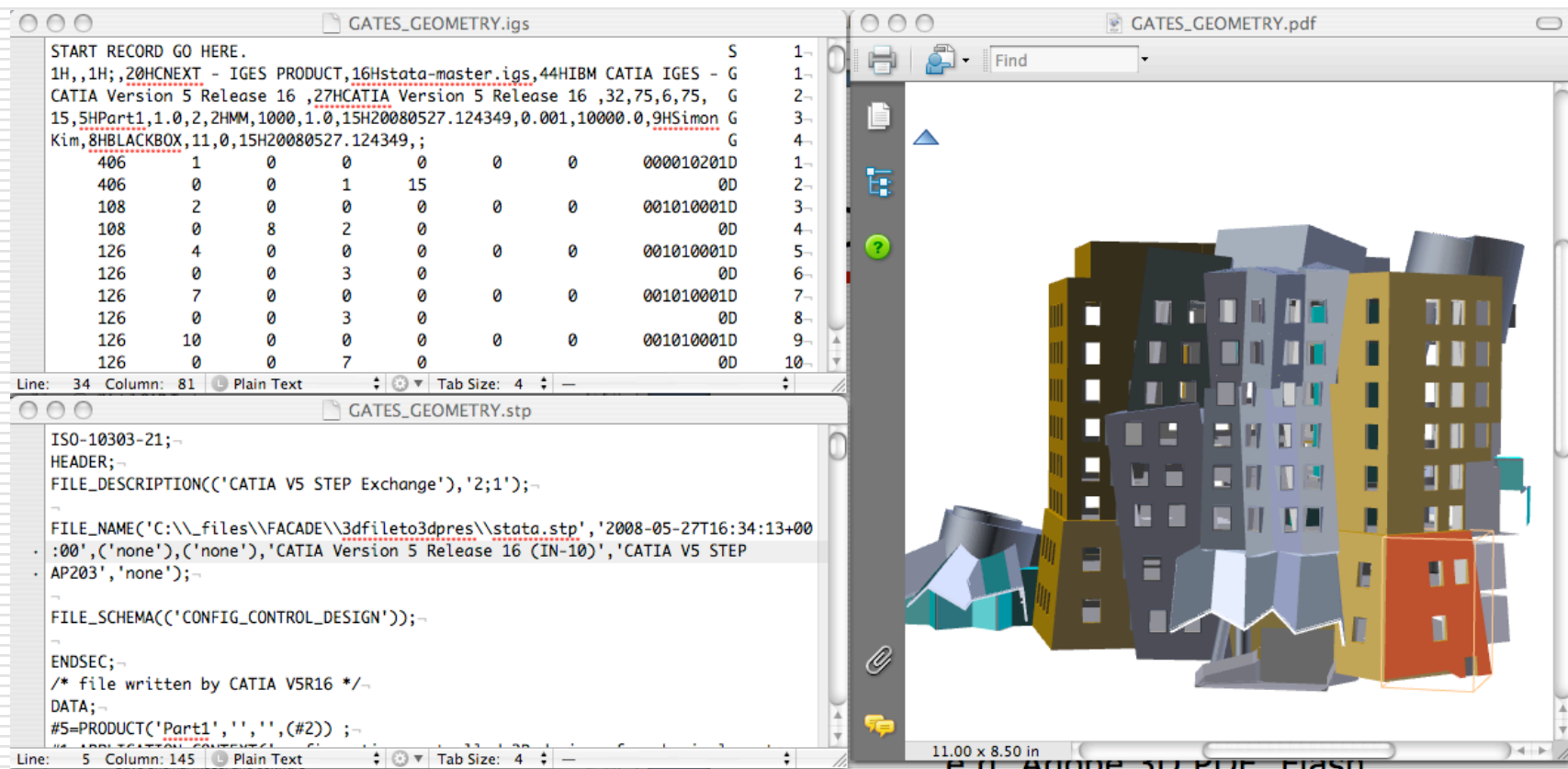
- *DXF / DWF*

- *DWG / DGN*

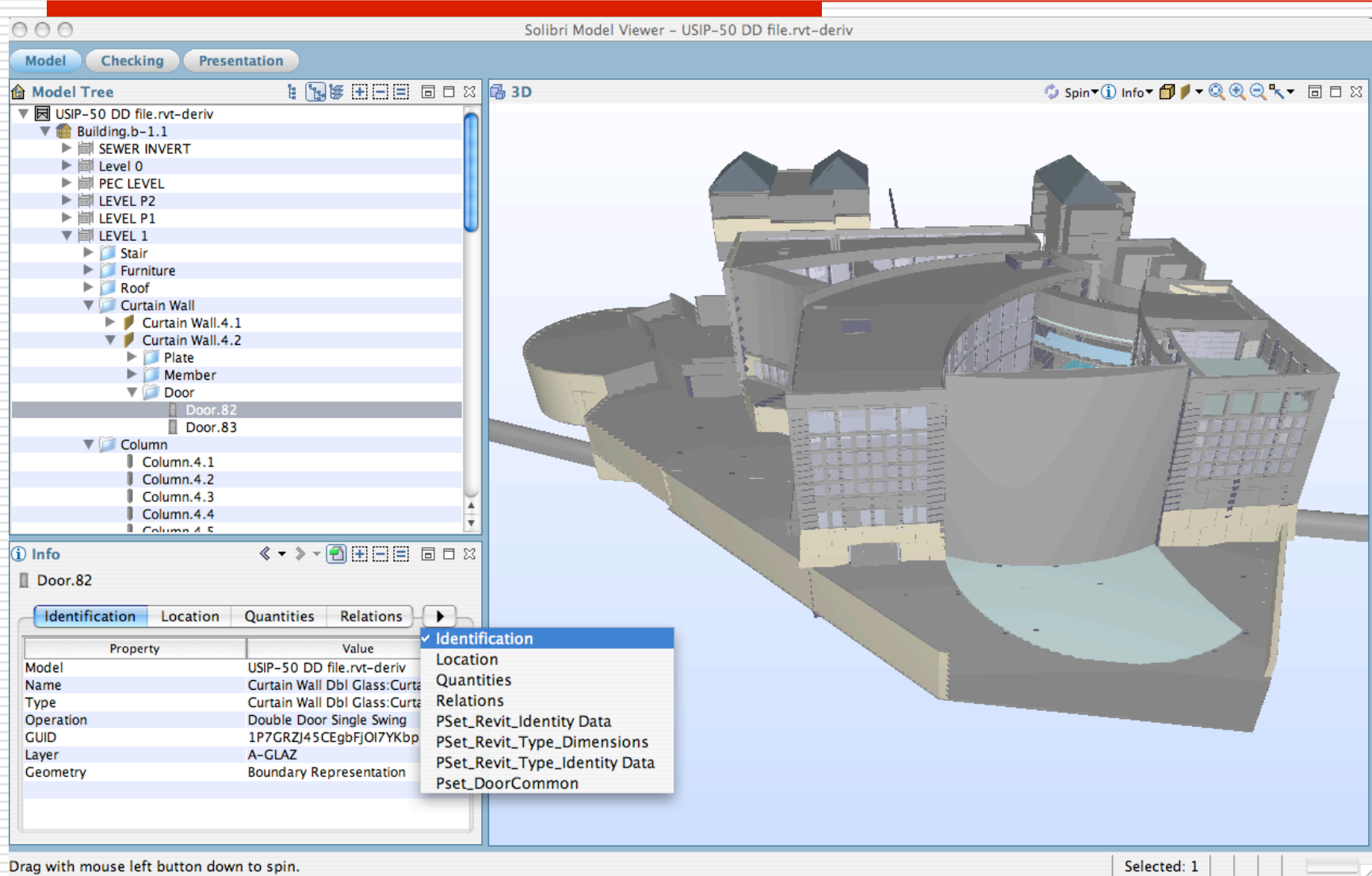
- *Viewers*

- *...*

3 Derivative Formats: IGES, STEP, 3D-PDF



IFC Viewer: Solibri



Ontology

- Project Information Model, Workflow
- Metadata, “Curators Workbench”
- DSpace Archive

PIM - Project Information Model

Entire architecture/design ***project***

- Initial sketches
- 3D CAD models, 2D CAD drawings
- Formal outputs (e.g. client presentations)
- Correspondence, RFIs, ASIs, etc.
- Consultant reports, obligatory certificates, documents
- Images, video, other media files
- Every client issuance

Linked together in a ***relationship map***

Early Ontology Design

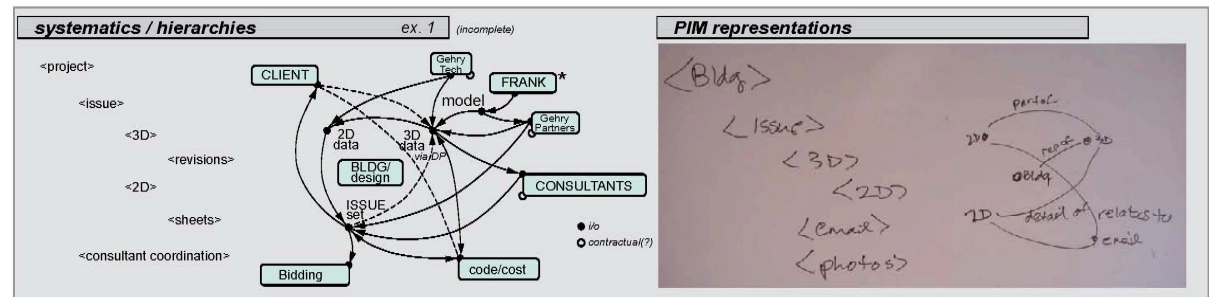
□ Prototype One

- "Business Objects"
- Context, relations
- Scaling issues...

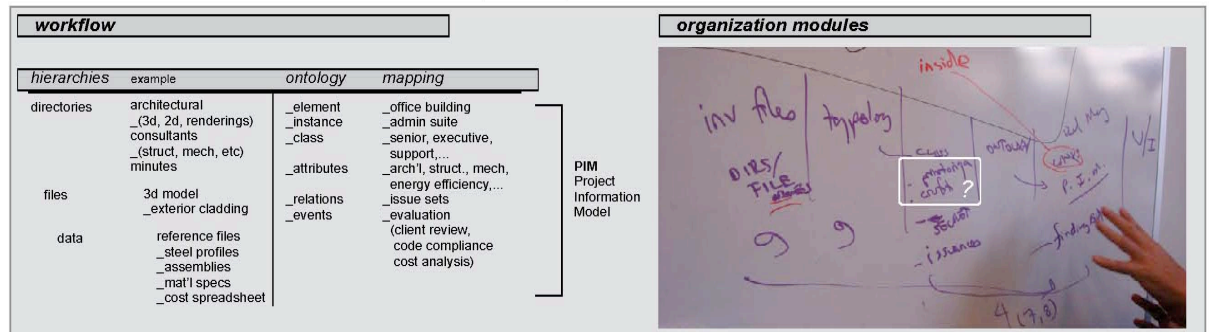
F.A.C.A.D.E. Project Information Model / ONTOLOGIES

the Project Information Model

sort and classify all the available data - 2d, 3d and construction administration (RFI's, change orders) - and map their relations. Model this as an ontology that can be called in an environment such as DSpace or the semantic web.
this formalization of building components is required so that they can be linked/represented in a predictable structure. In this manner, a reasoning methodology can be applied to other works.



* F. Gehry establishes and maintains his own contract separate from Gehry Partners



Properties on Objects [1 of 2]

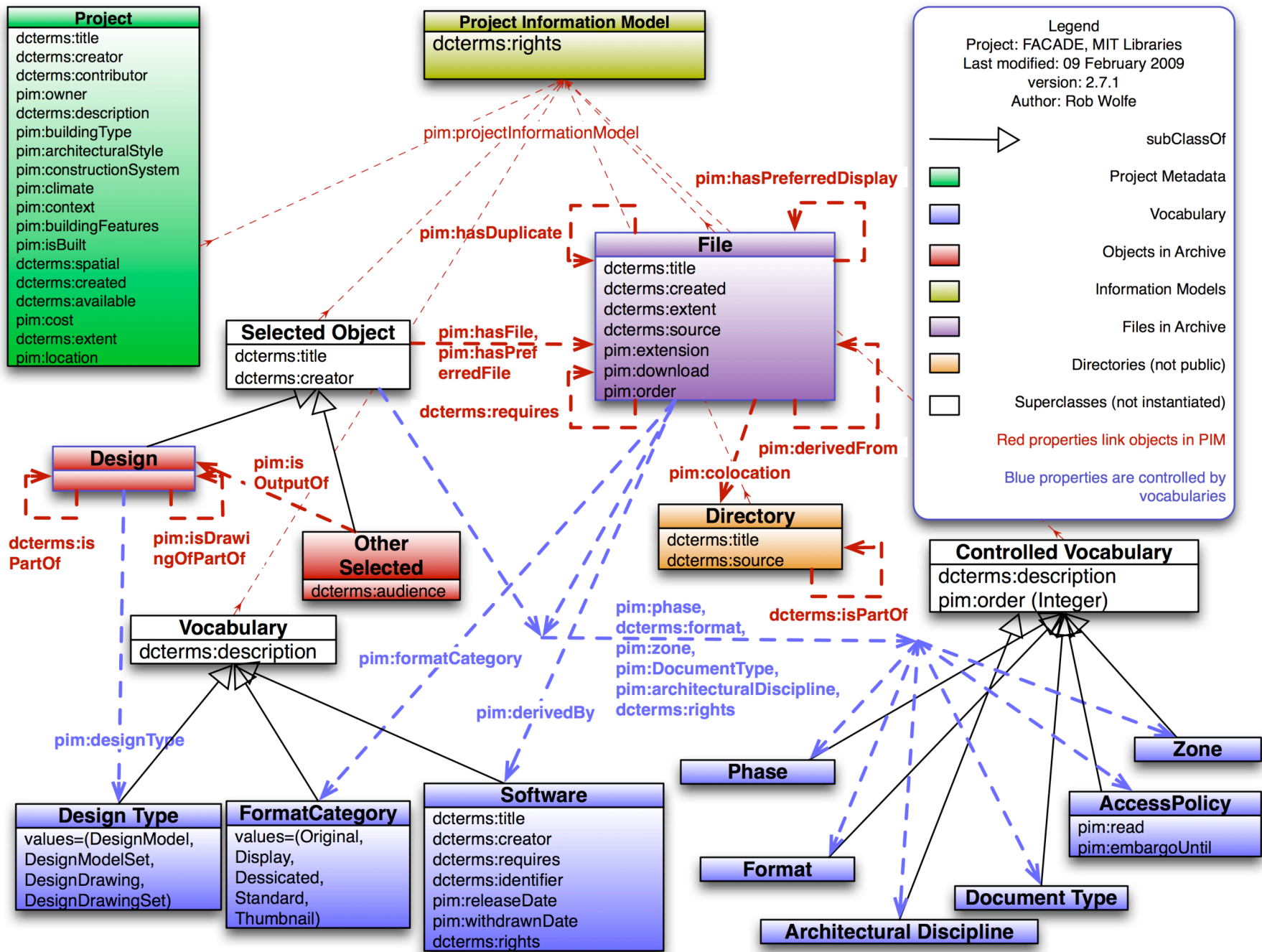
*Prototype Two
(latest approach)*

Every *File* gets five properties

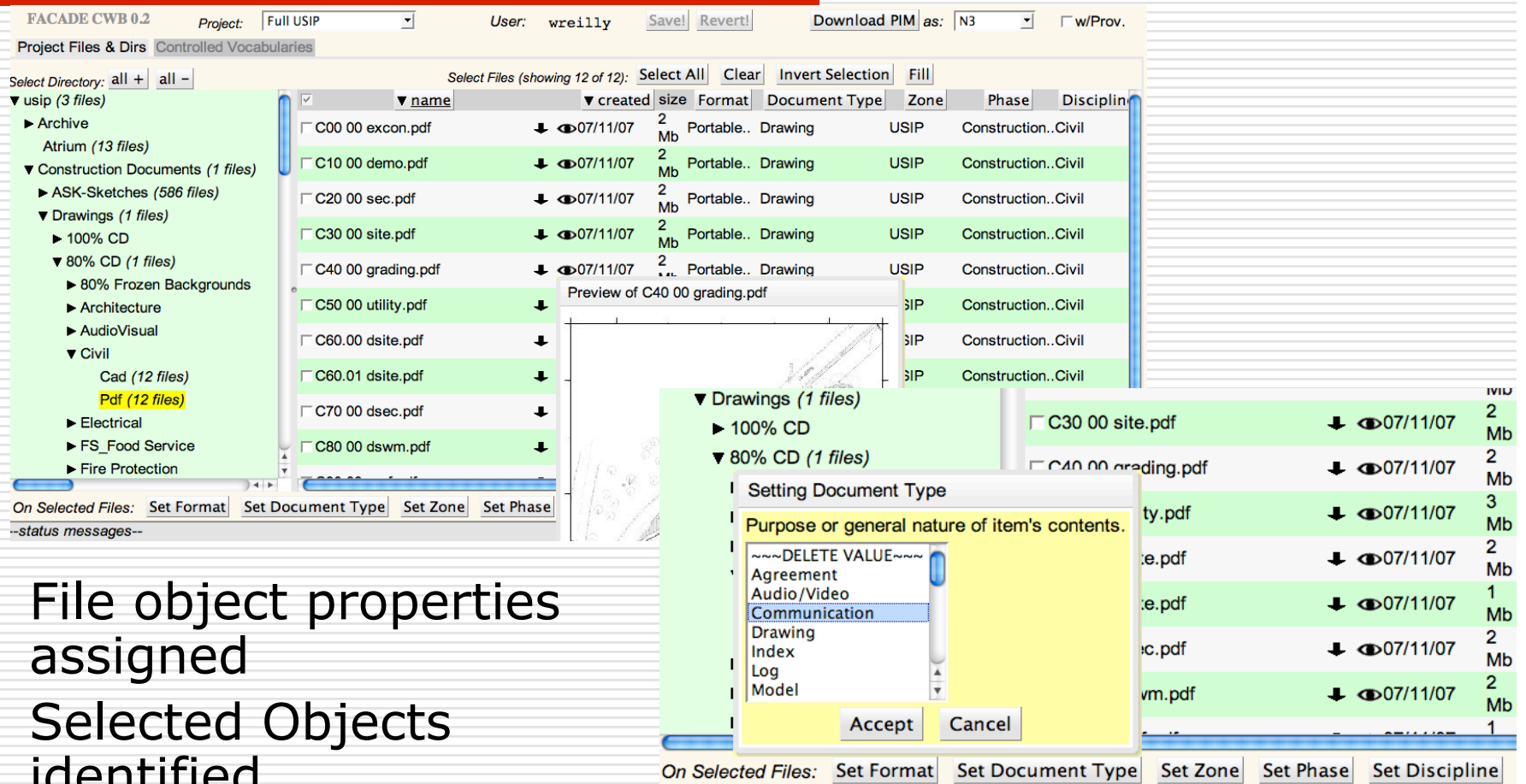
- ☐ Project Phase
e.g. concept, design, construction, etc.
- ☐ Building Zone/System
e.g. Stata Center, Gates Tower, 4th floor
- ☐ Architectural Discipline
e.g. architectural, electrical, mechanical, structural
- ☐ Document Type
e.g. presentation, drawing, communication
- ☐ File Format
e.g. CATIA, AutoCAD, Word, PDF

Properties on Objects [2 of 2]

- *Important files* further tagged
 - Specially curated “[Selected Objects](#)”
 - 3D models and 2D drawing sets
 - Client presentations, etc.
 - Privileged access in user interface



Curators' Workbench (CWB)



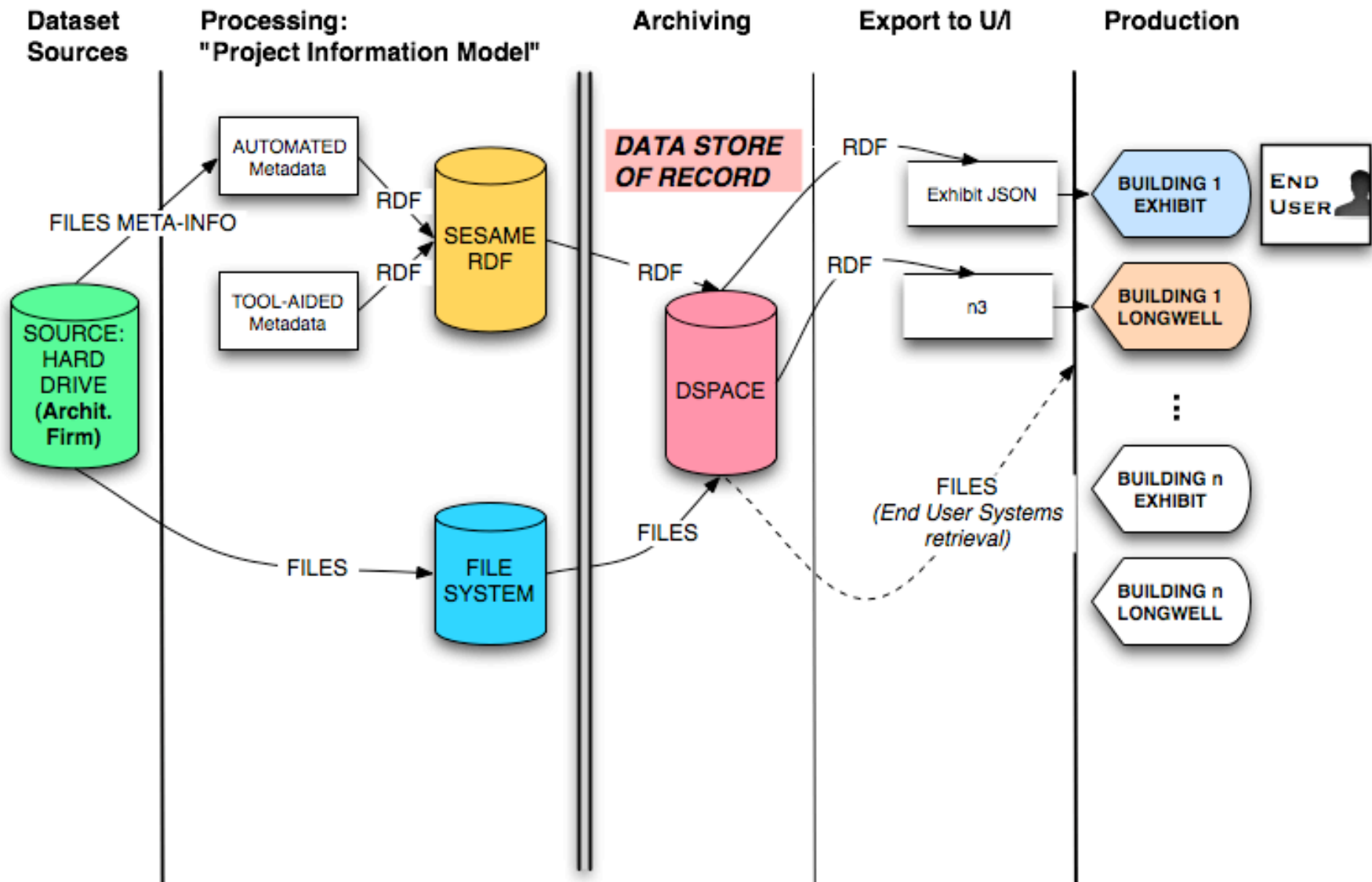
The screenshot displays the FACADE CWB 0.2 interface. The top bar shows the project name 'Full USIP', user 'wreilly', and options to 'Save!', 'Revert!', and 'Download PIM as: N3'. The left sidebar shows a tree view of project files and directories, including 'Archive', 'Construction Documents (1 files)', 'Drawings (1 files)', and '100% CD'. The main area shows a table of files with columns for name, created date, size, format, document type, zone, phase, and discipline. A preview window for 'C40 00 grading.pdf' is visible. A 'Setting Document Type' dialog box is open, showing a list of document types with 'Communication' selected. The bottom status bar shows 'On Selected Files: Set Format Set Document Type Set Zone Set Phase Set Discipline'.

On Selected Files: Set Format Set Document Type Set Zone Set Phase Set Discipline

- File object properties assigned
- Selected Objects identified

FACADE Data Stores, Data Flows

Last mod.: April 30, 2009 DRAFT



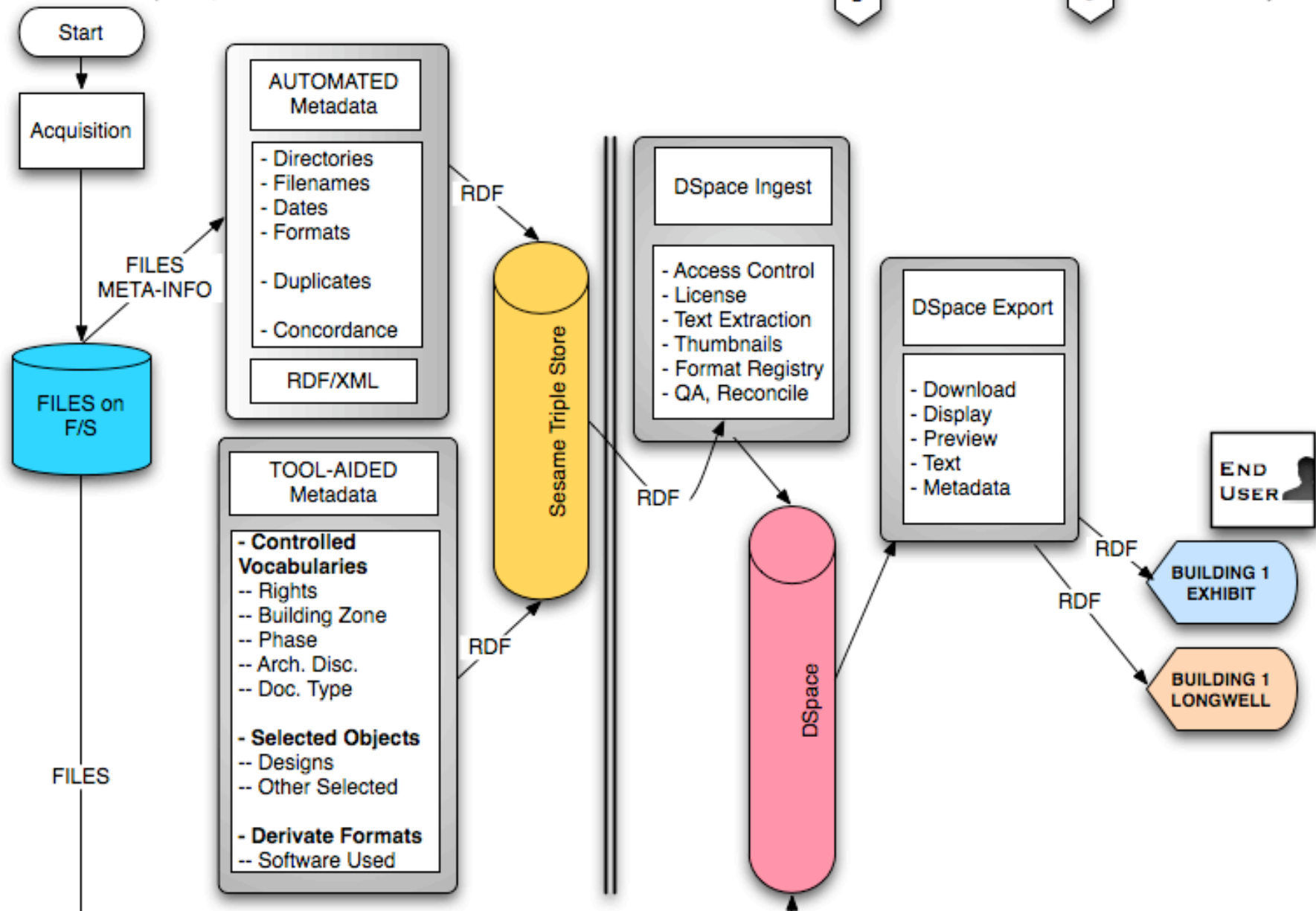
FACADE Data Processes

Last mod.: April 30, 2009 DRAFT

Publish Workflow

TODO Preview Workflow
B

TODO Re-Constitute Workflow / Lifecycle
C



DSpace Archive

- ❑ Preservation, dissemination, access control
- ❑ FACADE UI external to DSpace
- ❑ Bulk ingest tools (e.g. Curators' Workbench; DSpace "packager" importer)
- ❑ Format registry integration for technical curation (GDFR, PRONOM, DSpace internal)



FACADE DSpace Info Model

☐ Prototype One

- Selected Object = Item
 - ☐ File(s) = Bitstreams

☐ Prototype Two

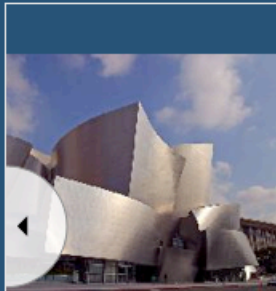
- File = Item
- File = Bitstream
- (Selected Objects constructed by RDF graph)

User Interface

FACADE Projects Catalog: Carousel View

FACADE PROJECTS

ITEMS • MAP • TIMELINE • CAROUSEL



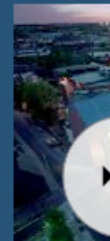
Disney Concert Hall
Gehry Partners, LLP



The U.S. Institute of Peace
Headquarters
Moshe Safdie and
Associates



Ray and Maria Stata Center
Gehry Partners, LLP



The Peabody Essex Museum
Moshe Safdie

Search

Is Built?

- false (3)
- true (6)

Extent

- 1,050,000 sq. ft. (1)
- 111,000 square feet (1)
- 150,000 square feet (1)
- 18,000 sq. ft. (1)
- 200,000 sq. ft. (1)
- 258,333 sq. ft. (1)
- 6,000,000 square feet (1)
- 605,000 sq. ft. (1)
- 720,000 sq. ft. (1)

Creator

- Gehry Partners, LLP (3)
- Morphosis (3)
- Moshe Safdie and Associates (3)

Context

- Government Campus (1)
- Small town (1)
- Urban (4)
- Urban University Campus (2)
- Urban Waterfront (1)

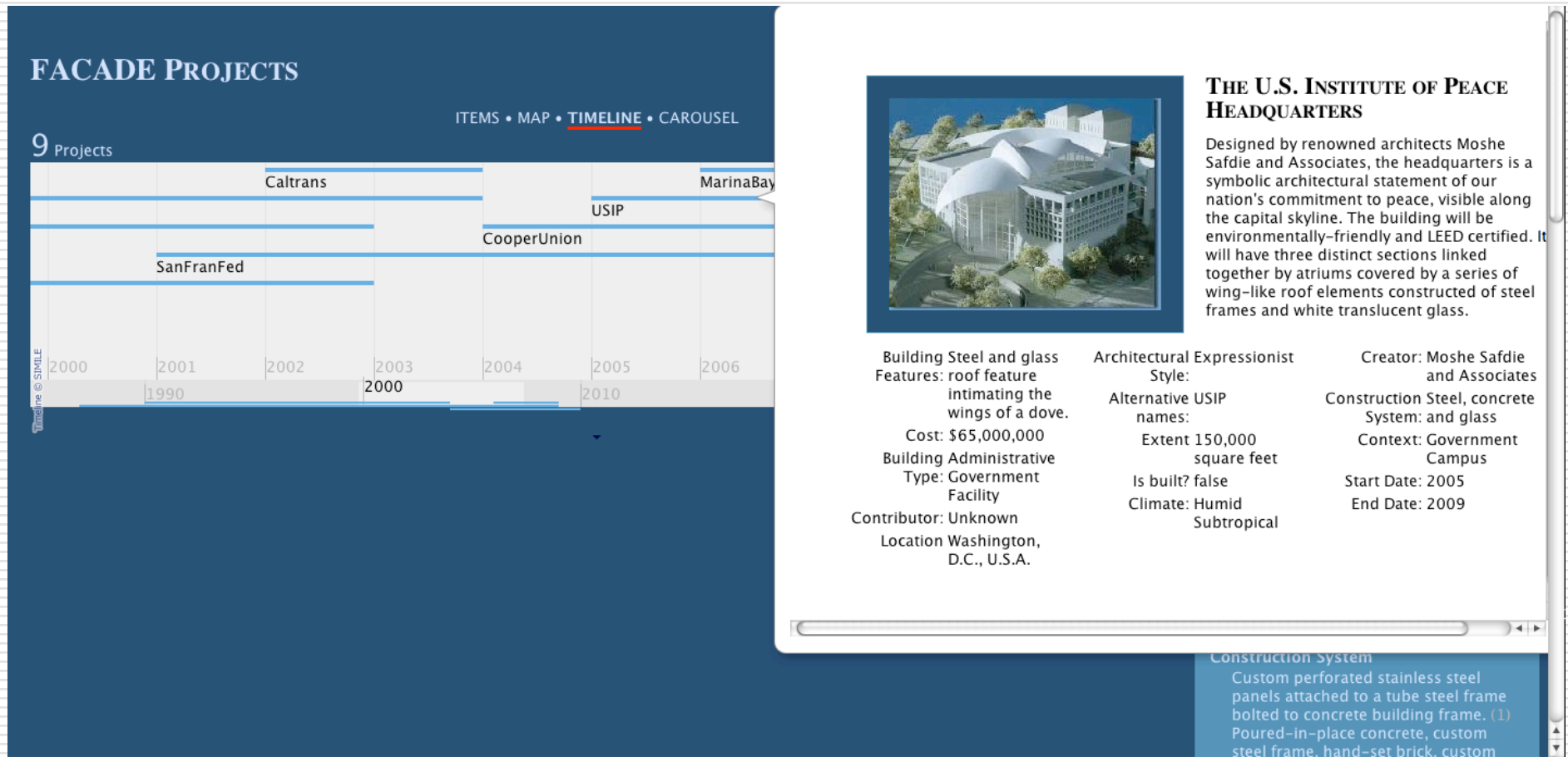
Climate

- Dry-Summer Subtropical Zone (2)
- Humid Continental (2)
- Humid Subtropical (2)
- Mediterranean (1)
- Oceanic (1)
- Tropical rainforest (1)

Construction System

- Custom perforated stainless steel panels attached to a tube steel frame bolted to concrete building frame. (1)
- Poured-in-place concrete, custom steel frame, hand-set brick, custom

FACADE Projects Catalog: Timeline View



Caltrans Project "Exhibit": Tiles View



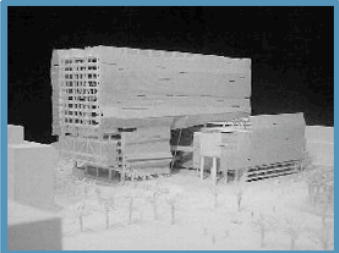
Caltrans District 7 Headquarters



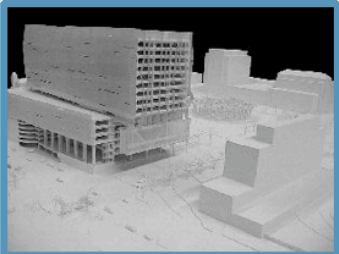
[Tiles](#) • [Table](#) • [Timeline](#)

5 File filtered from 55 originally ([Reset All Filters](#))

sorted by: [labels](#); then by... • ☒ grouped as sorted



[Source Path](#) site model images/enhanced final images/axon1.jpg
[Architectural Discipline](#) Architecture
[Zone](#) Caltrans
[Phase](#) Competition
[Doc Type](#) Model
[Format](#) JPEG File Interchange Format 1.02
[Extension](#) jpg
[File Size](#) 193405
[Original Directory Location](#) enhanced final images
[Created](#) 2001-11-06T04:48:38



[Source Path](#) site model images/enhanced final images/axon2.jpg
[Architectural Discipline](#) Architecture
[Zone](#) Caltrans
[Phase](#) Competition
[Doc Type](#) Model
[Format](#) JPEG File Interchange Format 1.02
[Extension](#) jpg
[File Size](#) 178675
[Original Directory Location](#) enhanced final images
[Created](#) 2001-11-06T04:46:16

Search

Type

5 File

Original Location

1 02-08-06

4 enhanced final images

Format

19 (missing this field)

3 ASCII Text

4 AutoDesSys Form.Z model

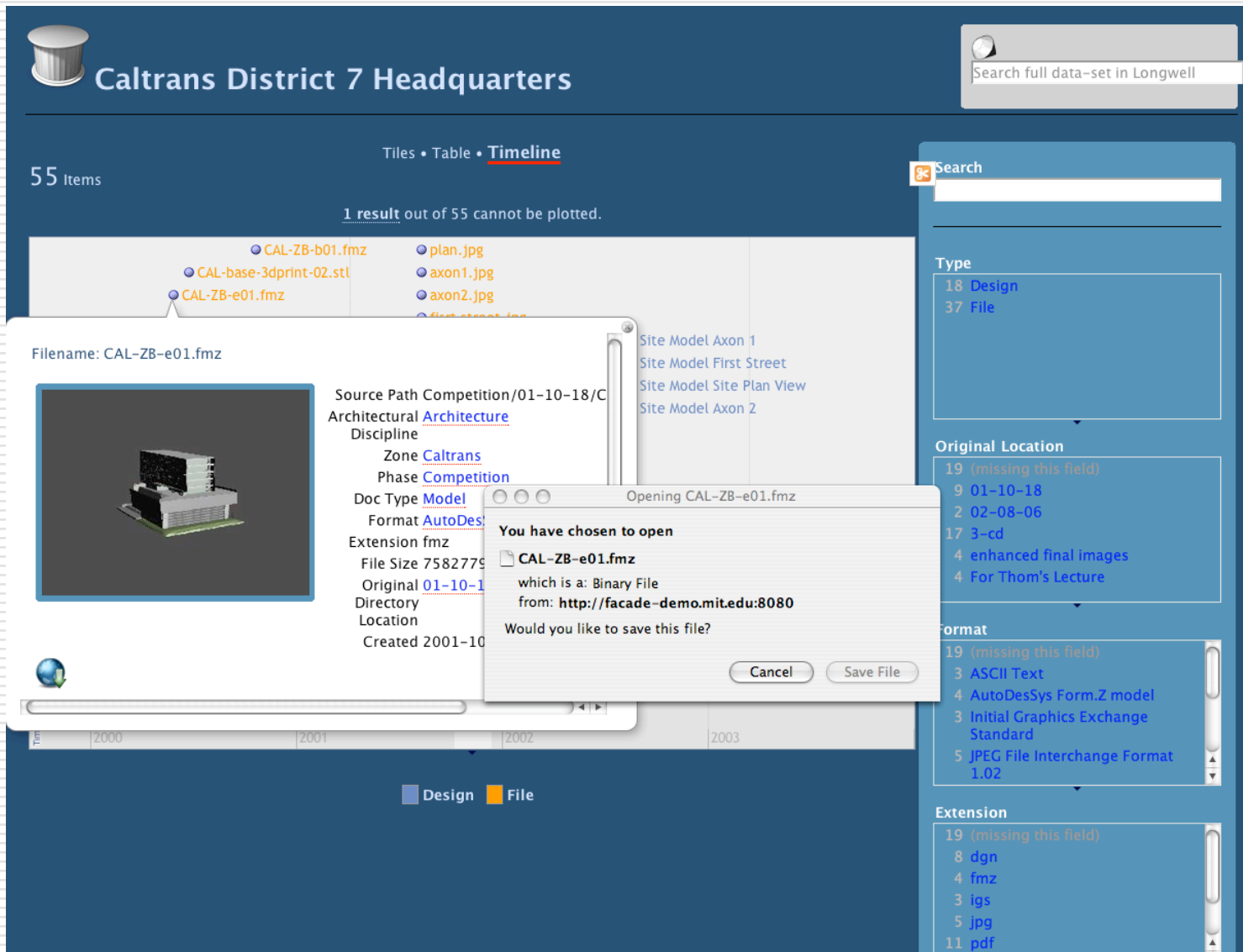
3 Initial Graphics Exchange Standard

5 JPEG File Interchange Format 1.02

Extension

5 jpg

Exhibit: Timeline, with Popup, Download



Caltrans District 7 Headquarters

Search full data-set in Longwell

55 Items

Tiles • Table • **Timeline**

1 result out of 55 cannot be plotted.

Filename: CAL-ZB-e01.f mz

Source Path Competition/01-10-18/C

Architectural [Architecture](#)

Discipline

Zone [Caltrans](#)

Phase [Competition](#)

Doc Type [Model](#)

Format [AutoDes](#)

Extension fmz

File Size 7582779

Original [01-10-1](#)

Directory

Location

Created 2001-10

Site Model Axon 1

Site Model First Street

Site Model Site Plan View

Site Model Axon 2

Opening CAL-ZB-e01.f mz

You have chosen to open

☒ CAL-ZB-e01.f mz

which is a: Binary File

from: <http://facade-demo.mit.edu:8080>

Would you like to save this file?

Cancel Save File

Search

Type

18 Design

37 File

Original Location

19 (missing this field)

9 01-10-18

2 02-08-06

17 3-cd

4 enhanced final images

4 For Thom's Lecture

Format

19 (missing this field)

3 ASCII Text

4 AutoDesSys Form.Z model

3 Initial Graphics Exchange Standard

5 JPEG File Interchange Format 1.02

Extension

19 (missing this field)

8 dgn

4 fmz

3 igs

5 jpg

11 pdf

■ Design ■ File

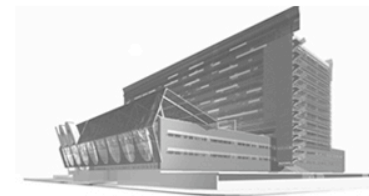
Caltrans "Longwell": "Starting Points" View

Caltrans District 7 Headquarters

FACADE Viewer // Data-set: CALTRANSv1 (12.16.2008)

Featured Data-Sets:

- [Design Drawings, Models and Sets](#)
- [Photographs](#)



🔍 Type here to search

Phases

- [\(missing\)](#) 13471
- [Construction Documents](#) 10373
- [Design Development](#) 1904
- [Competition](#) 512
- [Pre-Schematic Design](#) 506
- [Schematic Design](#) 380
- [Post-Construction Documents](#) 164
- [Does Not Apply](#) 2

Document Types

- [\(missing\)](#) 13485
- [Drawing](#) 10946
- [Photograph](#) 1641
- [Communication](#) 341
- [Specification](#) 301
- [Presentation](#) 132
- [Work File](#) 119
- [Unknown](#) 115
- [Model](#) 65
- [Product Brochure](#) 55
- [Rendering](#) 54
- [Sketch](#) 34
- [Other](#) 17
- [Circularly Filed](#) 3
- [Agreement](#) 2
- [Index](#) 2

Zones

- [\(missing\)](#) 13469
- [Caltrans](#) 12192
- [Core Building](#) 1344
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Longwell: Table View, with Popup

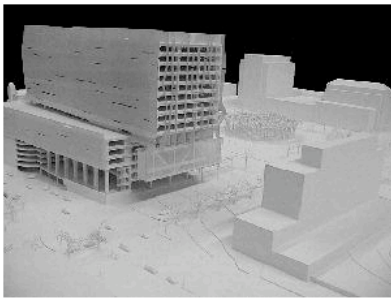
Caltrans District 7 Headquarters

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				✕ design type	✕ architectural discipline	✕ phase	✕ zone
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Architecture

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Source:

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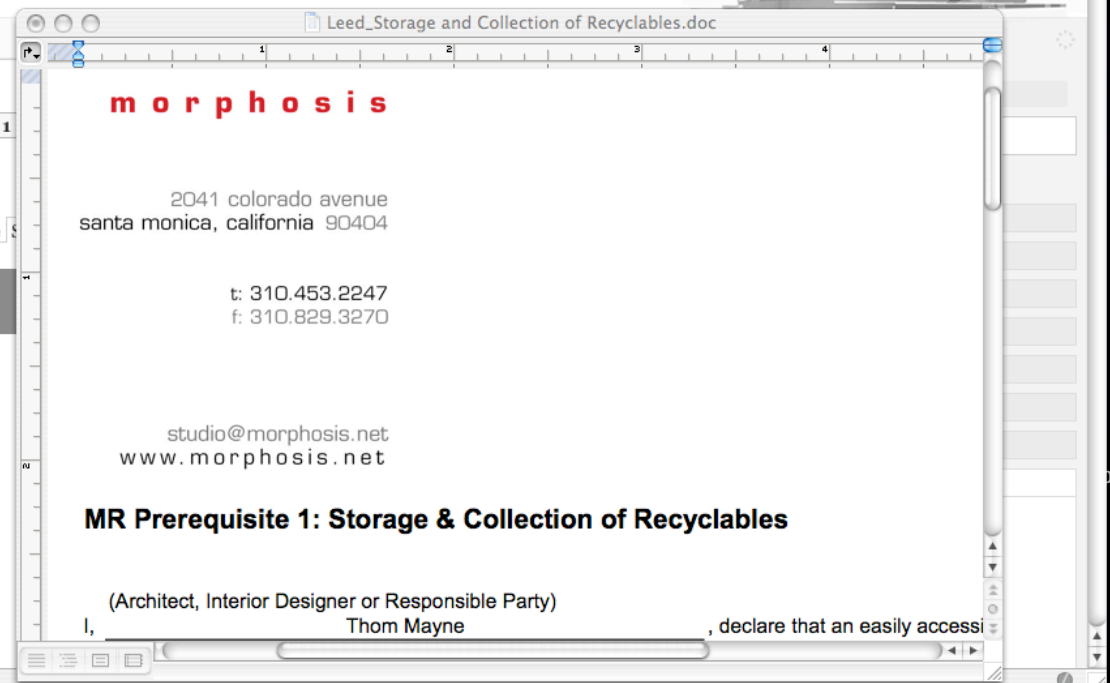
Format:

Microsoft Word for Windows Document 97-2003

Filesize:

108032

Done



Outcomes (*forthcoming...*)

INSTITUTIONS:

- ☐ Open source, production quality software (repository; U/I)
- ☐ Preservation strategy, format info, for 3D CAD
- ☐ Ontology, workflow

MIT:

- ☐ Evaluating work products
- ☐ Pilot Fall 2009

USERS:

- ☐ Avail. of materials
- ☐ Improvement over “File System” organization
- ☐ Some add’l. metadata

Acknowledgement



This project is made possible by a grant from the U.S. Institute of Museum and Library Services

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End User Path to Datasets

